Geotechnical Design Report

for the

H371.1, I-95 PAVEMENT RESURFACING OVERHEAD SIGN STRUCTURE DESIGN

Prepared by

KC Engineering and Land Surveying, P.C.

STATE OF NEW YORK · RAM MOHAN R KASTURI · 081878 · LICENSED PROFESSIONAL ENGINEER

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GEOTECHNICAL DESIGN REPORT

H371.1, I-95 PAVEMENT RESURFACING OVERHEAD SIGN STRUCTURE DESIGN

MAY 2025

PREPARED BY

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PREPARED FOR
NEW YORK STATE THRUWAY AUTHORITY

NEW YORK STATE

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1.0 Introduction

1.1 Purpose and Scope

This Geotechnical Design Report presents the results of the geotechnical exploration performed by KC Engineering and Land Surveying PC. along with the geotechnical engineering conclusions and foundation design recommendations for the proposed Overhead Sign Structures located at Harrison, New York.

This report has been generated as per D214892 Term Agreement for Design Services for Pavement Resurfacing Assignment 1, Section 7300.

The following information has been summarized in this report:

- Description of Geology and Subsurface conditions.
- Evaluation and Interpretation of the subsurface soil conditions and design parameters.
- Foundation Design Summary and Recommendations.
- Assessment of short-term and long-term performance of foundation elements.
- Construction considerations

This report has been prepared in general accordance with the requirements of applicable chapters from NYSDOT Overhead Sign Structural Manual, NYSDOT OSS Blue Pages 2007, NYSDOT Geotechnical Design Manual (GDM, 2022 & 2016), and AASHTO LRFD Bridge Design Specifications, 10^{th} Edition, 2024.

1.2 Project Location

The proposed overhead sign structures are located on Interstate 95 in Harrison, New York. Refer to Figure 1 – Project Location Map.

1.3 Proposed Construction

The proposed construction includes two (2) cantilever sign structures at different locations within the project area. Refer to Figure 2 – Project Structure Map for the location of the structures.

2.0 Site Geology

2.1 Geology

The project area physiographic setting consists of Manhattan Phong and is bordered by Taconic Mountain and Hudson-Mohawk Lowlands to the north, Alleghany Plateau and Atlantic Coastal Plain to the south and east, Newark Lowlands to the west.

The region is underlain by a series of intensely metamorphosed sediments. The rocks extend in parallel ridges; and folding has steeply upturned them so that differential erosion has developed the ridges. Resistant rocks of schist, gneiss and granodiorite form the ridges while less resistant marble is the valley maker. The topography is predominantly controlled by the bedrock with superimposed glacial deposits, alluvial deposits and swamps being the minor features. Glacial till, which is mostly sandy, overlies over a highly irregular bedrock surface.

3.0 Geotechnical Investigation

3.1 Subsurface Exploration

This section outlines the subsurface exploration performed by KC Engineering and Land Surveying PC. A total of two (2) Standard Penetration Test (SPT) borings were performed for the proposed overhead sign structures. See Table 1 for the list of borings.

Table 1 - List of Borings

Boring Number	Latitude (deg)	Longitude (deg)	Ground Surface Elevation (ft)	Termination Depth (ft)	Date Drilled	Proposed Structure
DM-X-1	40.974980	-73.719594	61	27	12/20/2024	Location 2 OHSS (S611.30)
DM-X-2	40.970809	-73.725238	77	27	12/19/2024	Location 1 OHSS (S610.90)

The borings were performed by Aquifer Drilling and Testing (ADT) and inspected by KC Engineering and Land Surveying, PC. *Appendix A* includes ***the Boring Location Plan*** and ***Subsurface Exploration Logs*** which provide detailed subsurface information. Boring logs were prepared using gINT software and the most recent gINT template and library files posted on the NYSTA website.

Standard Penetration Test (SPT) borings were conducted using a Geoprobe 7822DT equipped with a 140 lb. automatic hammer and tri-cone roller drill bit was used to advance the borings. The upper portion of the boreholes were stabilized using varying lengths of 4½ -inch O.D. steel casing driven by the automatic hammer. Drill mud rotary technique was used to bore the holes and Standard Penetration Test (SPT) was performed in general accordance with NYSTA Subsurface Exploration Specifications and NYSDOT GDM Chapter 4 with continuous sampling for the first 15 ft. followed by samples taken at 5-foot intervals. The soil samples extracted were classified per the USCS. [1]

USCS legend to identify the soil layers is included in *Appendix A*. The boring logs are based on field observations and have been revised based on the laboratory test results of selected soil samples and confirmation of their soil classification.

3.2 Summary of Laboratory Results

All soil samples obtained from the drilling operation were tested for Moisture content. Additionally, select soil samples were tested for Grain size analysis and Atterberg limits after consultation with NYSTA Geotechnical Engineer. All laboratory tests were performed by Colliers Engineering & Design, Mays Landing, NJ. Laboratory test results are presented in Appendix B.

3.3 Groundwater

The depth to groundwater as observed during soil boring inspections are summarized in Table 2. The design groundwater elevation at Location 1 (S610.90) is taken as 66.0 ft and that at location 2 (S611.30) is taken as 48.0 ft.

Table 2 – Summary of Groundwater Readings at OHSS Location 1 and Location 2

Boring	Approximate Ground Surface Elevation (ft)	Groundwater Reading Date and Time	Approximate Depth to Groundwater (ft)	Approximate Elevation of Groundwater (ft)
DM-X-1 (Loc 2 – S611.30)	61	19-Dec-24 12:00	10	51
		20-Dec-24 09:45	12	49
		20-Dec-24 10:00	16	45
DM-X-2 (Loc 1 – S610.90)	77	18-Dec-24 13:15	15	62
		18-Dec-24 11:00	8	69
		19-Dec-24 13:00	10	67

The groundwater elevation is subject to seasonal variation and tidal fluctuations.

[1] The Unified Soil Classification System as outlined in ASTM 2487 "Standard Practices for Classification of Soils for Engineering Purposes (Unified Soil Classification System)" provides a conventional system for classifying soils. Another option is the NYSDOT Geotechnical Testing Procedure Manual – An Engineering Description of Soils – Visual Manual Procedure describes the method of identifying soils based on visual examination and manual tests.

3.4 Subsurface Conditions

Based on the review of boring logs obtained from the subsurface investigation described in Section 3.1, the subsurface soil conditions at the project site comprise predominantly of sand and gravel, ranging from medium dense to very dense in consistency. Boring DM-X-1 indicated approximately 12 ft. thick gravel layer, underlain by medium dense to dense sand layer. Boring DM-X-2 indicated approximately 12 ft thick medium dense gravel layer, underlain by dense sand layer. Boulders were encountered at the boring location DM-X-2 at a depth of 8 ft. and 22 ft. Bedrock was not encountered in any of the boring within the boring depth.

4.0 Foundation Design and Analyses

4.1 Seismic Analysis

The requirements for seismic analysis are based on AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition, 2011. A summary of seismic design criteria is presented below. See Appendix D for detailed analysis.

Risk Category = 'I'
Site Class = 'D'
S_1 = 0.040
F_v = 2.4
S_{D1} = 0.10
SDC = 'A'

As per AASHTO Guide Specification for LRFD Seismic Bridge design, liquefaction assessment is not required for structures with SDC 'A'.

4.2 Design Soil Parameters

The design soil parameters shown in Table 3 and table 4 were used for the design of the cantilever sign structures at Location 1 and 2 respectively. Refer to Figure 3 and Figure 4 for idealized soil profile for sign structure at the two locations.

Table 3 – Design Soil Properties – Location 1 – S610.90

Soil Layer	Thickness of soil layer (ft.)	Soil Type	Measured SPT (N-Value)	Corrected SPT		Unit weight (pcf)	Friction angle (deg)	Cohesion (psf)
				N_{60}	$N_{1,60}$			
1	~12	Sandy GRAVEL	16	21	32	130	34	0
2	~15	Silty SAND	45	60	74	135	36	0

Table 4 – Design Soil Properties – Location 2 – S611.30

Soil Layer	Thickness of soil layer (ft.)	Soil Type	Measured SPT (N-Value)	Corrected SPT		Unit weight (pcf)	Friction angle (deg)	Cohesion (psf)
				N_{60}	$N_{1,60}$			
1	~12	Sandy GRAVEL	26	35	52	135	36	0
2	~2	Silty SAND	17	23	33	130	34	0
2	~6	Silty SAND	46	61	79	135	36	0
2	~7	Silty SAND	23	31	34	130	34	0

The design parameters are based on the corrected N-values and selected based on correlations provided in NYSDOT GDM Chapter 8 and AASHTO Table 10.4.6.2.4-1.

The SPT blow counts have been corrected to account for hammer impact efficiency of 60% and overburden pressure as presented in AASHTO Section 10.4.6.2. Refer to *Appendix B* for GDM and AASHTO references.

4.3 Foundation Recommendations

Standard designs from NYSDOT OSS BD sheets have been used for cantilever sign structure at both locations. The structure type selected is CT-11-20 at both locations. Standard drilled shaft foundations from NYSDOT OSS BD sheets were considered to support the sign structures. Drilled shaft foundations were chosen over spread footings for the following reasons:

1. The presence of shallow groundwater conditions.
2. Drilled shafts are more cost-effective to construct.
3. Drilled shaft construction causes less traffic disruption, significantly reducing the need for extensive MPT arrangements.

As per NYSDOT OSS BD Sheets, these structures shall have 5.5 ft diameter – 17 ft long drilled shaft foundations. At both locations, groundwater is present within the drilled shaft length. As per NYSDOT OSS Manual Section 2.7.2, special foundation designs are needed when these conditions are present. Additional analysis and calculations for the standard drilled shaft foundations have been performed. Based on the analysis, the standard drilled shaft foundations from NYSDOT BD Sheets are adequate and does not need any modifications to safely transfer the applied loads. Analysis and design check of standard drilled shaft foundations are included in Appendix C.

The axial capacity of drilled shafts was checked using the ASD methodologies outlined in NYSDOT GDM Chapter 11 and AASHTO LRFD Bridge Design Specifications, 10th Edition, 2024.

Drilled shaft settlement was calculated in accordance with methodologies outlined in AASHTO LRFD Bridge Design Specifications. Per NYSDOT GDM Section 11.10.2.6.3, settlement shall be checked when the structure is not installed to a bearing layer or rock. The anticipated total drilled shaft settlement is 0.33 inches at Location 1 and 0.51 inches at Location 2, which are less than the tolerable limit of 1 inch specified in NYSDOT GDM Chapter 11.

Lateral geotechnical analysis of drilled shaft was performed using LPILE software. The maximum anticipated lateral deflection at the top of the shaft is 0.35 inches at Location 1 and 0.54 inches at Location 2, which are less than the tolerable limit of 0.5 inches specified in NYSDOT GDM Chapter 11. Refer to Table 5 for the summary of drilled shaft design. Refer to Appendix C for detailed foundation analyses and design.

Table 5 – Design Summary – OHSS Foundation

DESCRIPTION	Location 1 (S610.90)	Location 2 (S611.30)
Shaft Diameter	5'-6"	5'-6"
Exposed Height Above Grade	2'-0"	2'-0"
Total Drilled Shaft Length	17'-0"	17'-0"
Design Embedment	15'-0"	15'-0"
Vertical Reinforcement	44 - #8 bars	44 - #8 bars
Lateral Reinforcement	#4 @ 6" c/c	#4 @ 6" c/c
Nominal Geotechnical Axial Resistance	1781 Kip	1788 Kip
Allowable Geotechnical Axial Capacity	890.3 Kip	894.1 Kip
Demand Capacity ratio for Axial Geotech Capacity[1]	0.10	0.10
Nominal Torsional Resistance	598 Kip.ft	782 Kip.ft
Allowable Torsional Resistance	460 Kip.ft	602 Kip.ft
Demand Capacity ratio for Torsional Resistance	0.87	0.67
Max. Lateral Deflection at Top of Shaft	0.35"	0.54"
Maximum Axial Load Applied	26.30 Kip	26.30 Kip
Maximum Moment	658.07 Kip.ft	661.35 Kip.ft
Maximum Shear	93.76 Kip	101.05 Kip
Maximum Torsion	402 Kip.ft	402 Kip.ft
Maximum Anticipated Total Settlement	0.33"	0.51"
Maximum Anticipated Post Construction Settlement	0"	0"

[1]Demand Capacity ratio for Axial Geotech Capacity considers self-weight of the drilled shaft.

5.0 Construction Considerations

5.1 Drilled Shaft Installation

The soil at the tip of the drilled shafts shall be verified for the presence of any unsuitable material. If such unsuitable material is encountered, the Engineer shall be contacted for design review and additional recommendations.

5.2 Site Conditions

If any obstructions are encountered during installation of drilled shafts, the contractor shall use suitable means and methods to overcome such obstructions to the extent possible and install the drilled shafts to the required elevation.

Based on the SUE performed at the site, there are multiple utilities in the area. Contractor shall verify the location of existing utilities and ensure that the foundation is clear of any such utilities at the time of installation. Where overhead utilities as present, location shall be verified by Contractor during installation of drilled shafts and keep required safe distance. Utilities shall be relocated if required, to avoid any conflict.

Due to the proximity of the sign structure location to the roadway traffic, required MPT shall be in place during construction.

5.3 Groundwater Control

Based on the water levels measured in the borings, groundwater issues are anticipated during the installation of drilled shafts. When dewatering is not utilized, use concrete that meets the appropriate mix design requirements specified in Table 2 of NYSDOT MP 501-2 in accordance with NYSDOT Standard Specification 555-3.05 Depositing Structural Concrete Under Water.

5.4 Excavation Consideration

All excavations shall be supported by installing the required temporary support of excavation (SOE). SOE to be designed for the maximum height of soil retained and any additional surcharge from construction equipment and/or traffic. Any required temporary excavations should be conducted in accordance with OSHA safety guidelines.

5.5 Control of Surface Water

The control of surface runoff will be necessary to prevent and control erosion of exposed soils, especially on slopes, and the softening of exposed subgrades in excavations. Surficial drainage of slopes, berms, ditches, trench drains, and pumping from sumps should be utilized as needed to readily remove any surface water, where needed.

5.6 Unanticipated Rock

Based on the borings, bedrock is not expected within the drilled shaft length at any location. However, if an unexpected sound rock is encountered within one diameter of bottom of the shaft elevation, full shaft length shown on Table 5 shall be provided. If unanticipated sound rock is encountered at higher elevations, the total shaft length maybe decreased from that shown on Table 5, such that the shaft penetrates a minimum of one diameter into sound rock. However, the total embedment shall not be less than one diameter plus 2'-0". All changes to shaft lengths must be approved and as ordered by the engineer.

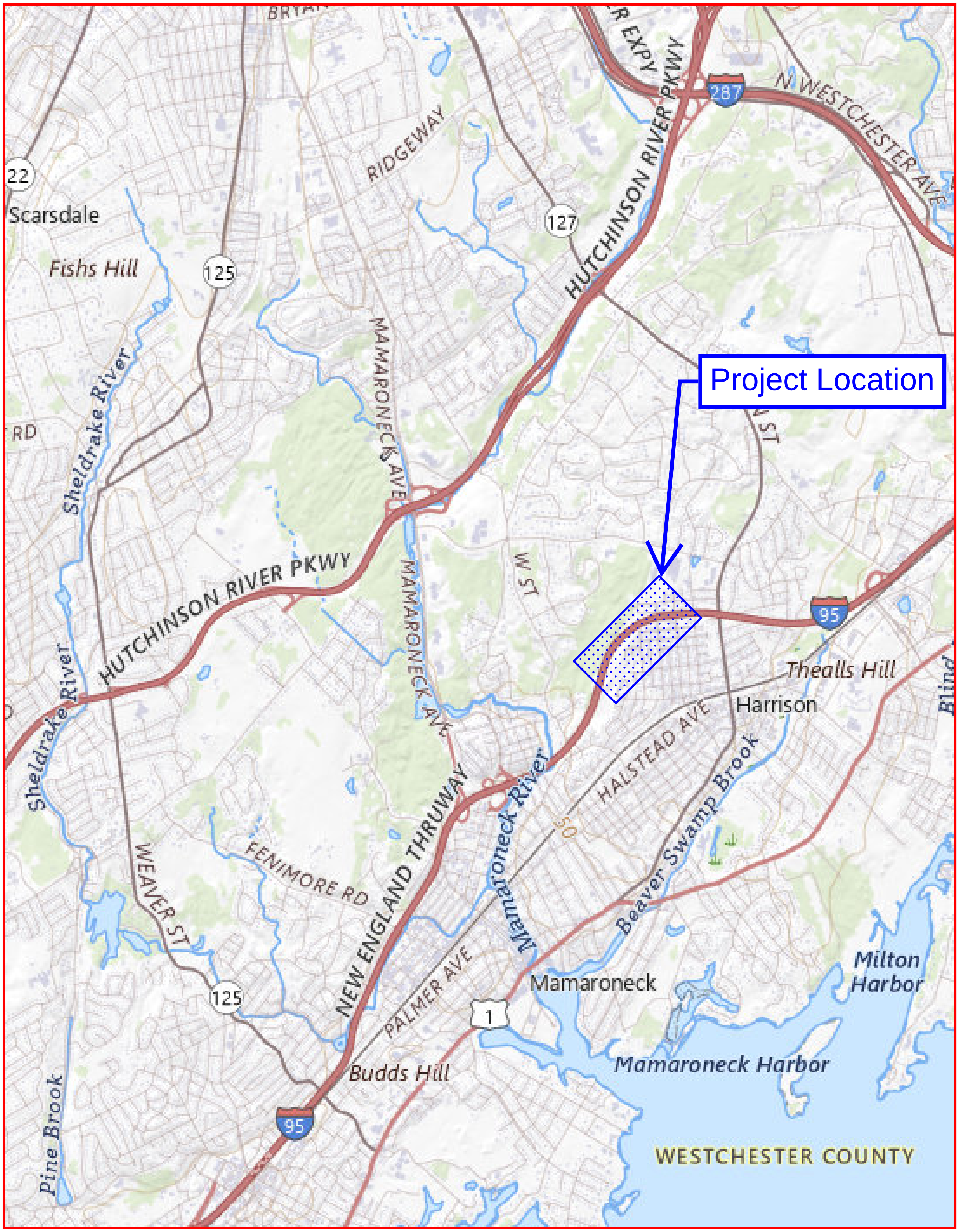
6.0 Limitations

This report presents our findings, recommendations and considerations for the design and construction of sign structures indicated in Section 1. It has been prepared in accordance with accepted engineering practice and in a manner consistent with the level of care and skill for this type of project within this geographic area. No warranty, expressed or implied, is made relative to liability for direct, indirect incidental, consequential or special loss or damage or other liability of any nature from said party's use of such report or reliance upon any of its content.

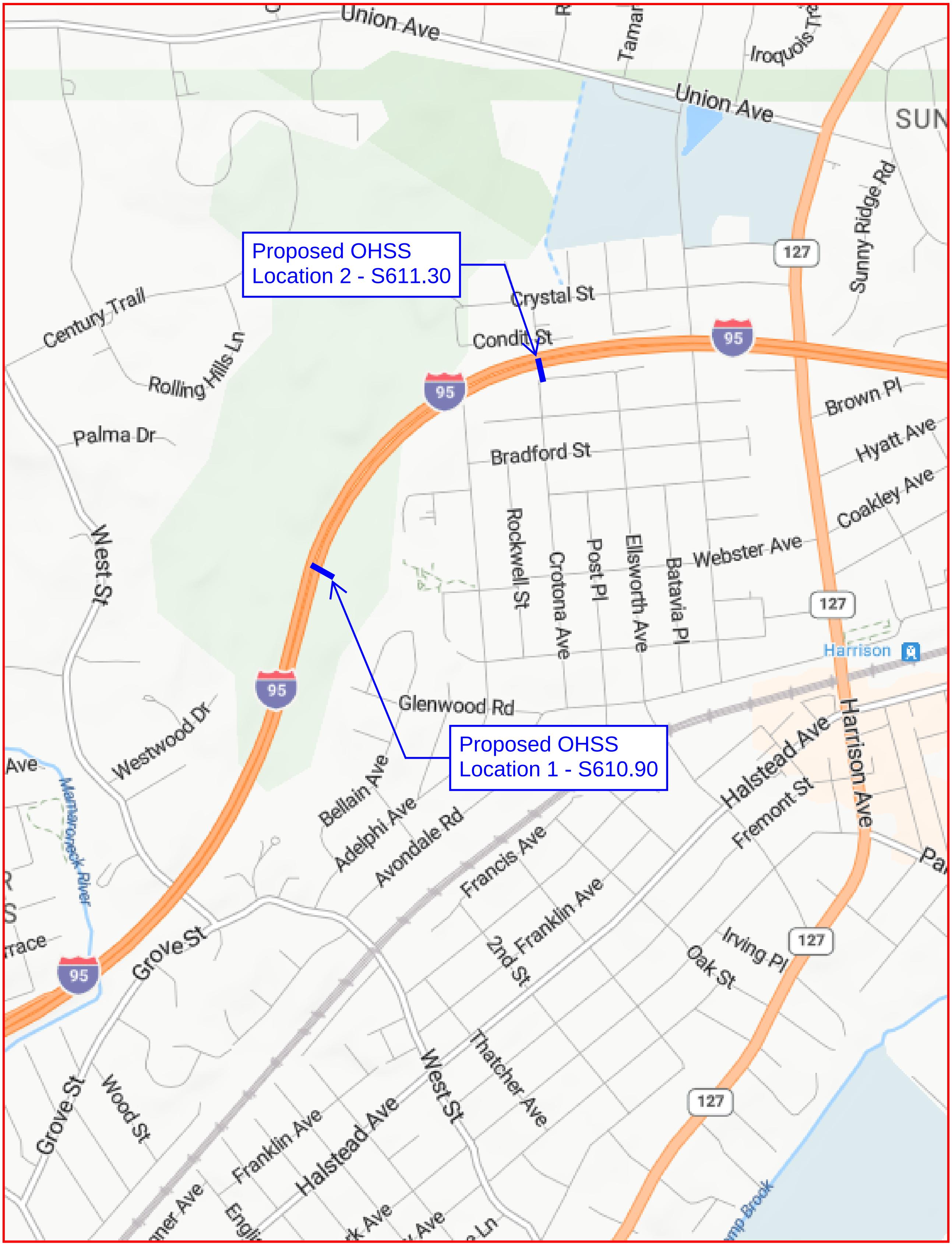
The conclusions and recommendations presented herein are based on field reconnaissance, research and available literature, the results of field exploration and laboratory materials testing, and the results of engineering analyses. KC Engineering and Land Surveying should be immediately contacted should subsurface conditions be encountered that are materially different than identified at the boring locations. Subsurface conditions that are materially different may require further investigation and supplemental recommendations.

Geotechnical engineering and the geologic sciences are characterized by uncertainty. Professional judgements presented herein are based partly on our understanding of the proposed construction, partly on our general experience, and on the state of the practice at the time of this writing.

FIGURES



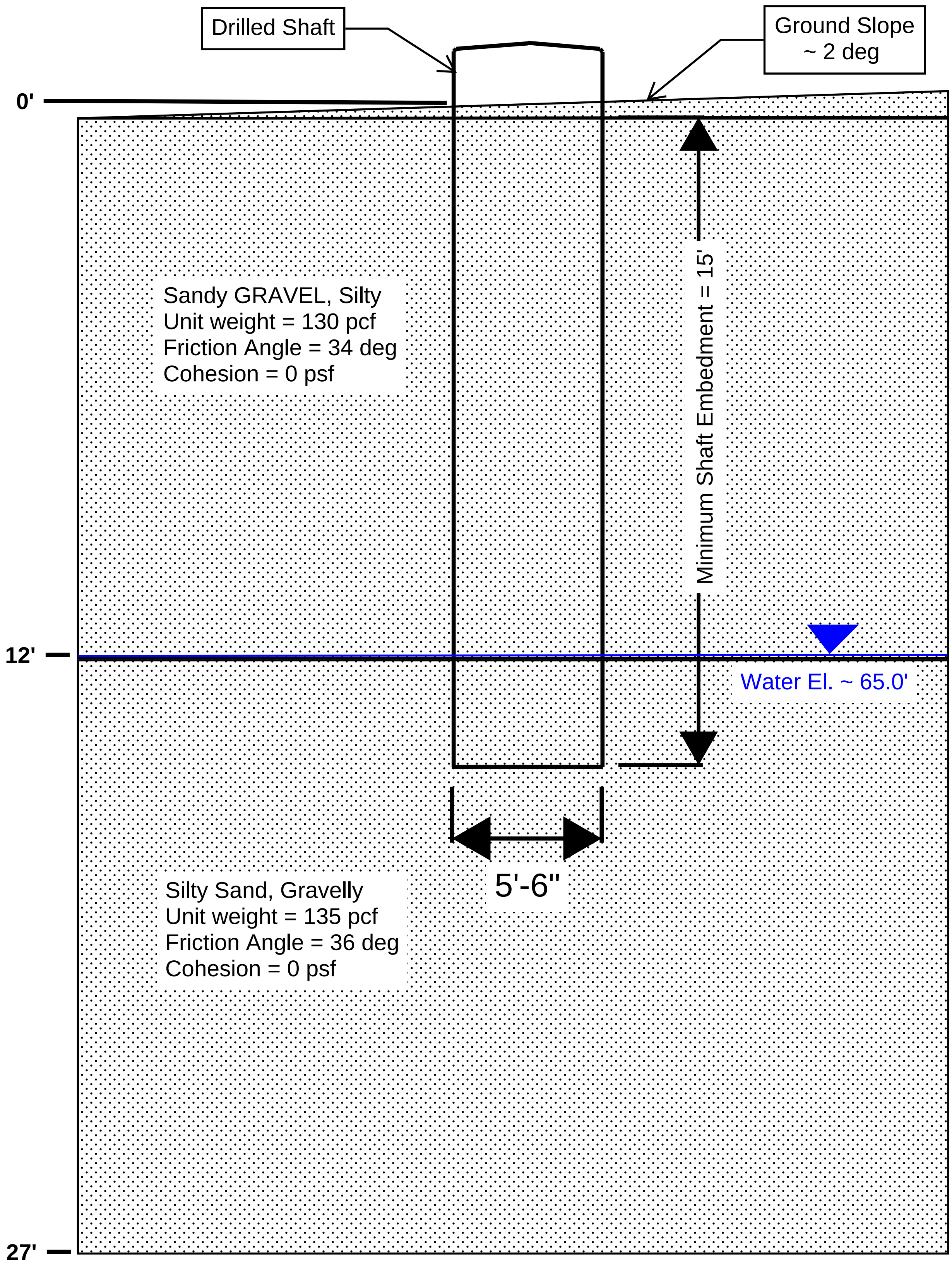
Engineering and Land Surveying, P.C.	FIGURE 1 PROJECT LOCATION MAP	PROJECT NO: 120186



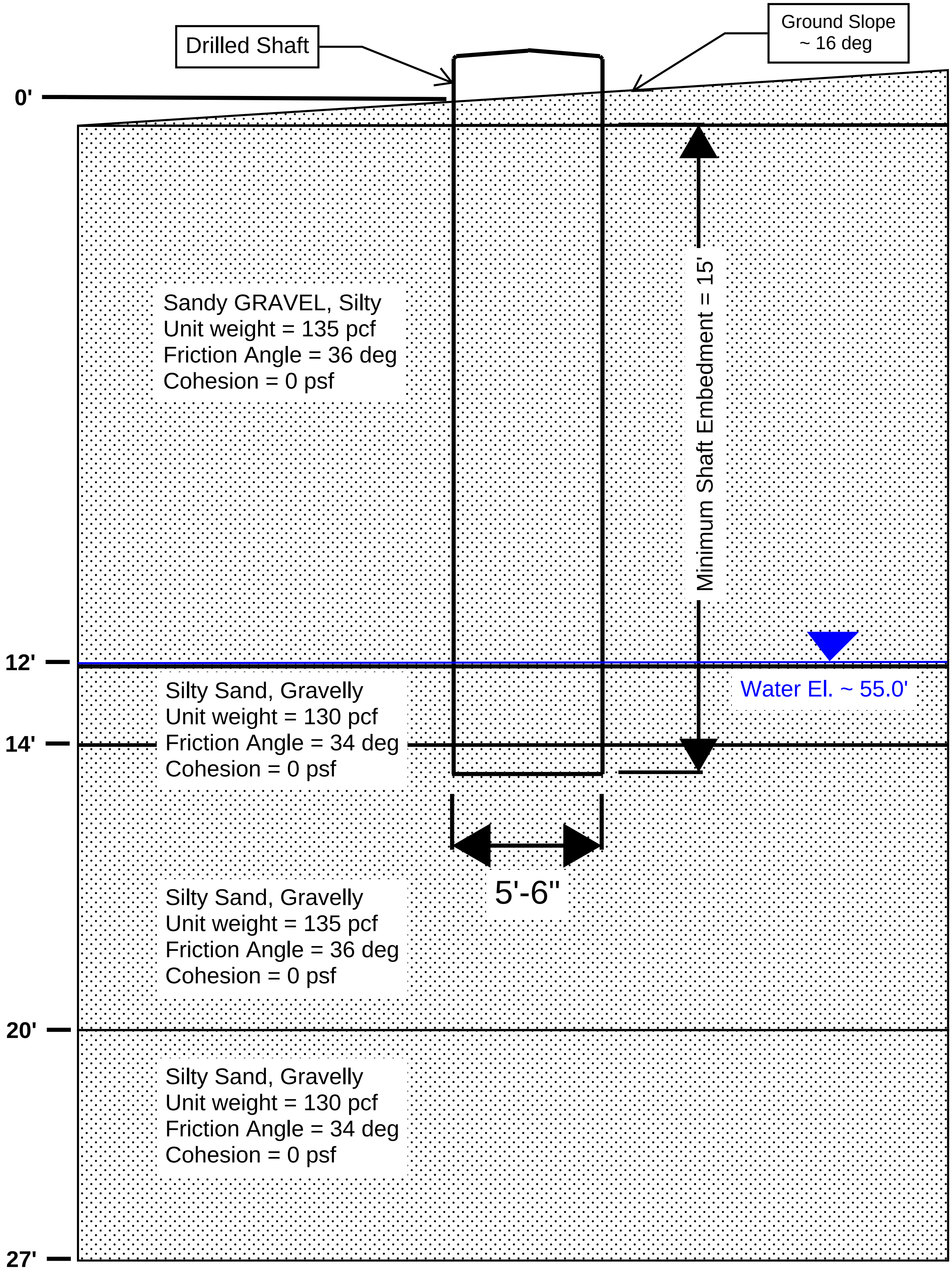
Engineering and Land Surveying, P.C.

FIGURE 2
SIGN STRUCTURE LOCATION MAP

PROJECT NO:
120186



KC Engineering and Land Surveying, P.C.	FIGURE 3: IDEALIZED SOIL CROSS SECTION LOCATION 1 OHSS (S610.90)	PROJECT NO: 120186



KC Engineering and Land Surveying, P.C.

FIGURE 4:
IDEALIZED SOIL CROSS SECTION
LOCATION 2 OHSS (S611.30)

PROJECT NO: 120186

APPENDIX A

BORING LOCATION PLAN

SOIL LEGEND

SOIL PROFILE

SUBSURFACE EXPLORATION LOGS

BORING LOCATION PLAN

CHECKED BY: K. REGMI
DRAFTED BY: R. PATEL
CHECKED BY: K. REGMI
DESIGNED BY: R. GHATAGE
DESIGN SUPERVISOR: R. KASTURI

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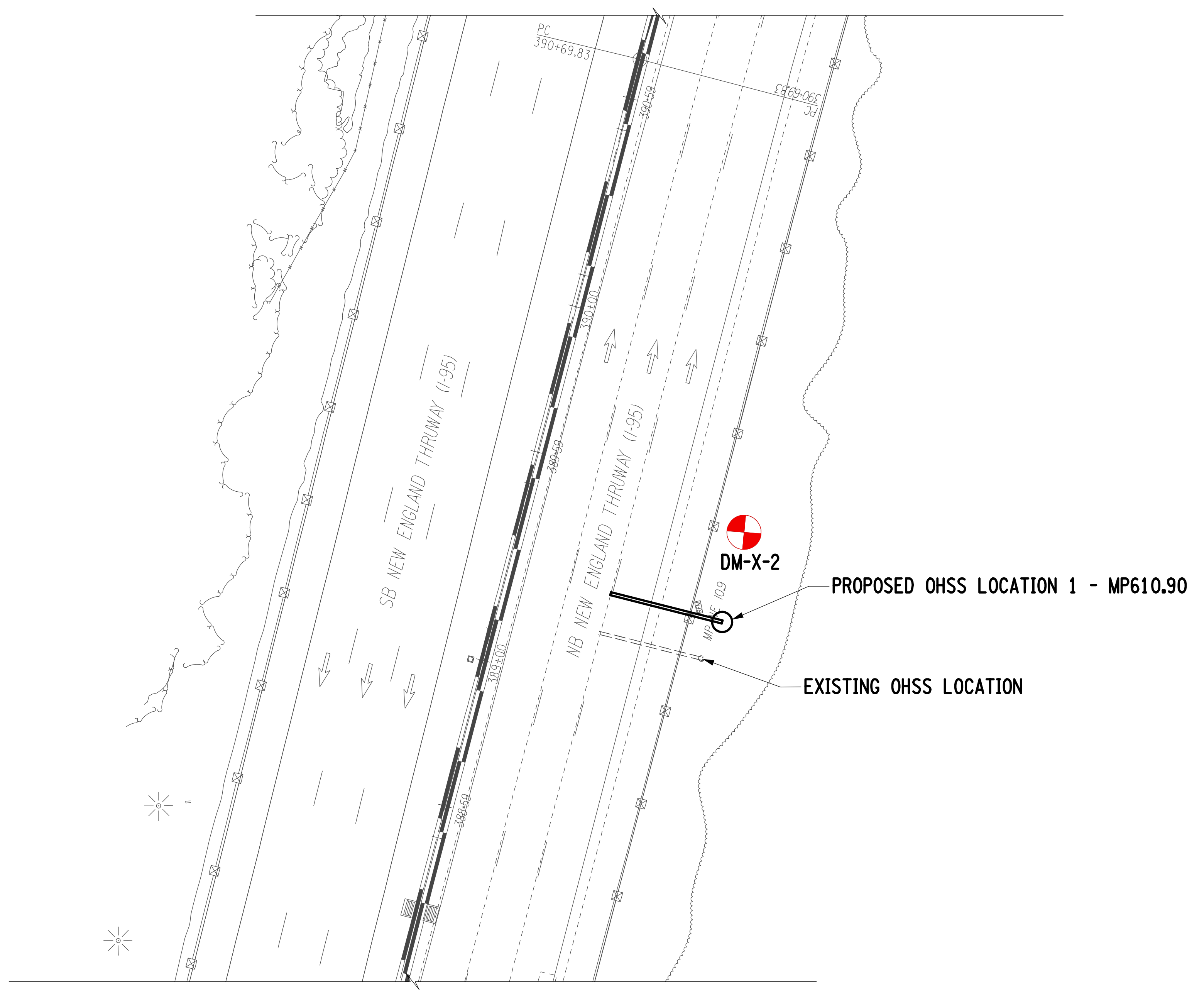

BORING LOCATION PLAN
OHSS LOCATION 1 - MP610.90

LEGEND
DM-X-XX BORING LOCATION

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KC Engineering and Land Surveying, P.C.

TITLE OF PROJECT: I-95 PAVEMENT REHABILITATION

LOCATION OF PROJECT: M.P. 608.8-610.8 SB AND M.P. 610.8-613.0 NB & SB

TITLE OF DRAWING: OVERHEAD SIGN STRUCTURES BORING LOCATION MAP LOCATION 1

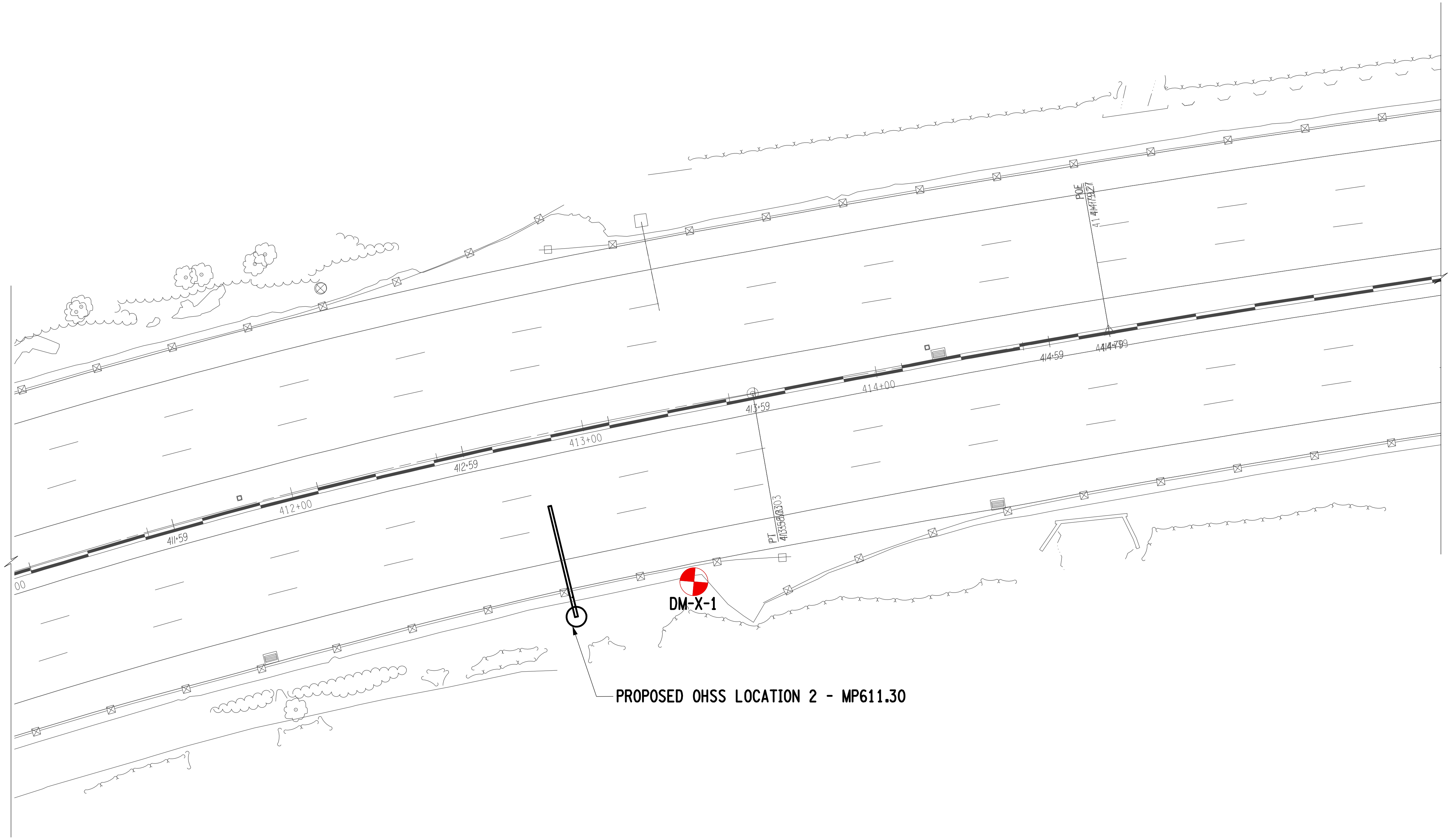
CONTRACT NUMBER:

DATE: XX/XX/XX

DRAWING NUMBER:

XXX
XXX

CHECKED BY: K. REGMI
DRAFTED BY: R. PATEL
CHECKED BY: K. REGMI
DESIGNED BY: R. GHATAGE
DESIGN SUPERVISOR: R. KASTURI



BORING LOCATION PLAN
OHSS LOCATION 2 - MP611.30

LEGEND
DM-X-XX BORING LOCATION

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TITLE OF DRAWING: OVERHEAD SIGN STRUCTURES BORING LOCATION MAP LOCATION 2

CONTRACT NUMBER: 120186

DATE: XX/XX/XX

DRAWING NUMBER: OS-10

SOIL LEGEND

USCS Soil Classification Legend

CH: USCS High Plasticity Clay	ASPHALT: Asphalt	BEDROCK: Bedrock	BLDRCBBL: Boulders and cobbles
CLS: USCS Low Plasticity Sandy Clay	CL: USCS Low Plasticity Clay	CLG: USCS Low Plasticity Gravelly Clay	CL-ML: USCS Low Plasticity Silty Clay
GP: USCS Poorly-graded Gravel	FILL: Fill (made ground)	GC: USCS Clayey Gravel	GM: USCS Silty Gravel
GW: USCS Well-graded Gravel	GP-GC: USCS Poorly-graded Gravel with Clay	GP-GM: USCS Poorly-graded Gravel with Silt	GPS: USCS Poorly-graded Sandy Gravel
MH: USCS Elastic Silt	GW-GC: USCS Well-graded Gravel with Clay	GW-GM: USCS Well-graded Gravel with Silt	GWS: USCS Well-graded Sandy Gravel
OL: USCS Low Plasticity Organic silt or clay	ML: USCS Silt	MLG: USCS Gravelly Silt	MLS: USCS Sandy Silt
SHALE: Shale	SANDSTONE: Sandstone	SC: USCS Clayey Sand	SC-SM: USCS Clayey Sand
SP-SC: USCS Poorly-graded Sand with Clay	SM: USCS Silty Sand	SP: USCS Poorly-graded Sand	SPG: USCS Poorly-graded Gravelly Sand
SW-SM: USCS Well-graded Sand with Silt	SP-SM: USCS Poorly-graded Sand with Silt	SWG: USCS Well-graded Gravelly Sand	SW-SC: USCS Well-graded Sand with Clay
	TILL: Glacial Till	TOPSOIL: Topsoil	

SOIL PROFILE

CHECKED BY: K. REGMI
DRAFTED BY: R. PATEL
CHECKED BY: K. REGMI
DESIGNED BY: R. GHATAGE
DESIGN SUPERVISOR: R. KASTURI

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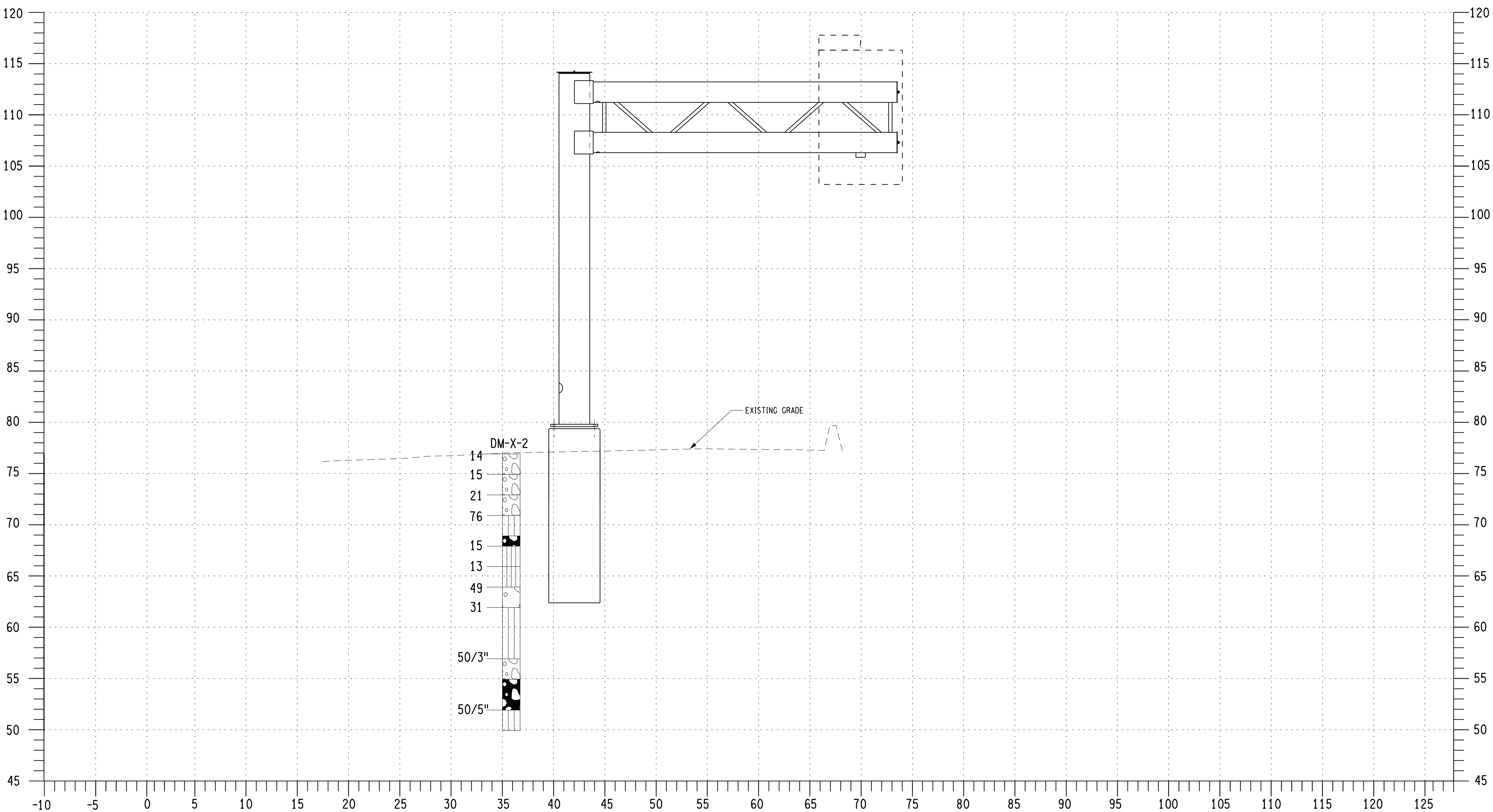

FENCE DIAGRAM
LOACATION 1 OHSS - MP610.90

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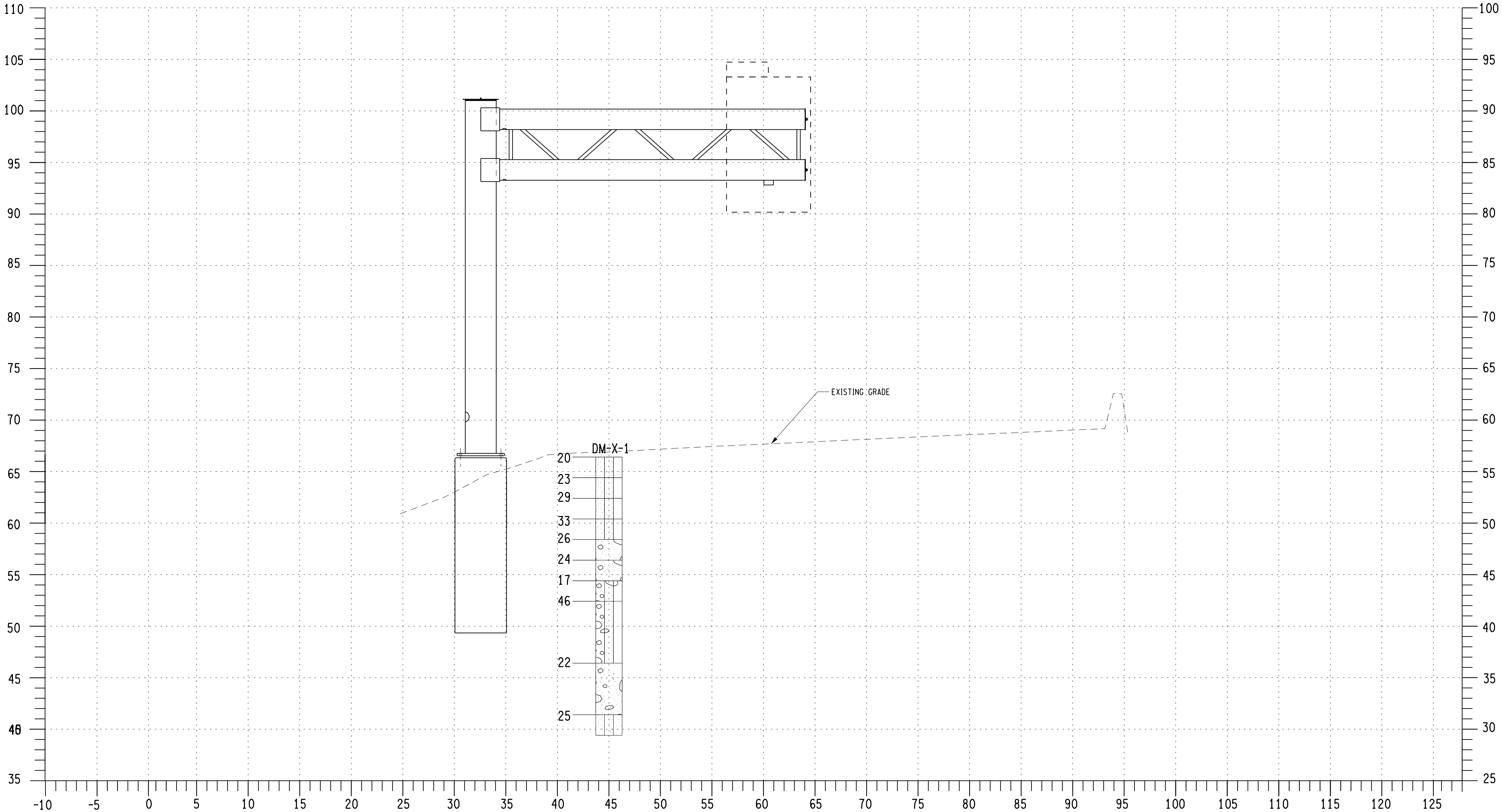
LOCATION OF PROJECT: M.P. 608.8-610.8 SB AND M.P. 610.8-613.0 NB & SB

TITLE OF DRAWING: OVERHEAD SIGN STRUCTURES LOCATION 2 FENCE DIAGRAM

CONTRACT NUMBER: D214892

DATE: 03/04/25

DRAWING NUMBER: XX-X



FENCE DIAGRAM
LOCATION 2 OHSS - MP611.30

DESIGNED BY: R. GHATAGE
CHECKED BY: K. REGMI
DRAFTED BY: R. PATEL
CHECKED BY: K. REGMI
DESIGN SUPERVISOR: R. KASTURI

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DRAWING NUMBER: XX-X

SUBSURFACE EXPLORATION LOGS

SM 282 E 12/02

PSN ______ BORNUM DM-X-1

NEW YORK STATE THRUWAY AUTHORITY
NEW YORK STATE CANAL CORPORATION
SUBSURFACE EXPLORATION LOG

DIVISION New York
COUNTY Westchester
PIN .
ROUTE Interstate 95 Northbound Right
MILEPOST 611.3
PROJECT H371.1, I-95 Pavement Resurfacing

HOLE DM-X-1
LINE
STA
OFFSET ft
SURF. ELEV. 66.619, NAVD 88
DEPTH TO WATER See Notes

COORDINATES (Lat) 40.974980°N (Long) 73.719594°W

DATE START 12/19/2024 **DATE FINISH** 12/20/2024

AUGER
CASING O. D. 4-1/2 in I. D. 3-3/4 in
SAMPLER O. D. 2 in I. D. 1-3/8 in

WT OF HAMMER-CASING 140 lb **HAMMER FALL-CASING** 30 in
WT OF HAMMER-SAMPLER 140 lb **HAMMER FALL-SAMPLER** 30 in
HAMMER TYPE Automatic

CASING BLOWS/ft	DEPTH (ft.) BELOW SURFACE	SAMPLE NO.	BLOWS ON SAMPLER (in.) 0/6	6/12	12/18	18/24	MOIST. CONT. (%)	Soil Recovery (in.)	Rock Recovery (ft.)	DESCRIPTION OF SOIL AND ROCK
	0.0	SS1	4	8	12	20	15.0%	15		Brown Silty SAND, Gravelly M - NPL
		SS2	24	15	8	8	8.7%	18		Brown Silty SAND, Gravelly M - NPL
	5.0	SS3	12	15	14	12	18.7%	16		Brown Silty SAND, Gravelly M - NPL
		SS4	15	16	17	10	67.3%	14		Brown Silty SAND, Gravelly M - NPL
	10.0	SS5	11	14	12	10	18.6%	12		Brown Gravelly SAND, Silty W - NPL
		SS6	6	10	14	12	17.3%	15		Brown Gravelly SAND, Silty W - NPL
		SS7	5	10	7	14	21.5%	24		Gray Silty GRAVEL, Sandy W - NPL
	15.0	SS8	9	18	28	30	7.2%	24		Gray Sandy GRAVEL, Silty W - NPL
	20.0	SS9	6	10	12	13	10.9%	10		Brown Gravelly SAND, Silty W - NPL
	25.0									

The subsurface information shown here was obtained for design and estimate purposes. It is made available so that users may have access to the same information available to the State. It is presented in good faith. By the nature of the exploration process, the information represents only a small fraction of the total volume of the material at the site. Interpolation between data samples may not be indicative of the actual material encountered.

DRILL RIG OPERATOR Dan Mendoza & Dan Toner
SOIL & ROCK DESCRIPTION Rohan Ghatage
INSPECTOR Rohan Ghatage
BIN ______
STRUCTURE NAME OHSS S611.30

CONTRACT D214892-01 **CONTRACTOR** ADT

SHEET 1 OF 2 HOLE DM-X

TWY-CAN SUBSURF EXPLORATION D214892-01_R1.GPJ TWYSE1TMPL_V06.GDT 2/20/25

SM 282 E 12/02

PSN ____________ BORNUM DM-X-1

DIVISION New York

COUNTY Westchester

PIN .

ROUTE Interstate 95 Northbound Right

MILEPOST 611.3

PROJECT H371.1, I-95 Pavement Resurfacing

NEW YORK STATE THRUWAY AUTHORITY
NEW YORK STATE CANAL CORPORATION

SUBSURFACE EXPLORATION LOG

HOLE DM-X-1

LINE

STA

OFFSET ft

SURF. ELEV. 66.619, NAVD 88

DEPTH TO WATER See Notes

COORDINATES (Lat) 40.974980°N (Long) 73.719594°W

DATE START 12/19/2024 **DATE FINISH** 12/20/2024

AUGER					**WT OF HAMMER-CASING**	140 lb	**HAMMER FALL-CASING**	30 in
CASING	**O. D.**	4-1/2 in	**I. D.**	3-3/4 in	**WT OF HAMMER-SAMPLER**	140 lb	**HAMMER FALL-SAMPLER**	30 in
SAMPLER	**O. D.**	2 in	**I. D.**	1-3/8 in	**HAMMER TYPE**	Automatic		

CASING BLOWS/ft	DEPTH (ft.) BELOW SURFACE	SAMPLE NO.	BLOWS ON SAMPLER (in.) 0/6	6/12	12/18	18/24	MOIST. CONT. (%)	Soil Recovery (in.)	Rock Recovery (ft.)	DESCRIPTION OF SOIL AND ROCK
	25.0	SS10	18	15	10	10	5.9%	16		Gray Silty SAND, Gravelly W - NPL

BOTTOM OF HOLE AT 27.00 ft

The Automatic Hammer was used for the SPT at all Sampling Depths.
Drilling Mud was used for drilling.
Casing was pushed to 30' into the ground.
Drill Rig - Geoprobe 7822DT

DATE	TIME	DEPTH (ft.) HOLE	CASING	WATER	ARTESIAN HEAD HEIGHT ABOVE GROUND	FILLED WITH WATER AT END OF DAY
19-Dec-24	12:00	12.00	10.00	10.00		
20-Dec-24	09:45	27.00	30.00	12.00		
20-Dec-24	10:00	27.00	0.00	16.00		

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DRILL RIG OPERATOR Dan Mendoza & Dan Toner

SOIL & ROCK DESCRIPTION Rohan Ghatage

INSPECTOR Rohan Ghatage

BIN ____________

STRUCTURE NAME OHSS S611.30

CONTRACT D214892-01 **CONTRACTOR** ADT

SM 282 E 12/02

NEW YORK STATE THRUWAY AUTHORITY
NEW YORK STATE CANAL CORPORATION
SUBSURFACE EXPLORATION LOG

PSN ____ BORNUM DM-X-2
DIVISION New York
COUNTY Westchester
PIN .
ROUTE Interstate 95 Northbound Right
MILEPOST 610.9
PROJECT H371.1, I-95 Pavement Resurfacing

HOLE DM-X-2
LINE
STA
OFFSET ft
SURF. ELEV. 76.917, NAVD 88
DEPTH TO WATER See Notes

COORDINATES (Lat) 40.970809°N (Long) 73.725238°W
DATE START 12/18/2024 **DATE FINISH** 12/19/2024

AUGER
CASING O. D. 4-1/2 in I. D. 3-3/4 in
SAMPLER O. D. 2 in I. D. 1-3/8 in
WT OF HAMMER-CASING 140 lb **HAMMER FALL-CASING** 30 in
WT OF HAMMER-SAMPLER 140 lb **HAMMER FALL-SAMPLER** 30 in
HAMMER TYPE Automatic

CASING BLOWS/ft	DEPTH (ft.) BELOW SURFACE	SAMPLE NO.	BLOWS ON SAMPLER (in.) 0/6	6/12	12/18	18/24	MOIST. CONT. (%)	Soil Recovery (in.)	Rock Recovery (ft.)	DESCRIPTION OF SOIL AND ROCK	
	0.0	SS1	5	6	8	4	9.9%	11		Brown Sandy GRAVEL, Silty (with 3" topsoil)	M - NPL
		SS2	5	6	9	10	19.6%	12		Brown Sandy GRAVEL, Silty	M - NPL
	5.0	SS3	15	9	12	17	9.0%	15		Brown Sandy GRAVEL, Silty	M - NPL
		SS4	18	36	40	20	15.9%	18		Brown Silty SAND, Gravelly	W - NPL
		NR							0	Drilled through a boulder from 8' to 9'	-
	10.0	SS5	9	8	7	6	8.7%	12		Brown Sandy SILT	W - NPL
		SS6	6	5	8	9	21.4%	20		Gray Sandy SILT, Gravelly	W - NPL
	15.0	SS7	15	20	29	10	14.7%	16		Gray Gravelly SAND, Silty	W - NPL
		SS8	16	20	11	18	17.8%	17		Gray Silty SAND, Gravelly	W - NPL
	20.0	SS9	26	28	50/3"		1.6%	7		Brown Sandy GRAVEL, Silty	W - NPL
	25.0	R1							1	RUN #1 Drilled from 22' - 25' Boulder Rec = 12", See Notes 3 Pieces + Fragments NX DOUBLE SWIVEL	-

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DRILL RIG OPERATOR Dan Mendoza & Dan Toner
SOIL & ROCK DESCRIPTION Rohan Ghatage
INSPECTOR Rohan Ghatage
BIN ____
STRUCTURE NAME OHSS S610.90

CONTRACT D214892-01 **CONTRACTOR** ADT

SHEET 1 OF 2 HOLE DM-X

TWY-CAN SUBSURF EXPLORATION D214892-01_R1.GPJ TWYSE1TMPL_V06.GDT 2/20/25

SM 282 E 12/02

PSN		BORNUM DM-X-2	
DIVISION	New York	**HOLE**	DM-X-2
COUNTY	Westchester	**LINE**	
PIN	.	**STA**	
ROUTE	Interstate 95 Northbound Right	**OFFSET**	ft
MILEPOST	610.9	**SURF. ELEV.**	76.917, NAVD 88
PROJECT	H371.1, I-95 Pavement Resurfacing	**DEPTH TO WATER**	See Notes

NEW YORK STATE THRUWAY AUTHORITY
NEW YORK STATE CANAL CORPORATION
SUBSURFACE EXPLORATION LOG

COORDINATES (Lat) 40.970809°N (Long) 73.725238°W

DATE START 12/18/2024 **DATE FINISH** 12/19/2024

AUGER					**WT OF HAMMER-CASING**	140 lb	**HAMMER FALL-CASING**	30 in
CASING	**O. D.** 4-1/2 in	**I. D.** 3-3/4 in			**WT OF HAMMER-SAMPLER**	140 lb	**HAMMER FALL-SAMPLER**	30 in
SAMPLER	**O. D.** 2 in	**I. D.** 1-3/8 in			**HAMMER TYPE**	Automatic		

CASING BLOWS/ft	DEPTH (ft.) BELOW SURFACE	SAMPLE NO.	BLOWS ON SAMPLER (in.) 0/6	6/12	12/18	18/24	MOIST. CONT. (%)	Soil Recovery (in.)	Rock Recovery (ft.)	DESCRIPTION OF SOIL AND ROCK
	25.0	SS10	13	50/5"			2.2%	10		Gray Silty SAND, Gravelly W - NPL

BOTTOM OF HOLE AT 27.00 ft

The Automatic Hammer was used for the SPT at all Sampling Depths
Drilling Mud was used for drilling.
Casing was pushed to 30' into the ground.
Drill Rig - Geoprobe 7822DT
SS9 - 50 Blows on Sampler for 3".
SS10 - 50 Blows on Sampler for 5"
SS3 & SS4 - encountered cobbles/ boulders
All Coring conducted at 180psi down pressure and 1700 rpm.
Time taken to core through every foot for RUN#1 from 22' to 25':
22' to 23': 03:15:18 min
23' to 24': 02:10:14 min
24' to 25': 01:50:30 min

DATE	TIME	DEPTH (ft.) HOLE	CASING	WATER	ARTESIAN HEAD HEIGHT ABOVE GROUND	FILLED WITH WATER AT END OF DAY
18-Dec-24	13:15	27.00	0.00	15.00		
18-Dec-24	11:00	10.00	10.00	8.00		
19-Dec-24	13:00	27.00	30.00	10.00		

The subsurface information shown here was obtained for design and estimate purposes. It is made available so that users may have access to the same information available to the State. It is presented in good faith. By the nature of the exploration process, the information represents only a small fraction of the total volume of the material at the site. Interpolation between data samples may not be indicative of the actual material encountered.

DRILL RIG OPERATOR Dan Mendoza & Dan Toner
SOIL & ROCK DESCRIPTION Rohan Ghatage
INSPECTOR Rohan Ghatage
BIN
STRUCTURE NAME
OHSS S610.90

CONTRACT D214892-01 **CONTRACTOR** ADT

APPENDIX B

SOIL PROPERTIES EVALUATION

SURFICIAL GEOLOGICAL MAP OF NEW YORK

GENERALIZED BEDROCK GEOLOGY OF NEW YORK STATE

LABORATORY TEST RESULTS

SPT CORRECTIONS

SOIL PROPERTIES EVALUATION

Engineering and Land Surveying, P.C.

Project:	H371.1 I-95 Pavement Resurfacing	Computed:	RG	Date:	5/23/2025
Subject:	Design Soil Parameters	Checked:	KR	Date:	5/23/2025
Task:	Determine soil properties for the design of OHSS Location 1 (S610.90)	Page:		of:	
Job #:	D214892	No:			

Boring Tag: DM-X-2
Ground Surf. Elevation (ft): 77.0
Water Elevation (ft): 66.0
Borehole diameter (in): 4.25
SPT Hammer Energy Ratio: 0.8 (For Automatic Hammer)

Layer	Depth at bottom of layer (ft)	Approx. Elevation		Soil	Plasticity	Average Measured SPT ($N_{measured}$)	Energy Correction Factor (C_E)[1]	N_{60} (bpf)				γ' (pcf)	σ'$_v$ (psf)	Other SPT Correction Factors[1]			$N^*_{1,60}$ (bpf)	NYSDOT GDM-8		Design Soil Properties			Lateral Soil Model[4]		
		From	To						γ (pcf)	φ (deg)	c (psf)			Overburden Correction Factor (C_N)	Rod Length Correction Factor (C_R)	Borehole Dia Correction Factor (C_B)		φ[2] (deg)	c[3] (psf)	γ (pcf)	φ (deg)	c (psf)	Soil Model	Soil Modulus Parameter K	Soil Strain Parameter E50
1	12	77.0	65.0	COHESIONLESS	-	16	1.33	21	123	31	0	60.4	362	1.6	0.94	1	32	38	0	130	34	0	Sand (Reese)	225	
2	27	65.0	50.0	COHESIONLESS	-	45	1.33	60	136	36	0	73.6	1276	1.3	0.99	1	74	40	0	135	36	0	Sand (Reese)	125	
3																									
4																									
5																									
6																									

1. SPT Correction factors are based on NYSDOT GDM Section 8.4.1
2. NYSDOT GDM Equation 8-41: ($\varphi' = (15.4N^*_{1,60})^{0.5} + 20°$)
3. NYSDOT GDM Equation 8-30 for low plastic clay ($\tau = C = 0.075N_{60}$) and Equation 8-31 for medium to high plastic clay ($\tau = C = 0.15N_{60}$)
4. Soil parameters for lateral soil model are based on LPILE v2022 User's Manual

Project: H371.1 I-95 Pavement Resurfacing	Computed: RG	Date: 5/23/2025	
Subject: Design Soil Parameters	Checked: KR	Date: 5/23/2025	z
Task: Determine soil properties for the design of OHSS Location 2 (S611.30)	Page:	of:	
Job #: D214892	No:		

Engineering and Land Surveying, P.C.

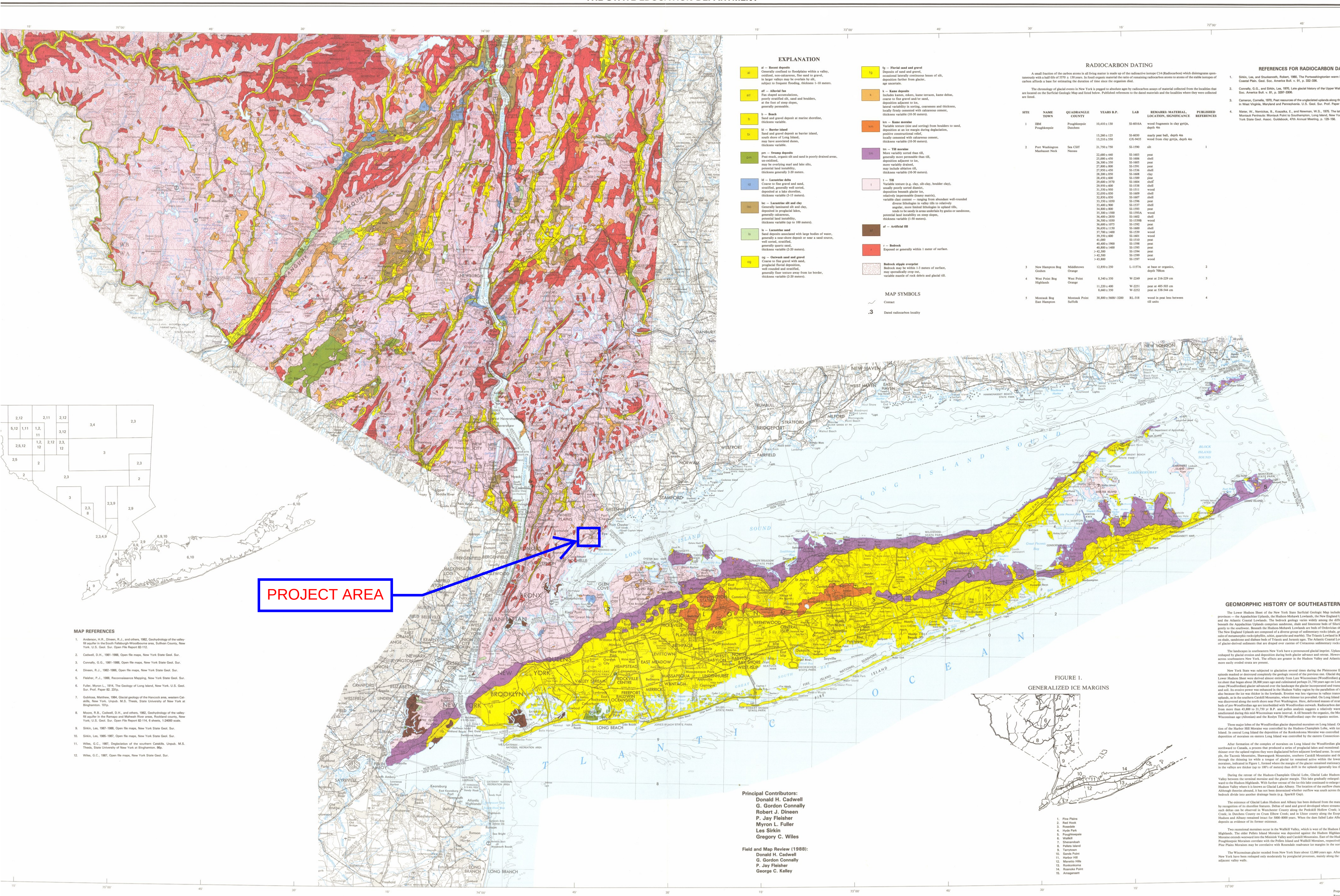
Boring Tag: **DM-X-1**
Ground Surf. Elevation (ft): **61.0**
Water Elevation (ft): **48.0**
Borehole diameter (in): **4.25**
SPT Hammer Energy Ratio: **0.8** (For Automatic Hammer)

Layer	Depth at bottom of layer (ft)	Approx. Elevation		Soil	Plasticity	Average Measured SPT ($N_{measured}$)	Energy Correction Factor (C_E)[1]	N_{60} (bpf)				γ' (pcf)	σ'$_v$ (psf)	Other SPT Correction Factors[1]			$N^*_{1,60}$ (bpf)	NYSDOT GDM-8		Design Soil Properties			Lateral Soil Model[4]		
		From	To						γ (pcf)	φ (deg)	c (psf)			Overburden Correction Factor (C_N)	Rod Length Correction Factor (C_R)	Borehole Dia Correction Factor (C_B)		φ[2] (deg)	c[3] (psf)	γ (pcf)	φ (deg)	c (psf)	Soil Model	Soil Modulus Parameter K	Soil Strain Parameter E50
1	12	61.0	49.0	COHESIONLESS	-	26	1.33	35	130	35	0	130	780	1.6	0.94	1	52	40	0	135	36	0	Sand (Reese)	225	
2	14	49.0	47.0	COHESIONLESS	-	17	1.33	23	123	31	0	60.9	1621	1.1	0.96	1	24	39	0	130	34	0	Sand (Reese)	125	
3	20	47.0	41.0	COHESIONLESS	-	46	1.33	61	136	36	0	73.7	1903	1.0	0.98	1	61	40	0	135	36	0	Sand (Reese)	125	
4	27	41.0	34.0	COHESIONLESS	-	23	1.33	31	130	34	0	67.6	2361	0.9	0.99	1	28	40	0	130	34	0	Sand (Reese)	125	-
5																									
6																									
7																									
8																									

1. SPT Correction factors are based on NYSDOT GDM Section 8.4.1
2. NYSDOT GDM Equation 8-41: ($\varphi' = (15.4N^*_{1,60})^{0.5} + 20°$)
3. NYSDOT GDM Equation 8-30 for low plastic clay ($\tau = C = 0.075N_{60}$) and Equation 8-31 for medium to high plastic clay ($\tau = C = 0.15N_{60}$)
4. Soil parameters for lateral soil model are based on LPILE v2022 User's Manual

SURFICIAL GEOLOGICAL MAP OF NEW YORK

UNIVERSITY OF THE STATE OF NEW YORK
THE STATE EDUCATION DEPARTMENT



SURFICIAL GEOLOGIC MAP OF NEW YORK

LOWER HUDSON SHEET

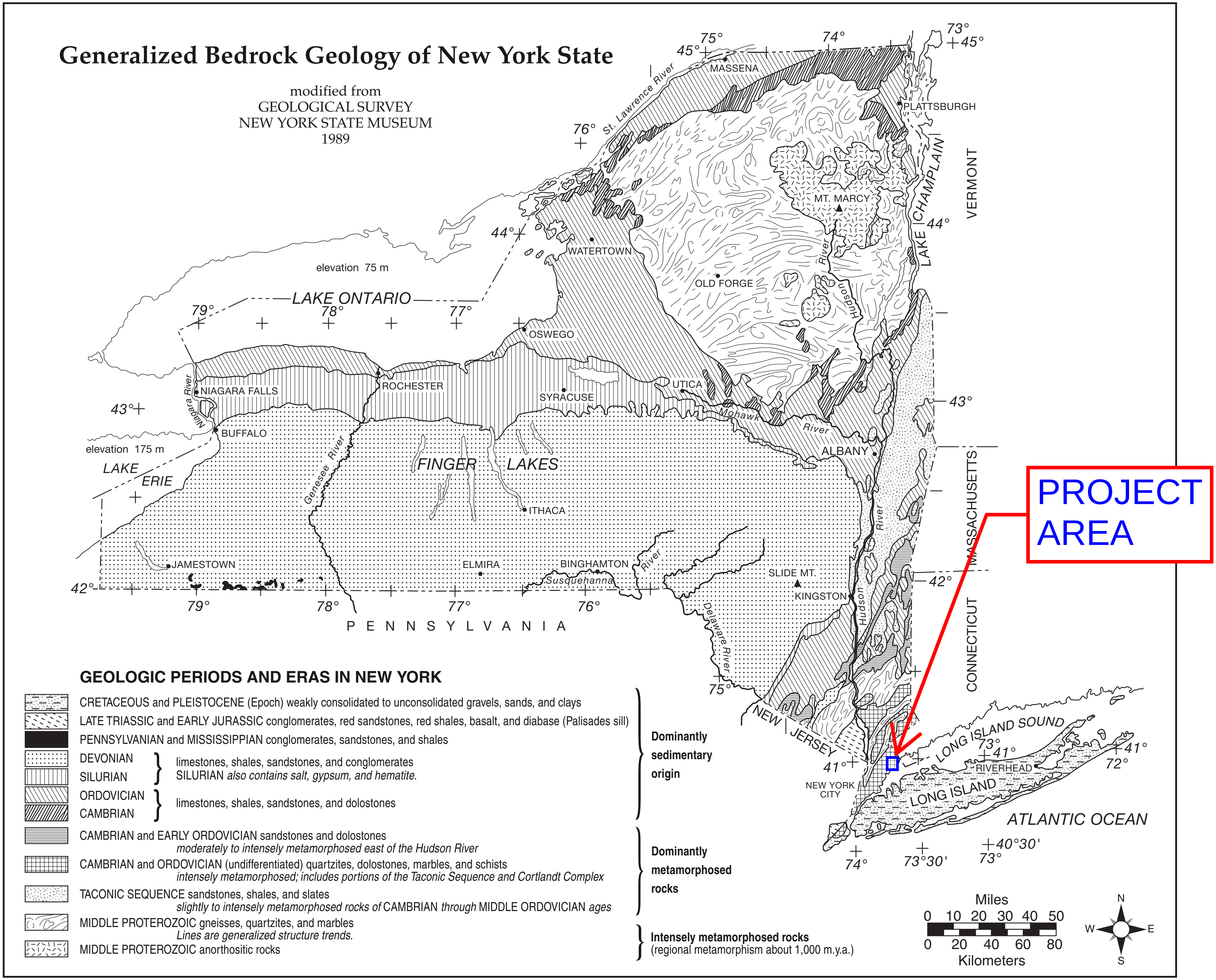
Compiled and Edited by Donald H. Cadwell

1989

Scale 1:250,000

CONTOUR INTERVAL 100 FEET

GENERALIZED BEDROCK GEOLOGY OF NEW YORK STATE


Generalized Bedrock Geology of New York State
modified from
GEOLOGICAL SURVEY
NEW YORK STATE MUSEUM
1989
PROJECT AREA
LAKE ONTARIO
elevation 75 m
LAKE ERIE
elevation 175 m
FINGER LAKES
MASSENA
PLATTSBURGH
MT. MARCY
WATERTOWN
OLD FORGE
OSWEGO
NIAGARA FALLS
ROCHESTER
SYRACUSE
UTICA
BUFFALO
ALBANY
ITHACA
JAMESTOWN
ELMIRA
BINGHAMTON
SLIDE MT.
KINGSTON
NEW YORK CITY
RIVERHEAD
LONG ISLAND
LONG ISLAND SOUND
ATLANTIC OCEAN
St. Lawrence River
Niagara River
Genesee River
Mohawk River
Hudson River
Susquehanna River
Delaware River
LAKE CHAMPLAIN
VERMONT
MASSACHUSETTS
CONNECTICUT
NEW JERSEY
P E N N S Y L V A N I A
GEOLOGIC PERIODS AND ERAS IN NEW YORK
CRETACEOUS and PLEISTOCENE (Epoch) weakly consolidated to unconsolidated gravels, sands, and clays
LATE TRIASSIC and EARLY JURASSIC conglomerates, red sandstones, red shales, basalt, and diabase (Palisades sill)
PENNSYLVANIAN and MISSISSIPPIAN conglomerates, sandstones, and shales
DEVONIAN
SILURIAN
limestones, shales, sandstones, and conglomerates
SILURIAN also contains salt, gypsum, and hematite.
ORDOVICIAN
CAMBRIAN
limestones, shales, sandstones, and dolostones
Dominantly sedimentary origin
CAMBRIAN and EARLY ORDOVICIAN sandstones and dolostones
moderately to intensely metamorphosed east of the Hudson River
CAMBRIAN and ORDOVICIAN (undifferentiated) quartzites, dolostones, marbles, and schists
intensely metamorphosed; includes portions of the Taconic Sequence and Cortlandt Complex
TACONIC SEQUENCE sandstones, shales, and slates
slightly to intensely metamorphosed rocks of CAMBRIAN through MIDDLE ORDOVICIAN ages
Dominantly metamorphosed rocks
MIDDLE PROTEROZOIC gneisses, quartzites, and marbles
Lines are generalized structure trends.
MIDDLE PROTEROZOIC anorthositic rocks
Intensely metamorphosed rocks
(regional metamorphism about 1,000 m.y.a.)
Miles
0 10 20 30 40 50
0 20 40 60 80
Kilometers
N
E
S
W

LABORATORY TEST RESULTS

Summary of Lab Test Results

	Sample No	Depth (ft)	Moisture Content (%)	% Passing (Sieve Analysis)														Atterburg Limits		
				4"	3"	2"	1"	3/4"	3/8"	#4	#8	#10	#16	#30	#60	#100	#200	LL	PL	PI
DM-X-1	SS1	0-2	15.0																	
	SS2	2-4	8.7																	
	SS3	4-6	18.7				100	92.9	85.9	79.3	74.3	72.9	68.4	60.7	45.9	37.1	29.8		NP	
	SS4	6-8	67.3																	
	SS5	8-10	18.6				100	89.6	74.9	68.4	64.2	63	59.4	52.7	38.7	28.7	22.3		NP	
	SS6	10-12	17.3																	
	SS7	12-14	21.5					100	75.5	69.9	65.1	64.4	62.2	57.8	48.7	41.1	35.4		NP	
	SS8	14-16	7.2					100	70.6	63.3	54.9	52.9	46.7	36.2	23.6	17.2	12.7			
	SS9	20-22	10.9					100	95.6	83.5	64.5	61.5	54.7	44.5	25.5	13.8	6.8			
	SS10	25-27	5.9																	
DM-X-2	SS1	0-2	9.9																	
	SS2	2-4	19.6																	
	SS3	4-6	9.0				100	77.2	54.6	47	40.8	39.3	35.1	28.3	17.7	12.6	8.8			
	SS4	6-8	15.9																	
	SS5	9-11	8.7																	
	SS6	11-13	21.4					100	92.3	91.6	90.3	89.9	88.6	85.1	73.4	65.5	57.2		NP	
	SS7	13-15	14.7					100	85	78.8	74.8	73.7	71	66.7	52.5	37.7	25.5			
	SS8	15-17	17.8						100	98	94.5	93.7	91.1	85.9	62.1	40.6	27.7		NP	
	SS9	20-22	1.6				100	62.1	45.5	38.8	33	31.9	28.9	24.9	17.4	12.4	8.2			
	SS10	25-27	2.2																	

AASHTO ACCREDITED

5439 Harding Highway
Mays Landing, New Jersey 08330
Main: 877 627 3772
colliersengineering.com

Colliers Engineering & Design

US Army Corps of Engineers
VALIDATED LABORATORY

GEOTECHNICAL LABORATORY TESTING RESULTS

CLIENT: KC Engineering and Land Surveying PC
7 Penn Plaza, Suite 1204
New York, NY 10001

ATTN: Mr. Kamal Regmi, PE

PROJECT: D214892-01, H371.1
I-95 Pavement Resurfacing Harrison, NY

Project # 25001420A **DATE:** January 23, 2025
PAGE: 1 of 1

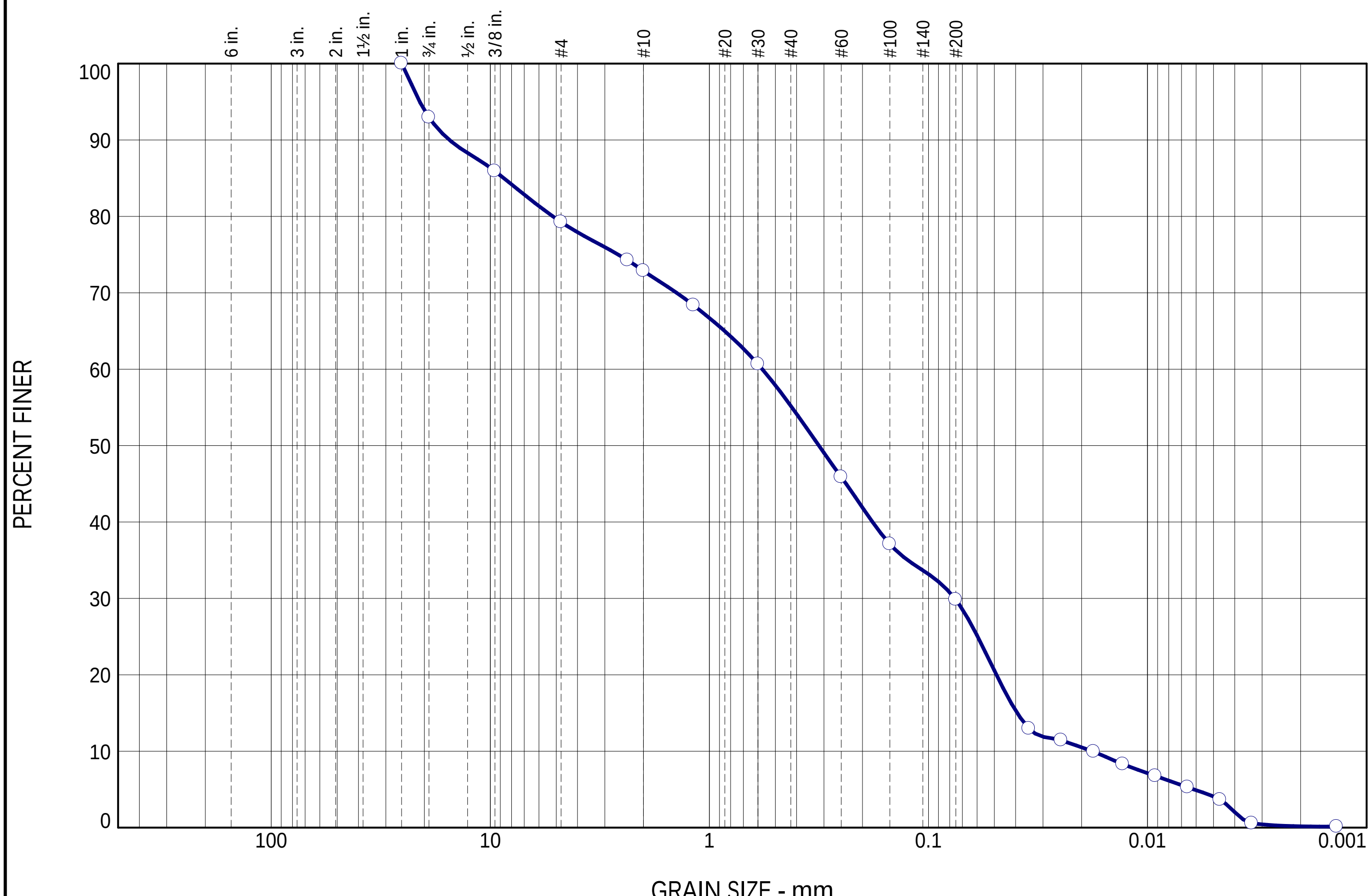
CHECKED BY: Eduardo M. Freire, P.E.
TITLE: Laboratory Manager

SAMPLES RECEIVED: January 7, 2025 **SAMPLES TESTED:** 1/7/25 - 1/20/25 **LAB TECHNICIAN(S):** K. Perry & J. Veach

Test Boring No.	Sample No.	Depth (ft)	Water Content (%) (ASTM D2216)	Atterberg Limits (ASTM D4318)			Particle Size Analysis (Sieve Only)* (ASTM D6913)	Particle Size Analysis with Hydrometer* (ASTM D6913/D7928)
				Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)		
DM-X-1	S-1	0-2	15.0					
	S-2	2-4	8.7					
	S-3	4-6	18.7	-	Non-Plastic	-		PSA-1
	S-4	6-8	67.3					
	S-5	8-10	18.6	-	Non-Plastic	-		PSA-2
	S-6	10-12	17.3					
	S-7	12-14	21.5	-	Non-Plastic	-		PSA-3
	S-8	14-16	7.2				PSA-4	
	S-9	20-22	10.9				PSA-5	
	S-10	25-27	5.9					
DM-X-2	S-1	0-2	9.9					
	S-2	2-4	19.6					
	S-3	4-6	9.0				PSA-6	
	S-4	6-8	15.9					
	S-5	9-11	8.7					
	S-6	11-13	21.4	-	Non-Plastic	-		PSA-7
	S-7	13-15	14.7				PSA-8	
	S-8	15-17	17.8	-	Non-Plastic	-		PSA-9
	S-9	20-22	1.6				PSA-10	
	S-10	25-27	2.2					
Testing Total:			**15**		**5**		**5**	**5**

Comments/Remarks: * See attached Plate(s)

Particle Size Distribution Report



% Cobbles	% Gravel		% Sand			% Fines
	Coarse	Medium	Fine	Coarse	Medium	Fine	
0.0	0.0	14.1	13.0	12.2	14.8	16.1	29.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1	100.0		
.75	92.9		
.375	85.9		
#4	79.3		
#8	74.3		
#10	72.9		
#16	68.4		
#30	60.7		
#60	45.9		
#100	37.1		
#200	29.8		

* (no specification provided)

Material Description

Brown coarse to fine Sand, some Silt, some medium to fine Gravel

Atterberg Limits

LL= PL= NP PI=

Coefficients

D_{85}= 8.6792 D_{60}= 0.5733 D_{50}= 0.3163
D_{30}= 0.0758 D_{15}= 0.0394 D_{10}= 0.0178
C_u= 32.14 C_c= 0.56

Classification

USCS= SM

Remarks

Water Content (WC): 18.7%
NP: Non-Plastic

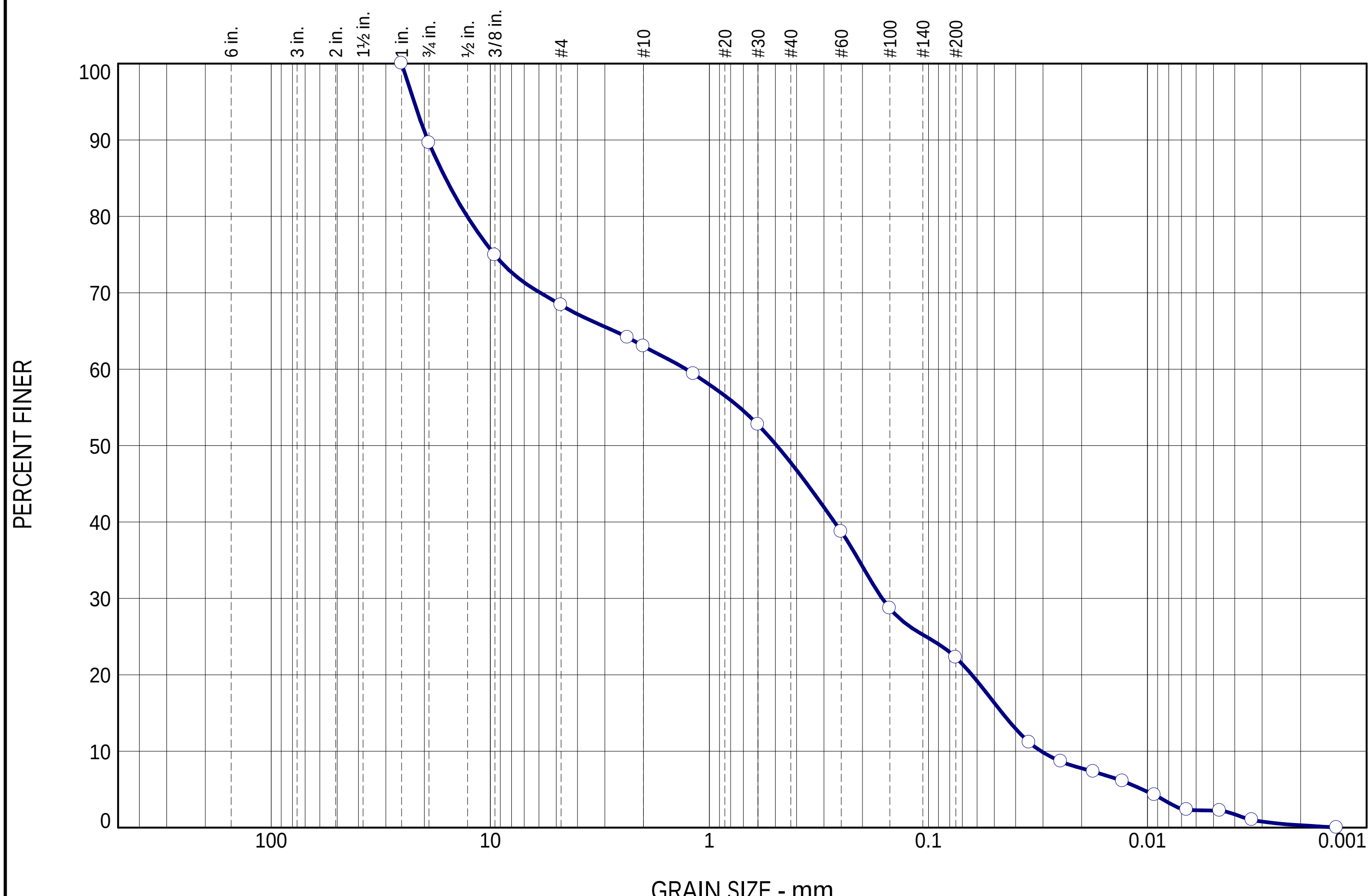
Source of Sample: DM-X-1 Depth: 4'-6'
Sample Number: S-3

Date: 1/22/25

5439 Harding Highway
Mays Landing New Jersey 08330
Main: 877 627 3772
Geotechnical Laboratory
Colliers Engineering & Design

Client: KC Engineering and Land Surveying, P.C.
Project: D214892-01, H371.1
I-95 Pavement Resurfacing Harrison, NY
Project No: 25001420A Plate PSA-1

Particle Size Distribution Report



% Cobbles	% Gravel			% Sand			% Fines
	Coarse	Medium	Fine	Coarse	Medium	Fine	
0.0	0.0	25.1	11.9	10.3	14.0	16.4	22.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1	100.0		
.75	89.6		
.375	74.9		
#4	68.4		
#8	64.2		
#10	63.0		
#16	59.4		
#30	52.7		
#60	38.7		
#100	28.7		
#200	22.3		

* (no specification provided)

Material Description

Dark gray coarse to fine Sand, and medium to fine Gravel some Silt

Atterberg Limits

LL= PL= NP PI=

Coefficients

D_{85}= 16.0024 D_{60}= 1.2769 D_{50}= 0.4922
D_{30}= 0.1626 D_{15}= 0.0460 D_{10}= 0.0306
C_u= 41.73 C_c= 0.68

Classification

USCS= SM

Remarks

WC: 18.6%

Source of Sample: DM-X-1 Depth: 8'-10'
Sample Number: S-5

Date: 1/22/25

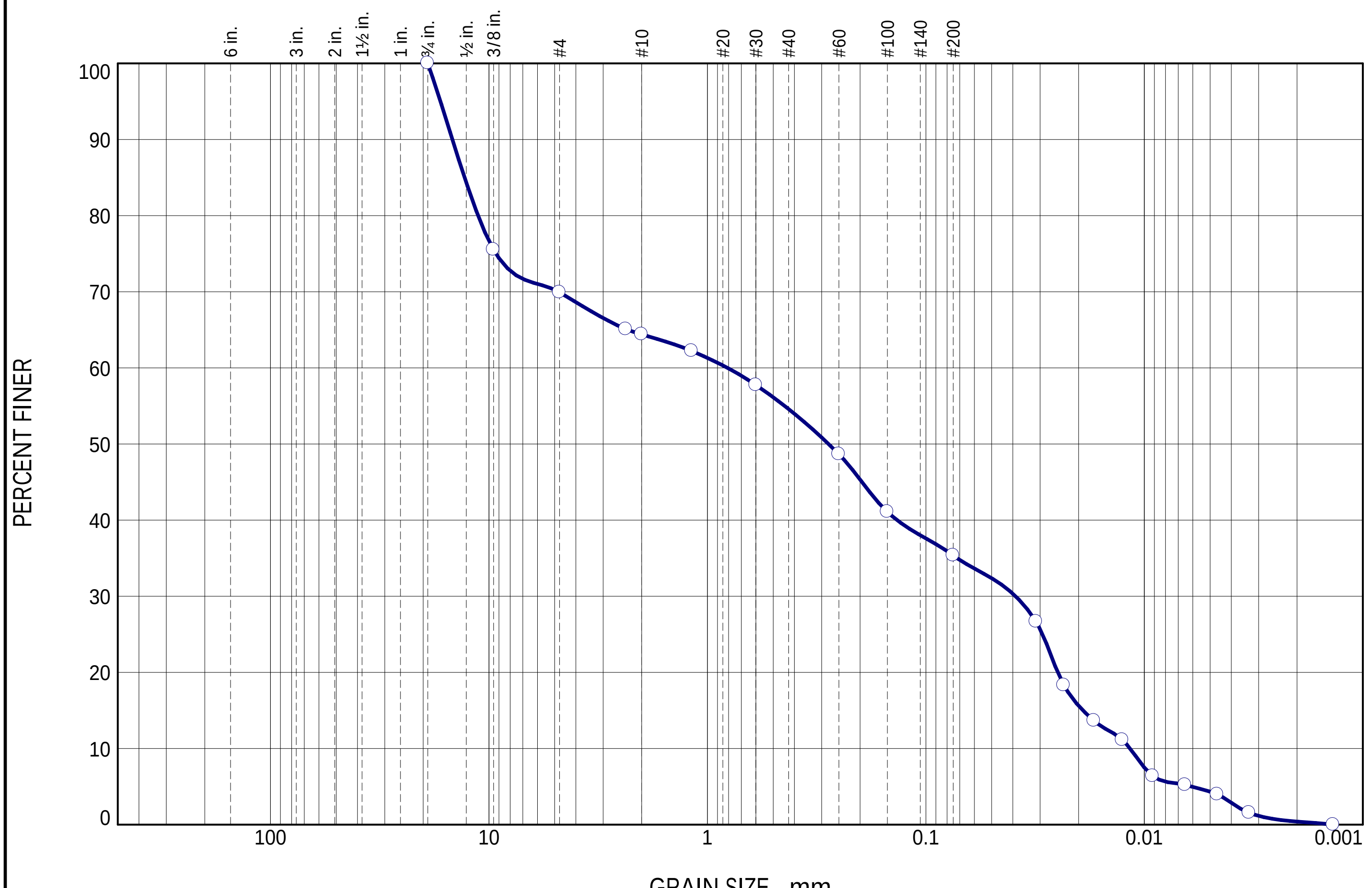
5439 Harding Highway
Mays Landing New Jersey 08330
Main: 877 627 3772

Geotechnical Laboratory

Colliers Engineering & Design

Client: KC Engineering and Land Surveying, P.C.
Project: D214892-01, H371.1
I-95 Pavement Resurfacing Harrison, NY
Project No: 25001420A Plate PSA-2

Particle Size Distribution Report



% Cobbles	% Gravel			% Sand			% Fines
	Coarse	Medium	Fine	Coarse	Medium	Fine	
0.0	0.0	24.5	11.1	6.6	9.1	13.3	35.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.375	75.5		
#4	69.9		
#8	65.1		
#10	64.4		
#16	62.2		
#30	57.8		
#60	48.7		
#100	41.1		
#200	35.4		

* (no specification provided)

Material Description

Dark gray medium to fine Gravel, and Silt, some coarse to fine Sand

Atterberg Limits

LL= PL= NP PI=

Coefficients

D_{85}= 12.9259 D_{60}= 0.8097 D_{50}= 0.2789
D_{30}= 0.0388 D_{15}= 0.0191 D_{10}= 0.0116
C_u= 69.65 C_c= 0.16

Classification

USCS= SM

Remarks

WC: 21.5%

Source of Sample: DM-X-1 Depth: 12'-14'
Sample Number: S-7

Date: 1/22/25

5439 Harding Highway
Mays Landing New Jersey 08330
Main: 877 627 3772

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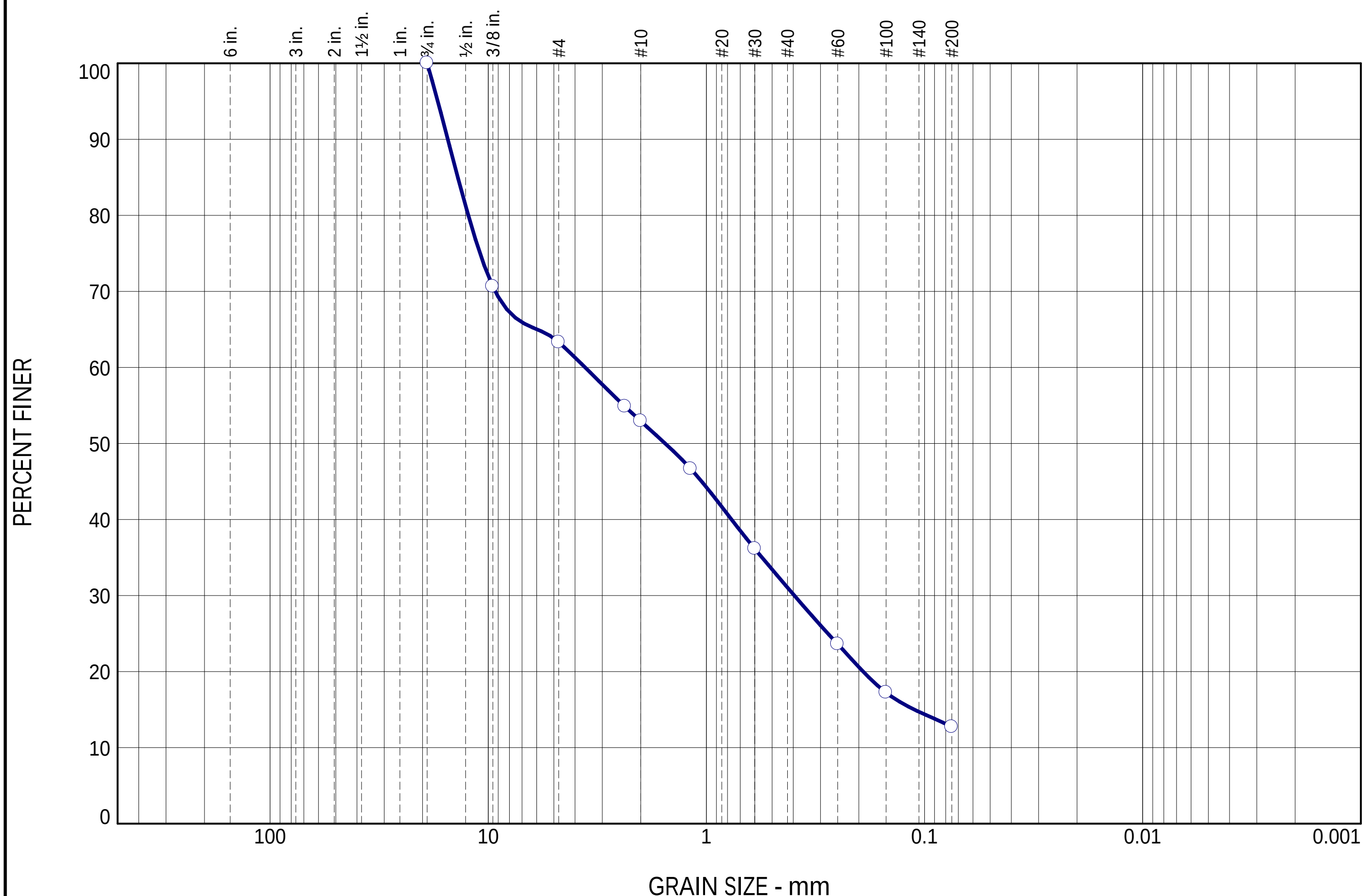
Client: KC Engineering and Land Surveying, P.C.
Project: D214892-01, H371.1
I-95 Pavement Resurfacing Harrison, NY
Project No: 25001420A Plate PSA-3

Particle Size Distribution Report



% Cobbles	% Gravel			% Sand			% Fines
	Coarse	Medium	Fine	Coarse	Medium	Fine	
0.0	0.0	29.4	17.7	16.7	12.6	10.9	12.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.375	70.6		
#4	63.3		
#8	54.9		
#10	52.9		
#16	46.7		
#30	36.2		
#60	23.6		
#100	17.2		
#200	12.7		

* (no specification provided)

Material Description

Light gray medium to fine Gravel, and coarse to fine Sand, little [Fines: (Silt/Clay)]

Atterberg Limits

LL= PL= PI=

Coefficients

D_{85}= 13.7811 D_{60}= 3.5939 D_{50}= 1.5447
D_{30}= 0.3951 D_{15}= 0.1112 D_{10}=
C_u= C_c=

Classification

USCS= SM\SC

Remarks

WC: 7.2%

Source of Sample: DM-X-1 Depth: 14'-16'
Sample Number: S-8

Date: 1/22/25

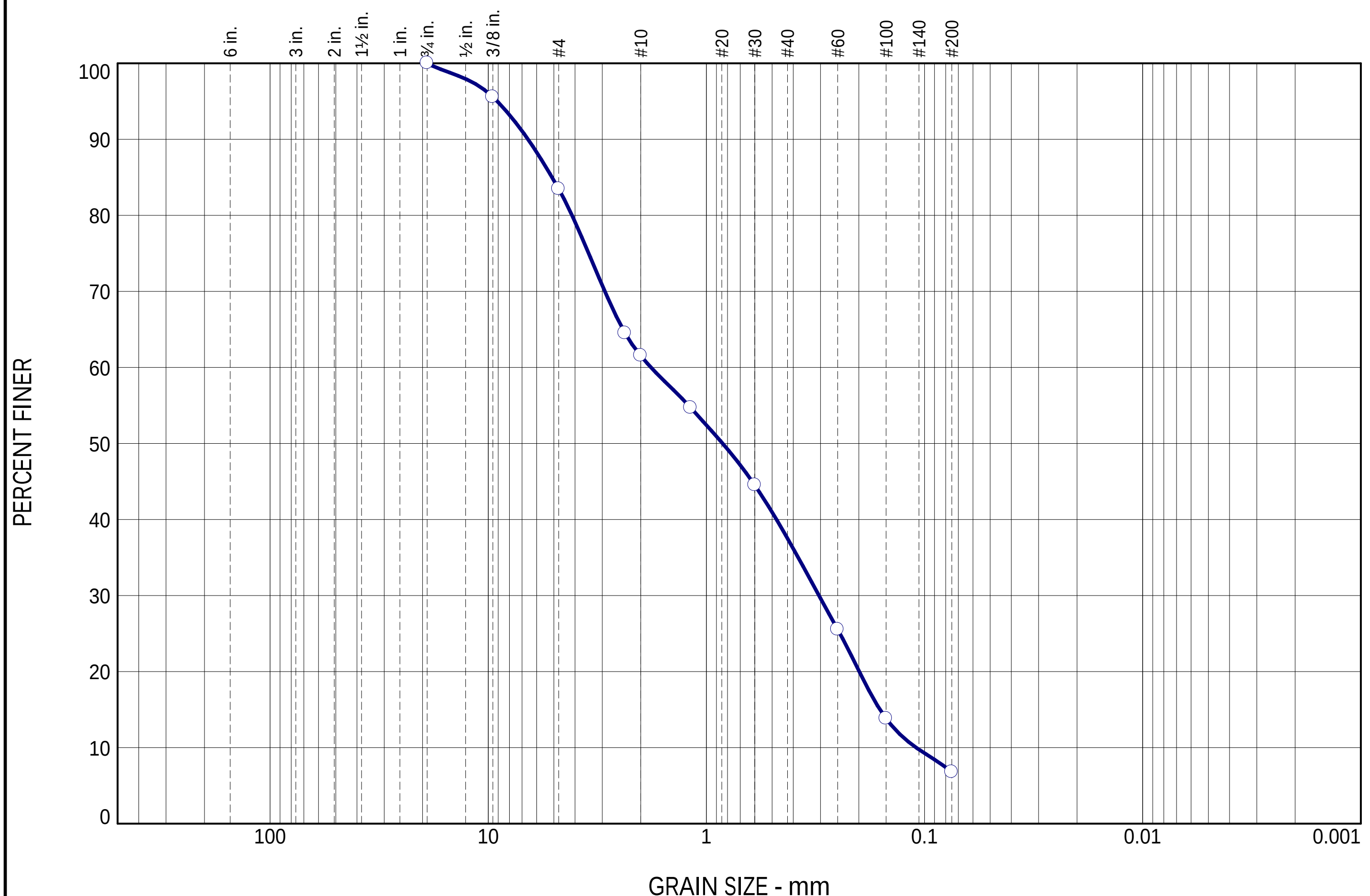
5439 Harding Highway
Mays Landing New Jersey 08330
Main: 877 627 3772

Geotechnical Laboratory

Colliers Engineering & Design

Client: KC Engineering and Land Surveying, P.C.
Project: D214892-01, H371.1
I-95 Pavement Resurfacing Harrison, NY
Project No: 25001420A Plate PSA-4

Particle Size Distribution Report



% Cobbles	% Gravel			% Sand			% Fines
	Coarse	Medium	Fine	Coarse	Medium	Fine	
0.0	0.0	4.4	34.1	17.0	19.0	18.7	6.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.375	95.6		
#4	83.5		
#8	64.5		
#10	61.5		
#16	54.7		
#30	44.5		
#60	25.5		
#100	13.8		
#200	6.8		

* (no specification provided)

Material Description

Brown coarse to fine SAND, and medium to fine Gravel, trace [Fines: (Silt/Clay)]

Atterberg Limits

LL= PL= PI=

Coefficients

D_{85}= 5.0969 D_{60}= 1.7960 D_{50}= 0.8427
D_{30}= 0.3045 D_{15}= 0.1601 D_{10}= 0.1091
C_u= 16.47 C_c= 0.47

Classification

USCS= SP-SM\SC

Remarks

WC: 10.9%

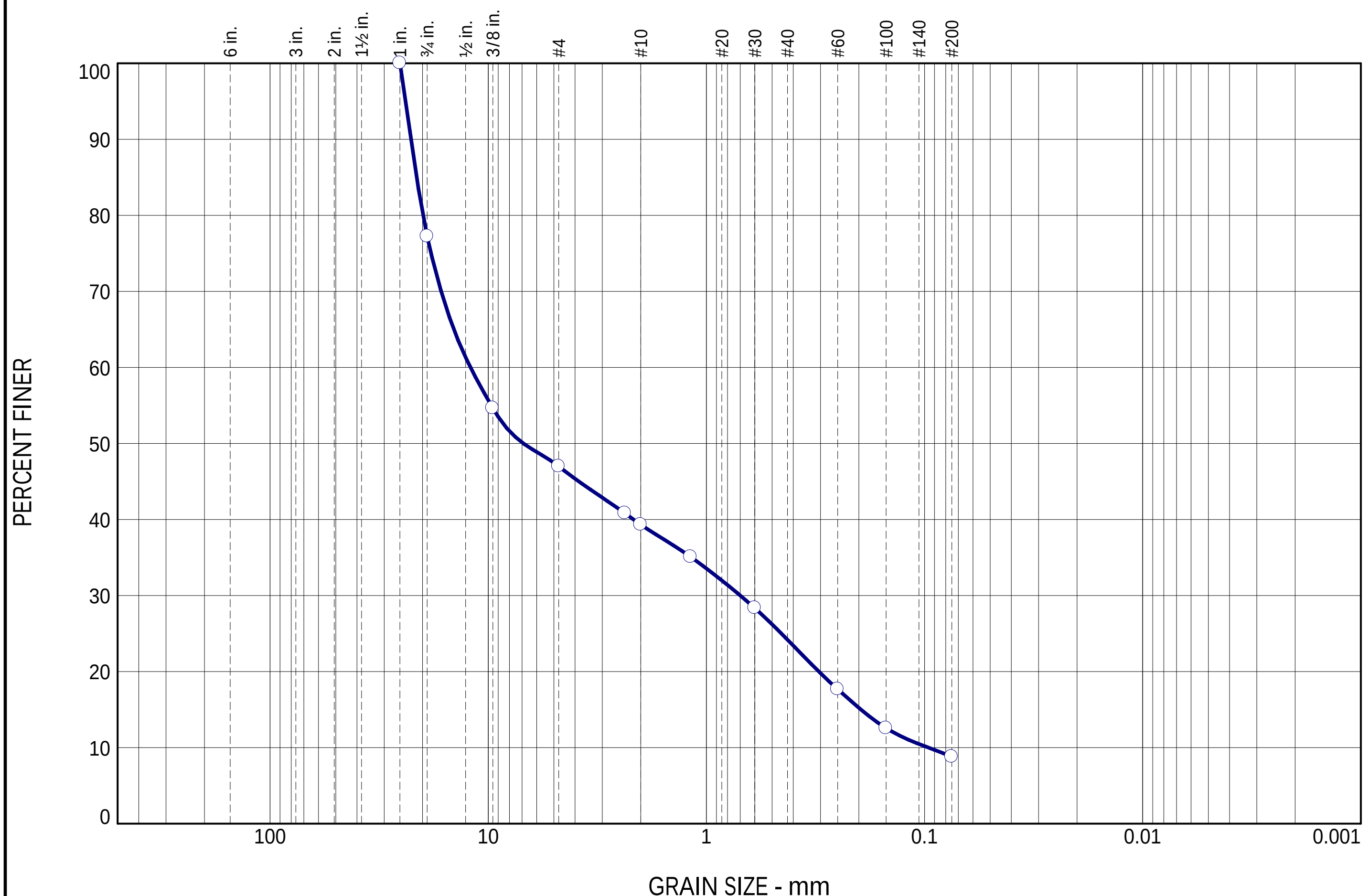
Source of Sample: DM-X-1 Depth: 20'-22'
Sample Number: S-9

Date: 1/22/25

5439 Harding Highway
Mays Landing New Jersey 08330
Main: 877 627 3772
Geotechnical Laboratory
Colliers Engineering & Design

Client: KC Engineering and Land Surveying, P.C.
Project: D214892-01, H371.1
I-95 Pavement Resurfacing Harrison, NY
Project No: 25001420A Plate PSA-5

Particle Size Distribution Report



% Cobbles	% Gravel			% Sand			% Fines
	Coarse	Medium	Fine	Coarse	Medium	Fine	
0.0	0.0	45.4	15.3	11.0	10.6	8.9	8.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1	100.0		
.75	77.2		
.375	54.6		
#4	47.0		
#8	40.8		
#10	39.3		
#16	35.1		
#30	28.3		
#60	17.7		
#100	12.6		
#200	8.8		

* (no specification provided)

Material Description

Brown medium to fine GRAVEL, some coarse to fine Sand, trace [Fines: (Silt/Clay)]

Atterberg Limits

LL= PL= PI=

Coefficients

D_{85}= 21.2757 D_{60}= 12.0655 D_{50}= 6.8943
D_{30}= 0.6992 D_{15}= 0.1954 D_{10}= 0.0959
C_u= 125.82 C_c= 0.42

Classification

USCS= GP-GM\GC

Remarks

WC: 9.0%
Trace Mica

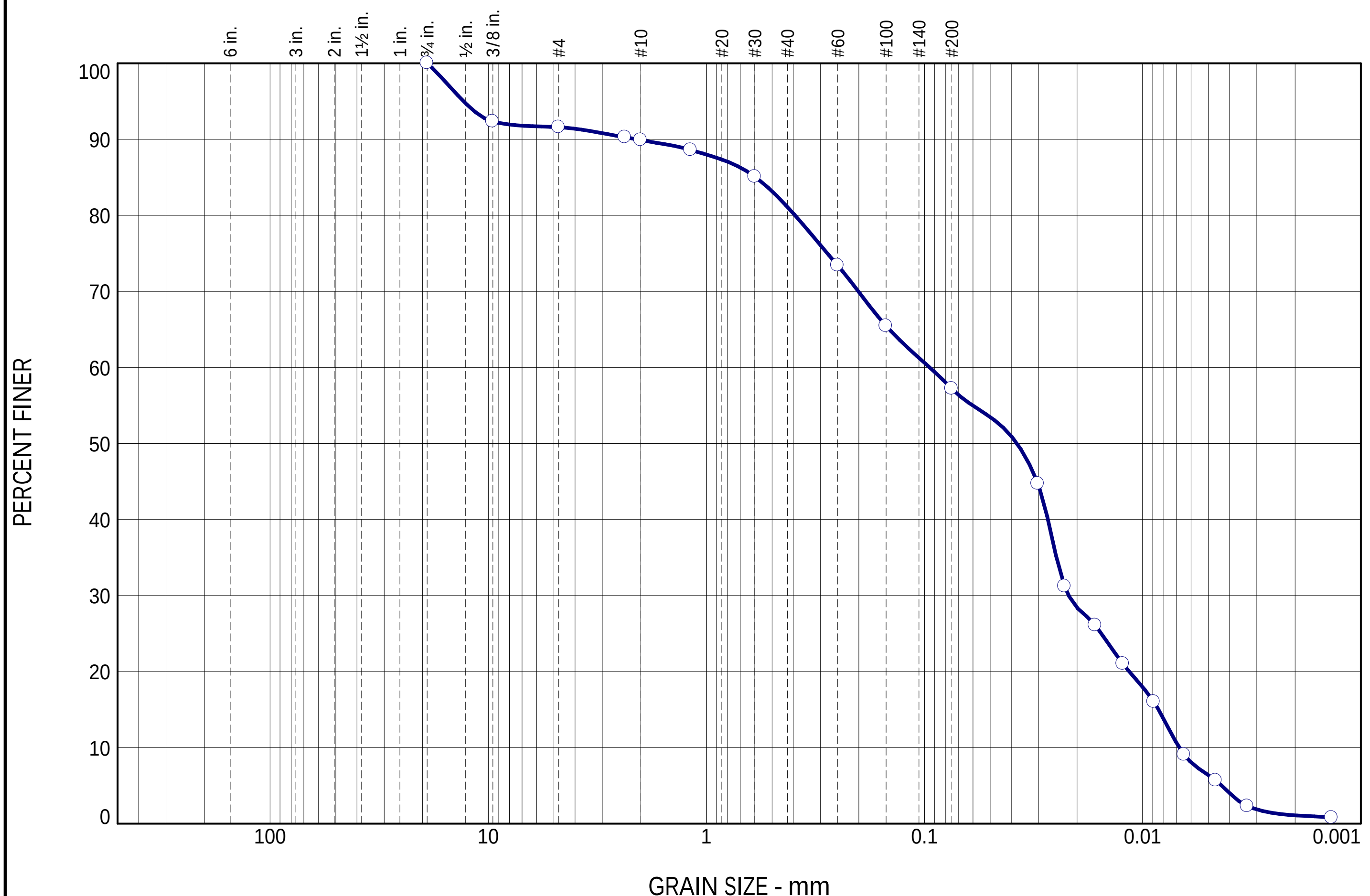
Source of Sample: DM-X-2 Depth: 4'-6'
Sample Number: S-3

Date: 1/22/25

5439 Harding Highway
Mays Landing New Jersey 08330
Main: 877 627 3772
Geotechnical Laboratory
Colliers Engineering & Design

Client: KC Engineering and Land Surveying, P.C.
Project: D214892-01, H371.1
I-95 Pavement Resurfacing Harrison, NY
Project No: 25001420A Plate PSA-6

Particle Size Distribution Report



% Cobbles	% Gravel			% Sand			% Fines
	Coarse	Medium	Fine	Coarse	Medium	Fine	
0.0	0.0	7.7	2.4	4.8	11.7	16.2	57.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.375	92.3		
#4	91.6		
#8	90.3		
#10	89.9		
#16	88.6		
#30	85.1		
#60	73.4		
#100	65.5		
#200	57.2		

* (no specification provided)

Material Description

Dark gray SILT, some coarse to fine Sand, little medium to fine Gravel

Atterberg Limits

LL= PL= NP PI=

Coefficients

D_{85}= 0.5943 D_{60}= 0.0948 D_{50}= 0.0377
D_{30}= 0.0218 D_{15}= 0.0085 D_{10}= 0.0068
C_u= 13.95 C_c= 0.74

Classification

USCS= ML

Remarks

WC: 21.4%

Source of Sample: DM-X-2 Depth: 11'-13'
Sample Number: S-6

Date: 1/22/25

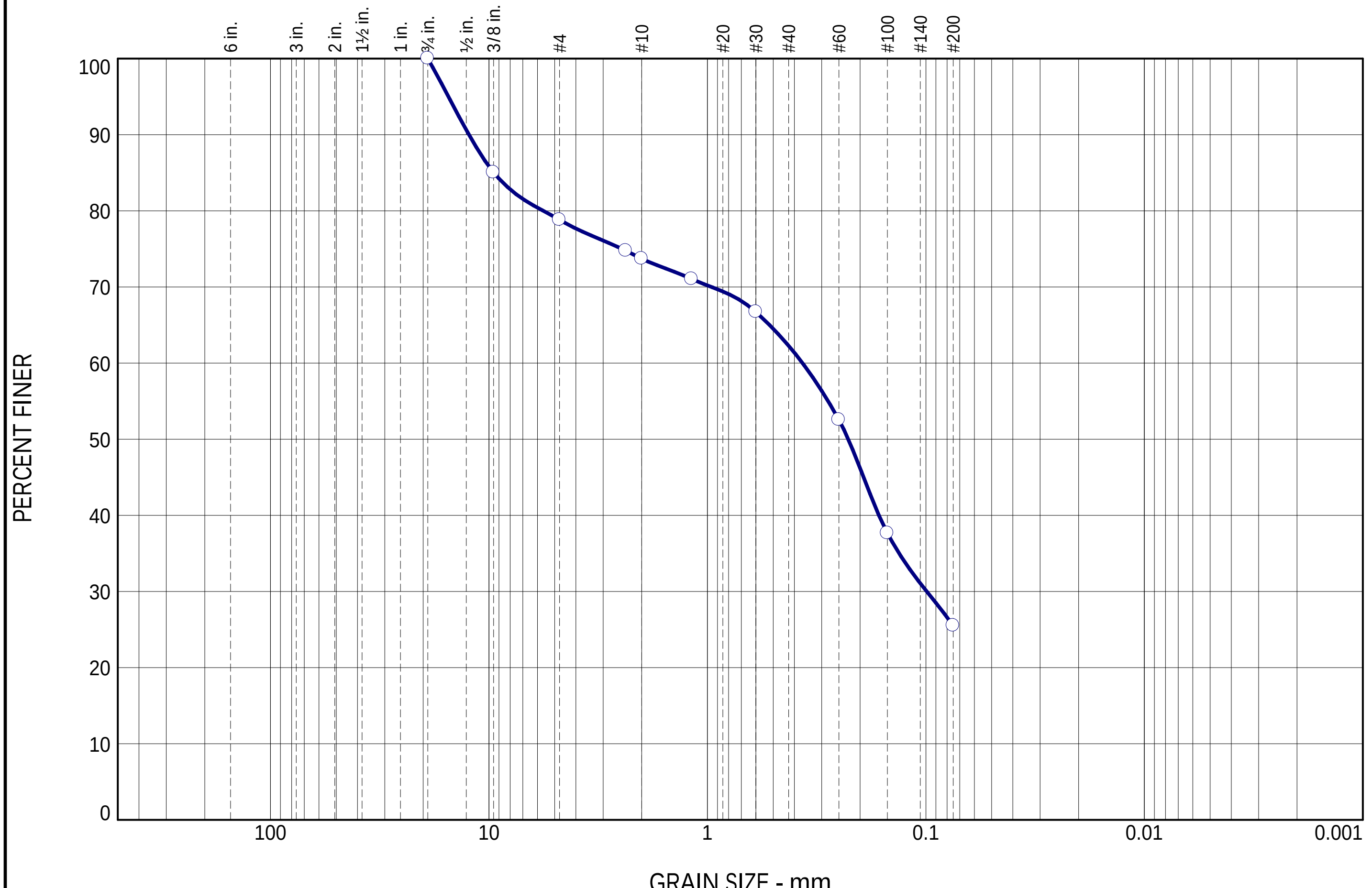
5439 Harding Highway
Mays Landing New Jersey 08330
Main: 877 627 3772

Geotechnical Laboratory

Colliers Engineering & Design

Client: KC Engineering and Land Surveying, P.C.
Project: D214892-01, H371.1
I-95 Pavement Resurfacing Harrison, NY
Project No: 25001420A Plate PSA-7

Particle Size Distribution Report



% Cobbles	% Gravel			% Sand			% Fines
	Coarse	Medium	Fine	Coarse	Medium	Fine	
0.0	0.0	15.0	11.3	7.0	14.2	27.0	25.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.375	85.0		
#4	78.8		
#8	74.8		
#10	73.7		
#16	71.0		
#30	66.7		
#60	52.5		
#100	37.7		
#200	25.5		

* (no specification provided)

Material Description

Dark gray coarse to fine Sand, some medium to fine Gravel, some [Fines: (Silt/Clay)]

Atterberg Limits

LL= PL= PI=

Coefficients

D_{85}= 9.4942 D_{60}= 0.3670 D_{50}= 0.2266
D_{30}= 0.0991 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SM\SC

Remarks

WC: 14.7%
Trace Mica

Source of Sample: DM-X-2 Depth: 13'-15'
Sample Number: S-7

Date: 1/22/25

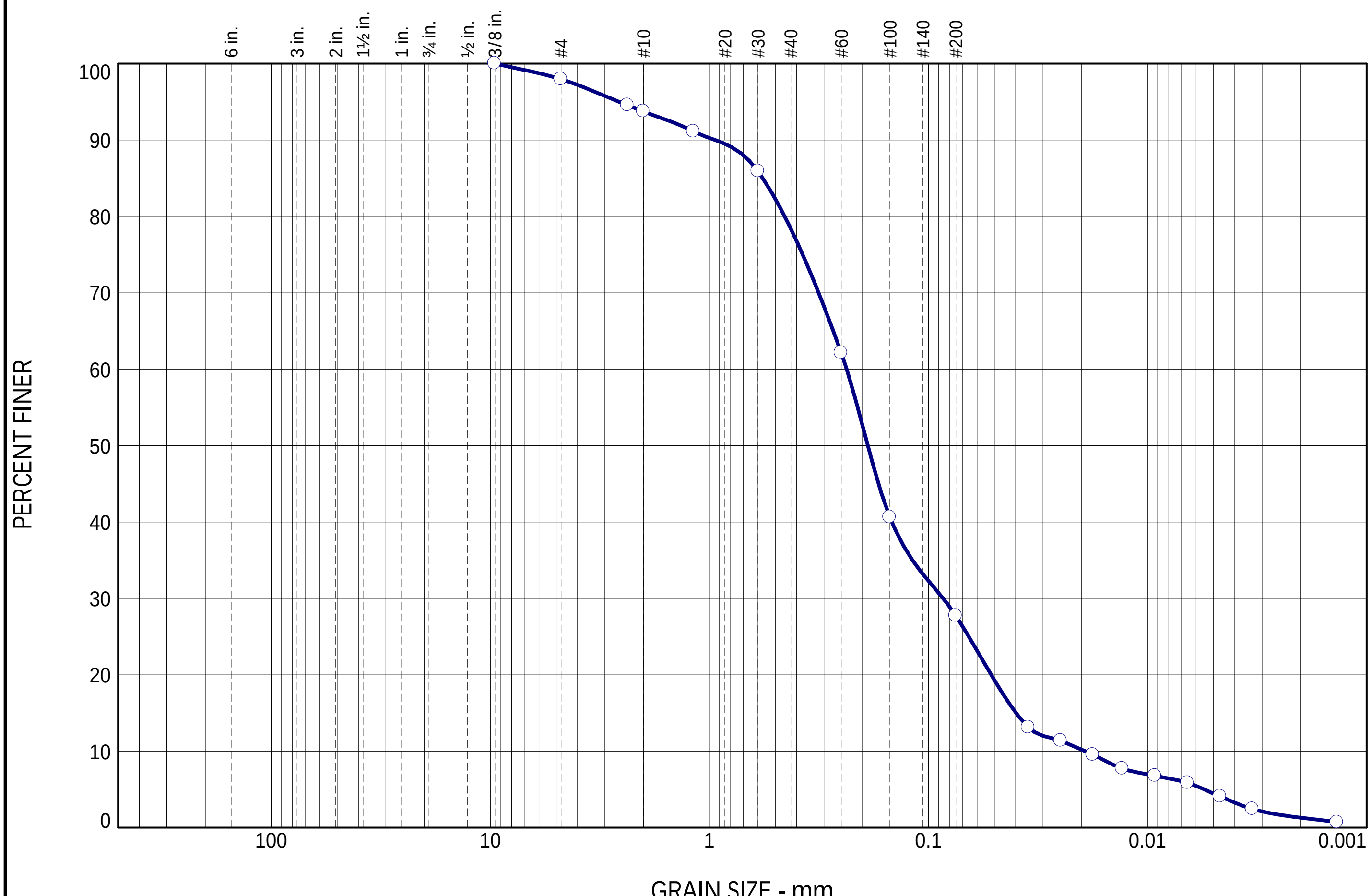
5439 Harding Highway
Mays Landing New Jersey 08330
Main: 877 627 3772

Geotechnical Laboratory

Colliers Engineering & Design

Client: KC Engineering and Land Surveying, P.C.
Project: D214892-01, H371.1
I-95 Pavement Resurfacing Harrison, NY
Project No: 25001420A Plate PSA-8

Particle Size Distribution Report



% Cobbles	% Gravel			% Sand			% Fines
	Coarse	Medium	Fine	Coarse	Medium	Fine	
0.0	0.0	0.0	6.3	7.8	23.8	34.4	27.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.375	100.0		
#4	98.0		
#8	94.5		
#10	93.7		
#16	91.1		
#30	85.9		
#60	62.1		
#100	40.6		
#200	27.7		

* (no specification provided)

Material Description

Dark gray coarse to fine SAND, some Silt, trace fine Gravel

Atterberg Limits

LL= PL= NP PI=

Coefficients

D_{85}= 0.5710 D_{60}= 0.2361 D_{50}= 0.1891
D_{30}= 0.0857 D_{15}= 0.0398 D_{10}= 0.0192
C_u= 12.28 C_c= 1.62

Classification

USCS= SM

Remarks

WC: 17.8%

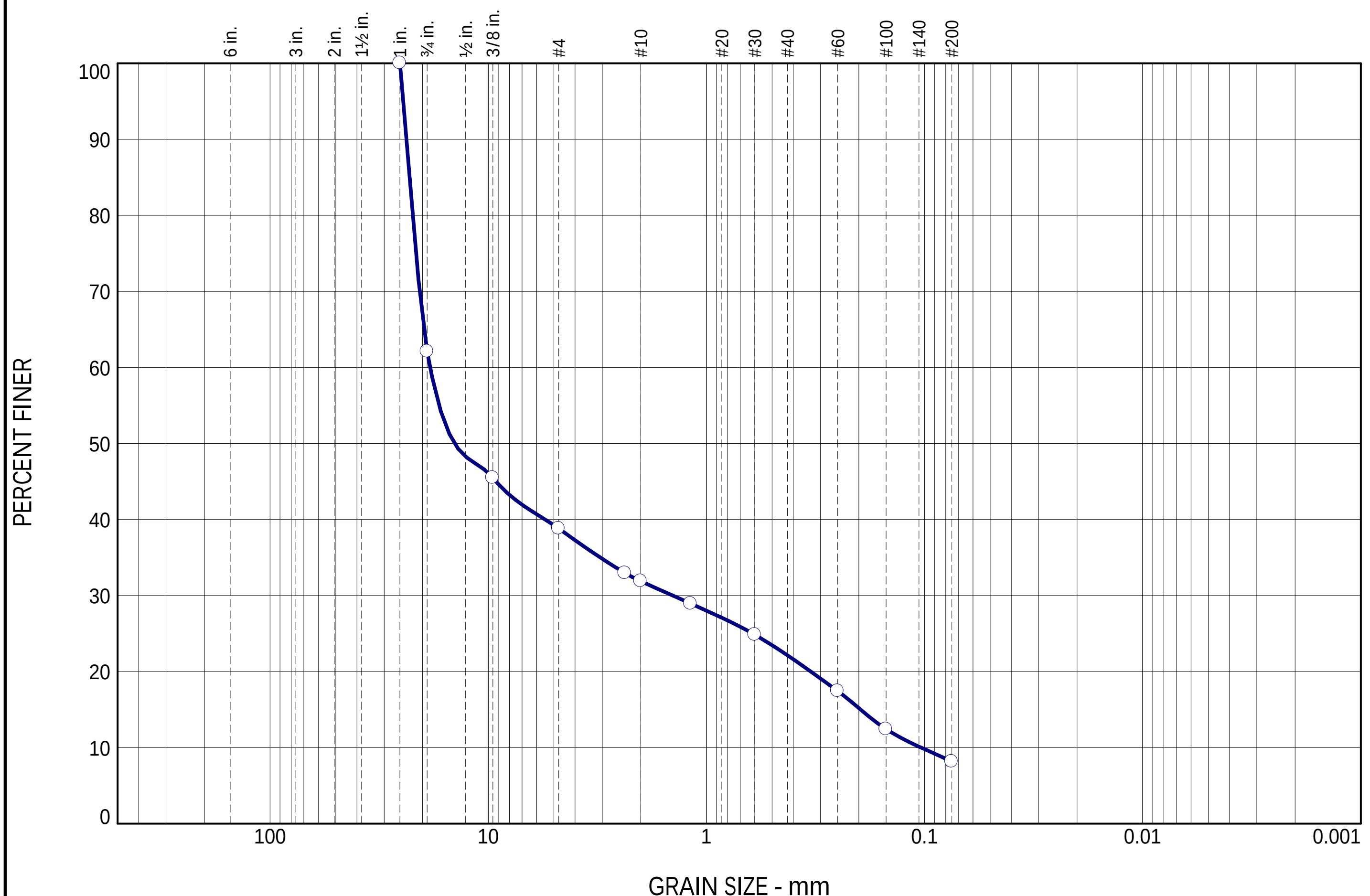
Source of Sample: DM-X-2 Depth: 15'-17'
Sample Number: S-8

Date: 1/22/25

5439 Harding Highway
Mays Landing New Jersey 08330
Main: 877 627 3772
Geotechnical Laboratory
Colliers Engineering & Design

Client: KC Engineering and Land Surveying, P.C.
Project: D214892-01, H371.1
I-95 Pavement Resurfacing Harrison, NY
Project No: 25001420A Plate PSA-9

Particle Size Distribution Report



% Cobbles	% Gravel			% Sand			% Fines
	Coarse	Medium	Fine	Coarse	Medium	Fine	
0.0	0.0	54.5	13.6	7.0	7.5	9.2	8.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1	100.0		
.75	62.1		
.375	45.5		
#4	38.8		
#8	33.0		
#10	31.9		
#16	28.9		
#30	24.9		
#60	17.4		
#100	12.4		
#200	8.2		

* (no specification provided)

Material Description

Brown medium to fine GRAVEL, some coarse to fine Sand, trace [Fines: (Silt/Clay)]

Atterberg Limits

LL= PL= PI=

Coefficients

D_{85}= 22.9176 D_{60}= 18.4584 D_{50}= 14.2682
D_{30}= 1.4247 D_{15}= 0.1963 D_{10}= 0.1035
C_u= 178.26 C_c= 1.06

Classification

USCS= GW-GM\GC

Remarks

WC: 1.6%

Source of Sample: DM-X-2 Depth: 20'-22'
Sample Number: S-9

Date: 1/22/25

5439 Harding Highway
Mays Landing New Jersey 08330
Main: 877 627 3772
Geotechnical Laboratory
Colliers Engineering & Design

Client: KC Engineering and Land Surveying, P.C.
Project: D214892-01, H371.1
I-95 Pavement Resurfacing Harrison, NY
Project No: 25001420A Plate PSA-10

SPT CORRECTIONS

Many correlations exist that relate the corrected N-values (sampler blow counts) to relative density (D_r), peak effective angle of internal friction (φ'), undrained shear strength (S_u), and other parameters; therefore it is incumbent upon the designer to understand the correlations being used and the requirements of the correlations for corrected N-values. Design methods are also available for using corrected N-values directly in the design of driven piles, embankments, spread footings, and drilled shafts. N-value corrections are especially important in liquefaction potential assessments (NYSDOT GDM Chapter 9). Design calculations using SPT N-value correlations should be performed using corrected N-values, however, only the actual field SPT blow count (N_{meas}) values should be plotted on the soil logs and profiles depicting the results of SPT borings. Inclusion of the hammer type on the soil logs allows the geotechnical designer to determine the corrected N-values. Each of the corrections is discussed in greater detail in the following sections.

8.4.1.1 Energy Correction (C_E)

Drop hammers used for soil penetration testing and sampling in test borings are typically donut, safety or automatic hammers. The type of hammer used to collect split-spoon samples must be noted on the boring logs. Typically correlations used between soil parameters and N-values are based on a hammer having an energy potential of 60 percent of the theoretical maximum. The energy ratio (ER) is the measured energy divided by the theoretical maximum (i.e. 140-pound hammer dropping 30 inches or 4,200 inch-pounds). A split-spoon sampler advanced with a manual safety hammer will have an approximate energy level of 60 percent (ER ≈ 60%).

Split-spoon samples are also advanced with either an automatic hammer (ER ≈ 90%) or a donut hammer (ER ≈ 45%) **[Reminder:** ***The NYSDOT retrofitted their drill rigs with automatic hammers for safety reasons*****]**. The corrections for the donut hammer are provided for information only because some past projects were performed using the donut hammer. N-values obtained using either the automatic or the donut hammer will require correction prior to being used in engineering analysis. The energy correction factor (C_E) shall be determined using the following equation. Typical C_E values are provided in Table 8-1 for each hammer type. These correction factors should only be used when the actual hammer energy has not been previously measured.

Equation 8-1

$$C_E = \frac{ER}{60}$$

Where ER is the measured energy expressed as an integer (i.e. 90 percent energy is ER = 90).

Hammer Type	Energy Ratio (ER) %	C_E
Automatic	80	1.33
Safety	60	1.00
Donut	45	0.75

Table 8-1 Energy Ratio by Hammer Type (CE)

8.4.1.1.1 NYSDOT Hammer Study

The geotechnical design recommendations prepared by the Geotechnical Engineering Bureau are largely based on the information obtained by progressing subsurface explorations. In addition to the actual samples, information regarding the resistance of the soil to sampler driving is also obtained. Historically, the Geotechnical Engineering Bureau has used what is termed as a 300 lb. donut hammer with a drop height of 18 in. to drive the casing and sampler. This method was originally recommended by the Anny Corps of Engineers. It had been used by the New York State Department of Transportation and its predecessor, the Department of Public Works, since 1946. In 2001, it was noted that the industry has adopted the Standard Penetration Test (SPT) to advance the sampler. This consists of driving the sampler with a 140 lb. hammer using a 30 in. drop. This method was officially accepted by ASTM and designated D1586 "Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils".

The Geotechnical Engineering Bureau progressed a hammer study to investigate the differences between the historical method vs. the SPT method of progressing a hole. This study determined, consistent with the work of others, that the ASTM Standard Penetration Test provides results very consistent with those obtained using the 300 lb. donut hammer. The important distinction being that an automatic hammer is used with the SPT. The actual energy imparted through the drill rods to the sampler with the automatic hammer was found to be equal or slightly greater than that transmitted through the drill rods with the 300 lb. donut hammer. For this study, the 140 lb. automatic hammer required approximately 95% of the blows required by the 300 lb. donut hammer when sampling similar soils.

The automatic hammer also provides for increased safety to the user in that it is a "hands free" operation. Numerous injuries have occurred over the years due to the free fall nature of the dropping 300 lb. weight onto an exposed impact plate. The automatic hammer has an enclosed striking point which minimizes the potential for injury.

The Standard Penetration Test (SPT) was adopted in 2002 by the NYSDOT as the standard method for obtaining split-spoon samples for its projects. However, the Departmental Geotechnical Engineer should always check the subsurface exploration log to confirm the hammer type.

8.4.1.2 Overburden Correction (C_N)

N_{meas} values will increase with depth due to increasing overburden pressure. The overburden correction is used to standardize all N-values to a reference overburden pressure. The reference overburden pressure is 1 ton per square foot (tsf) (1 atmosphere). The overburden correction factor (C_N) (Cetin et al., 2004) is provided below.

Equation 8-2

$$C_N = \left(\frac{1}{\sigma_v^{'}}\right)^{0.5} \leq 1.6$$

Where,
C_N = Overburden correction factor
σ'_v = actual effective overburden stress at the depth of the in-situ SPT (atmospheres)

8.4.1.3 Rod Length Correction (C_R)

N_{meas} values measured in the field should be corrected for the length of the rod used to obtain the sample. The original N_{60} value measurements were obtained using long rods (i.e. rod length greater than 33 feet); therefore, a correction to obtain “equivalent” N_{60} values for short rod length (i.e. rod length less than 33 feet) is required. Typically the rod length will be the depth of the sample (d) plus an assumed 7 feet of stick up above the ground surface. The rod length correction factor (C_R) equation is provided below with typical values presented in Table 8-2 (McGregor and Duncan, 1998).

Equation 8-3

$$C_R = e^{-e^{(-0.11d-0.77)}}$$

Where,
C_R = Rod length correction factor
e = Euler’s number (constant) ≈ 2.71828183
d = rod length

Rod Length (ft.)	C_R
<13	0.75
13 - 20	0.85
20.1 - 33	0.95
>33	1.00

Table 8-2 Rod Length Correction (C_R)

$$N_{60} = \left(\frac{ER}{60\%}\right)N \quad (10.4.6.2.4\text{-}2)$$

where:

N_{60} = *SPT* blow count corrected for hammer efficiency (blows/ft)
ER = hammer efficiency expressed as percent of theoretical free fall energy delivered by the hammer system actually used (dim)
N = uncorrected *SPT* blow count (blows/ft)

When *SPT* blow counts have been corrected for both overburden effects and hammer efficiency effects, the resulting corrected blow count shall be denoted as $N1_{60}$, determined as:

$$N1_{60} = C_N N_{60} \quad (10.4.6.2.4\text{-}3)$$

The drained friction angle of granular deposits should be determined based on the following correlation.

Table 10.4.6.2.4-1—Correlation of *SPT* $N1_{60}$ Values to Drained Friction Angle of Granular Soils (modified after Bowles, 1977)

$N1_{60}$	ϕ_f
<4	25–30
4	27–32
10	30–35
30	35–40
50	38–43

For gravels and rock fill materials where *SPT* testing is not reliable, Figure 10.4.6.2.4-1 should be used to estimate the drained friction angle.

Rock Fill Grade	Particle Unconfined Compressive Strength (ksf)
A	>4,610
B	3,460–4,610
C	2,590– 3,460
D	1,730– 2,590
E	≤1,730

reflect the greater energy delivered to the sampler by these systems.

Hammer efficiency (ER) for specific hammer systems used in local practice may be used in lieu of the values provided. If used, specific hammer system efficiencies shall be developed in general accordance with ASTM D4945 for dynamic analysis of driven piles or other accepted procedure.

The following values for ER may be assumed if hammer specific data are not available, e.g., from older boring logs:

ER = 60 percent for conventional drop hammer using rope and cathead
ER = 80 percent for automatic trip hammer

Corrections for rod length, hole size, and use of a liner may also be made if appropriate. In general, these are only significant in unusual cases or where there is significant variation from standard procedures. These corrections may be significant for evaluation of liquefaction. Information on these additional corrections may be found in Youd and Idriss (1997).

The $N1_{60}$-ϕ_f correlation used is modified after Bowles (1977). The correlation of Peck, Hanson, and Thornburn (1974) falls within the ranges specified. Experience should be used to select specific values within the ranges. In general, finer materials or materials with significant silt-sized material will fall in the lower portion of the range. Coarser materials with less than five percent fines will fall in the upper portion of the ranges. The geologic history and angularity of the particles may also need to be considered when selecting a value for ϕ_f.

Care should be exercised when using other correlations of *SPT* results to soil parameters. Some published correlations are based on corrected values ($N1_{60}$) and some are based on uncorrected values (N).

The designer should ascertain the basis of the correlation and use either $N1_{60}$ or N as appropriate.

Care should also be exercised when using *SPT* blow counts to estimate soil shear strength if in soils with coarse gravel, cobbles, or boulders. Large gravels, cobbles, or boulders could cause the *SPT* blow counts to be unrealistically high.

The secant friction angle derived from the procedure to estimate the drained friction angle of gravels and rock fill materials depicted in Figure 10.4.6.2.4-1 is based on a straight line from the origin of a Mohr diagram to the intersection with the strength envelope at the effective normal stress. Thus, the angle derived is applicable only to analysis of field conditions subject to similar normal stresses. See Terzaghi, Peck, and Mesri (1996) for additional details regarding this procedure.

APPENDIX C

FOUNDATION ANALYSIS AND DESIGN

APPENDIX C1

FOUNDATION LOADS

D.3 Cantilever Structures

These loads are effective at the bottom of base plate at the centerline of the single pedestal or shaft supporting the structure. The Foundation Type categories have been established based on groupings of maximum combined moments (longitudinal and transverse) in the case of the shaft foundations, and footing size in the case of the footing foundations.

D.3.1 Shaft Foundations

These foundation loads represent the loads resulting from the family of OSS included in each moment category used during the design of the shaft foundations for the cantilever structures. Since there is a single shaft per structure, the maximum moments and shears shown are the resultants of the combination of the longitudinal and transverse directions.

CANTILEVER SHAFT FOUNDATION LOADS

MAXIMUM MOMENT k-ft (kN-m)	SHAFT DIAMETER ft (m)	SHAFT LENGTH ft (m)	VERTICAL LOAD kips (kN)		MAXIMUM TORSION k-ft (kN-m)	MAXIMUM SHEAR kips (kN)
			MAXIMUM	MINIMUM		
75 (100)	3.5 (1.1)	9.8 (3)	4.3 (19)	2.2 (10)	30 (40)	2.2 (10)
150 (200)	3.5 (1.1)	13.1 (4)	5.0 (22)	2.7 (12)	41 (55)	3.6 (16)
	4.0 (1.2)	11.5 (3.5)	8.1 (36)	3.6 (16)	81 (109)	4.5 (20)
225 (300)	4.0 (1.2)	13.1 (4)	10.8 (48)	4.7 (21)	109 (147)	6.1 (27)
	4.5 (1.4)	13.1 (4)	11.2 (50)	6.7 (30)	128 (173)	6.7 (30)
295 (400)	4.0 (1.2)	14.8 (4.5)	7.2 (32)	5.8 (26)	51 (68)	7.9 (35)
	4.5 (1.4)	14.8 (4.5)	13.7 (61)	6.7 (30)	150 (203)	8.8 (39)
370 (500)	4.5 (1.4)	16.4 (5)	16.4 (73)	7.0 (31)	178 (241)	10.6 (47)
	5.0 (1.5)	14.8 (4.5)	18.7 (83)	9.2 (41)	245 (332)	11.2 (50)
445 (600)	5.5 (1.7)	14.8 (4.5)	19.6 (87)	12.4 (55)	290 (393)	12.4 (55)
520 (700)	5.0 (1.5)	16.4 (5)	21.6 (96)	15.7 (70)	300 (406)	13.5 (60)
590 (800)	5.5 (1.7)	16.4 (5)	26.3 (117)	12.1 (54)	402 (545)	16.6 (74)

APPENDIX C2

DESIGN OF DRILLED SHAFT FOUNDATION

(LOCATION 1 – S610.90 & LOCATION 2 – S611.30)

AXIAL GEOTECHNICAL DESIGN

LATERAL GEOTECHNICAL DESIGN

SETTLEMENT ANALYSIS

STRUCTURAL DESIGN

AXIAL GEOTECHNICAL DESIGN

Geotechnical Design of Drilled Shaft

References:

1. NYSDOT Geotechnical Design Manual
2. AASHTO LRFD Bridge Design, 9th Edition 2020

Legends

Input Intermediate results Recalling previously established value Final Result

Soil Profile:

$\gamma_w := 62.4 \cdot pcf$ (Unit weight of water)

$d := 12 \cdot ft$ (Depth of ground water)

Layer 1 Description: Sandy GRAVEL, Silty

$D_1 := 12 \cdot ft$ (Thickness of soil layer 1)

$\gamma_1 := 130 \cdot pcf$ (Moist Unit Weight of soil layer 1)

$\phi_1 := 34 \cdot deg$ (Friction angle of soil layer 1)

$\gamma'_1 := \gamma_1 - \gamma_w = 67.6\ pcf$ (Effective unit weight of soil layer 1)

$s_{u1} := 0 \cdot psf$ (Undrained shear strength of soil layer 1)

$N_{1.60} := 21$ (SPT Value at Soil layer 1 corrected for energy)

$N_{1.160} := 32$ (SPT Value at Soil layer 1 corrected for energy and overburden pressure)

Layer 2 Description: Silty SAND, Gravelly

$D_2 := 15 \cdot ft$ (Thickness of soil layer 2)

$\gamma_2 := 135 \cdot pcf$ (Moist Unit Weight of soil layer 2)

$\phi_2 := 36 \cdot deg$ (Friction angle of soil layer 1)

$\gamma'_2 := \gamma_2 - \gamma_w = 72.6\ pcf$ (Effective unit weight of soil layer 2)

$s_{u2} := 0 \cdot psf$ (Undrained shear strength of soil layer 2)

$N_{2.60} := 60$ (SPT Value at Soil layer 2 corrected for energy)

$N_{2.160} := 74$ (SPT Value at Soil layer 2 corrected for energy and overburden pressure)

Layer 3 Description: Silty SAND NOT USED

$D_3 := 0 \cdot ft$ (Thickness of soil layer 3)

$\gamma_3 := 130 \cdot pcf$ (Moist Unit Weight of soil layer 3)

$\phi_3 := 36 \cdot deg$ (Friction angle of soil layer 1)

$\gamma'_3 := \gamma_3 - \gamma_w = 67.6\ pcf$ (Effective unit weight of soil layer 3)

$s_{u3} := 0 \cdot psf$ (Undrained shear strength of soil layer 3)

$N_{3.60} := 41$ (SPT Value at Soil layer 3 corrected for energy)

$N_{3.160} := 58$ (SPT Value at Soil layer 3 corrected for energy and overburden pressure)

Layer 4 Description: Silty SAND NOT USED

$D_4 := 0 \cdot ft$ (Thickness of soil layer 4)

$\gamma_4 := 125 \cdot pcf$ (Moist Unit Weight of soil layer 4)

$\gamma'_4 := \gamma_4 - \gamma_w = 62.6\ pcf$ (Effective unit weight of soil layer 4)

$s_{u4} := 0 \cdot psf$ (Undrained shear strength of soil layer 4)

$N_{4.60} := 1$ (SPT Value at Soil layer 4 corrected for energy)

$N_{4.160} := 1$ (SPT Value at Soil layer 4 corrected for energy and overburden pressure)

Layer 5 Description: Sandy SILT NOT USED

$D_5 := 0 \cdot ft$ (Thickness of soil layer 5)

$\gamma_5 := 128 \cdot pcf$ (Moist Unit Weight of soil layer 5)

$\gamma'_5 := \gamma_5 - \gamma_w = 65.6\ pcf$ (Effective unit weight of soil layer 5)

$s_{u5} := 0 \cdot psf$ (Undrained shear strength of soil layer 5)

$N_{5.60} := 1$ (SPT Value at Soil layer 5 corrected for energy)

$N_{5.160} := 1$ (SPT Value at Soil layer 5 corrected for energy and overburden pressure)

Depth to the bottom of each layer:

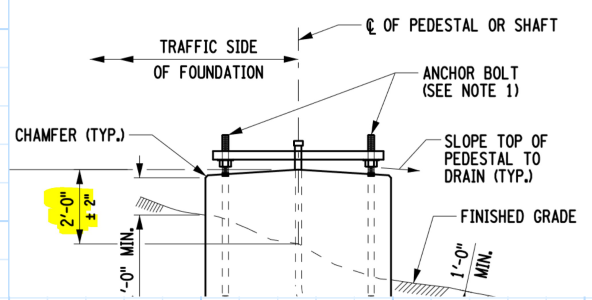
$D_{1e} := D_1$ $\qquad D_{1e} = 12\ ft$

$D_{2e} := D_{1e} + D_2$ $\qquad D_{2e} = 27\ ft$

$D_{3e} := D_{2e} + D_3$ $\qquad D_{3e} = 27\ ft$

$D_{4e} := D_{3e} + D_4$ $\qquad D_{4e} = 27\ ft$

$D_{5e} := D_{4e} + D_5$ $\qquad D_{5e} = 27\ ft$



$L := 17 \cdot ft$ (Length of drilled shaft)

$d_{embed} := L - 2\ ft = 15\ ft$ (Embedment of drilled shaft)

$B := 5.5 \cdot ft$ (Diameter of drilled shaft)

$Q_{structure} := 26.3 \cdot kip$ (Maximum Vertical load, see foundation loads)

$U := 0\ kip$ (Maximum Uplift load, see foundation loads)

$W_{self\_wt} := (0.25 \cdot \pi \cdot B^2 \cdot L) \cdot (150 \cdot pcf)$ (Self weight of drilled shaft)

$W_{self\_wt} = 60.584\ kip$

$Q := Q_{structure} + W_{self\_wt} = 86.884\ kip$ (Total vertical load)

$T_{shaft} := 4824 \cdot kip \cdot in$ (Maximum Torsional load, see foundation loads)

Calculating effective vertical stresses at each soil layer:

Effective vertical stress at mid-point of Layer 1:

$D_{1m} := \frac{D_1}{2}$ (Depth of mid-point of layer 1 from ground surface)

$$p'_{1m} := \begin{cases} \gamma_1 \cdot \frac{D_1}{2} & \text{if } d > D_{1m} \\ \gamma_1 \cdot d + \gamma'_1 \cdot (D_{1m} - d) & \text{else} \end{cases}$$

$p'_{1m} = 780\ psf$

Effective vertical stress at Start of Layer 2:

$$p'_{2s} := \begin{cases} \gamma_1 \cdot D_1 & \text{if } d > D_{1e} \\ \gamma_1 \cdot d + \gamma'_1 \cdot (D_1 - d) & \text{else} \end{cases}$$

$p'_{2s} = 1560\ psf$

Effective vertical stress at mid-point of Layer 2:

$$D_{2m} := D_1 + \frac{D_2}{2}$$ (Depth of mid-point of layer 2 from ground surface)

$$p'_{2m} := \begin{cases} \gamma_1 \cdot D_1 + \gamma_2 \cdot \frac{D_2}{2} & \text{if } d > D_{2m} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot (d - D_{1e}) + \gamma'_2 \cdot (D_{2m} - d) & \text{also if } D_1 < d \le D_{2m} \\ \gamma_1 \cdot d + \gamma'_1 \cdot (D_1 - d) + \gamma'_2 \cdot \frac{D_2}{2} & \text{else} \end{cases}$$

$p'_{2m} = 2105\ psf$

Effective vertical stress at start of Layer 3:

$$p'_{3s} := \begin{cases} \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 & \text{if } d > D_{2e} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot (d - D_{1e}) + \gamma'_2 \cdot (D_{2e} - d) & \text{also if } D_{1e} < d \le D_{2e} \\ \gamma_1 \cdot d + \gamma'_1 \cdot (D_1 - d) + \gamma'_2 \cdot D_2 & \text{else} \end{cases}$$

$p'_{3s} = 2649\ psf$

Effective vertical stress at mid-point of Layer 3:

$$D_{3m} := D_{2e} + \frac{D_3}{2}$$ (Depth of mid-point of layer 3 from ground surface)

$$p'_{3m} := \begin{cases} \gamma_1 \cdot D_1 + D_2 \cdot \gamma_2 + \gamma_3 \cdot \frac{D_3}{2} & \text{if } d > D_{3m} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot (d - D_{2e}) + \gamma'_3 \cdot (D_{3m} - d) & \text{also if } D_{2e} < d \le D_{3m} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot (d - D_{1e}) + \gamma'_2 \cdot (D_{2e} - d) + \gamma'_3 \cdot \frac{D_3}{2} & \text{also if } D_{1e} < d \le D_{2e} \\ \gamma_1 \cdot d + \gamma'_1 \cdot (D_{1e} - d) + \gamma'_2 \cdot D_2 + \gamma'_3 \cdot \frac{D_3}{2} & \text{else} \end{cases}$$

$p'_{3m} = 2649\ psf$

Effective vertical stress at start of Layer 4:

$$p'_{4s} := \begin{cases} \gamma_1 \cdot D_1 + D_2 \cdot \gamma_2 + \gamma_3 \cdot D_3 & \text{if } d > D_{3e} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot (d - D_{2e}) + \gamma'_3 \cdot (D_{3e} - d) & \text{also if } D_{2e} < d \le D_{3e} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot (d - D_{1e}) + \gamma'_2 \cdot (D_{2e} - d) + \gamma'_3 \cdot D_3 & \text{also if } D_{1e} < d \le D_{2e} \\ \gamma_1 \cdot d + \gamma'_1 \cdot (D_{1e} - d) + \gamma'_2 \cdot D_2 + \gamma'_3 \cdot D_3 & \text{else} \end{cases}$$

$p'_{4s} = 2649\ psf$

Effective vertical stress at mid-point of Layer 4:

$$D_{4m} := D_1 + D_2 + D_3 + \frac{D_4}{2}$$ (Depth of mid-point of layer 4 from ground surface)

$$p'_{4m} := \begin{cases} \gamma_1 \cdot D_1 + D_2 \cdot \gamma_2 + \gamma_3 \cdot D_3 + \gamma_4 \cdot \frac{D_4}{2} & \text{if } d > D_{4m} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot D_3 + \gamma_4 \cdot (d - D_{3e}) + \gamma'_4 \cdot (D_{4m} - d) & \text{also if } D_{3e} < d \le D_{4m} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot (d - D_{2e}) + \gamma'_3 \cdot (D_{3e} - d) + \gamma'_4 \cdot \frac{D_4}{2} & \text{also if } D_{2e} < d \le D_{3e} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot (d - D_{1e}) + \gamma'_2 \cdot (D_{2e} - d) + \gamma'_3 \cdot D_3 + \gamma'_4 \cdot \frac{D_4}{2} & \text{also if } D_{1e} < d \le D_{2e} \\ \gamma_1 \cdot d + \gamma'_1 \cdot (D_{1e} - d) + \gamma'_2 \cdot D_2 + \gamma'_3 \cdot D_3 + \gamma'_4 \cdot \frac{D_4}{2} & \text{else} \end{cases}$$

$p'_{4m} = 2649\ psf$

Effective vertical stress at start of Layer 5:

$$p'_{5s} := \begin{cases} \gamma_1 \cdot D_1 + D_2 \cdot \gamma_2 + \gamma_3 \cdot D_3 + \gamma_4 \cdot D_4 & \text{if } d > D_{4e} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot D_3 + \gamma_4 \cdot (d - D_{3e}) + \gamma'_4 \cdot (D_{4e} - d) & \text{also if } D_{3e} < d \le D_{4e} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot (d - D_{2e}) + \gamma'_3 \cdot (D_{3e} - d) + \gamma'_4 \cdot D_4 & \text{also if } D_{2e} < d \le D_{3e} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot (d - D_{1e}) + \gamma'_2 \cdot (D_{2e} - d) + \gamma'_3 \cdot D_3 + \gamma'_4 \cdot D_4 & \text{also if } D_{1e} < d \le D_{2e} \\ & \text{else} \end{cases}$$

$p'_{5s} = 2649\ psf$

$$\gamma_1 \cdot d + \gamma'_1 \cdot (D_{1e} - d) + \gamma'_2 \cdot D_2 + \gamma'_3 \cdot D_3 + \gamma'_4 \cdot D_4$$

Effective vertical stress at mid-point of Layer 5:

$$D_{5m} := D_1 + D_2 + D_3 + D_4 + \frac{D_5}{2}$$ (Depth of mid-point of layer 5 from ground surface)

$$p'_{5m} := \begin{cases} \gamma_1 \cdot D_1 + D_2 \cdot \gamma_2 + \gamma_3 \cdot D_3 + \gamma_4 \cdot D_4 + \gamma_5 \cdot \frac{D_5}{2} & \text{if } d > D_{5m} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot D_3 + \gamma_4 \cdot D_4 + \gamma_5 \cdot (d - D_{4e}) + \gamma'_5 \cdot (D_{5m} - d) & \text{also if } D_{4e} < d \le D_{5m} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot D_3 + \gamma_4 \cdot (d - D_{3e}) + \gamma'_4 \cdot (D_{4e} - d) + \gamma'_5 \cdot \frac{D_5}{2} & \text{also if } D_{3e} < d \le D_{4e} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot (d - D_{2e}) + \gamma'_3 \cdot (D_{3e} - d) + \gamma'_4 \cdot D_4 + \gamma'_5 \cdot \frac{D_5}{2} & \text{also if } D_{2e} < d \le D_{3e} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot (d - D_{1e}) + \gamma'_2 \cdot (D_{2e} - d) + \gamma'_3 \cdot D_3 + \gamma'_4 \cdot D_4 + \gamma'_5 \cdot \frac{D_5}{2} & \text{also if } D_{1e} < d \le D_{2e} \\ \gamma_1 \cdot d + \gamma'_1 \cdot (D_1 - d) + \gamma'_2 \cdot D_2 + \gamma'_3 \cdot D_3 + \gamma'_4 \cdot D_4 + \gamma'_5 \cdot \frac{D_5}{2} & \text{else} \end{cases}$$

$$p'_{5m} = 2649 \ psf$$

Side resistance

Side resistance in cohesive soil

Side resistance of drilled shaft in cohesive soil

$q_s = \alpha \cdot S_u$ (AASHTO 10.8.3.5.1b-1)

$p_a := 2.12\ ksf$ (Atmospheric pressure)

Determine adhesion factor α for each layers:

$$\alpha_1 := \begin{cases} \text{if } \dfrac{s_{u1}}{p_a} \le 1.5 & 0.55 \\ \text{else if } 1.5 \le \dfrac{s_{u1}}{p_a} \le 2.5 & 0.55 - 0.1 \cdot \left(\dfrac{s_{u1}}{p_a} - 1.5\right) \\ \text{else if } \dfrac{s_{u1}}{p_a} \ge 2.5 & 0.55 - 0.1\ (2.5 - 1.5) \\ \text{else} & \text{"NA"} \end{cases} = 0.55$$

$$\alpha_2 := \begin{cases} \text{if } \dfrac{s_{u2}}{p_a} \le 1.5 & 0.55 \\ \text{else if } 1.5 \le \dfrac{s_{u2}}{p_a} \le 2.5 & 0.55 - 0.1 \cdot \left(\dfrac{s_{u2}}{p_a} - 1.5\right) \\ \text{else if } \dfrac{s_{u2}}{p_a} \ge 2.5 & 0.55 - 0.1\ (2.5 - 1.5) \\ \text{else} & \text{"NA"} \end{cases} = 0.55$$

$$\alpha_3 := \begin{cases} \text{if } \dfrac{s_{u3}}{p_a} \le 1.5 & 0.55 \\ \text{else if } 1.5 \le \dfrac{s_{u3}}{p_a} \le 2.5 & 0.55 - 0.1 \cdot \left(\dfrac{s_{u3}}{p_a} - 1.5\right) \\ \text{else if } \dfrac{s_{u3}}{p_a} \ge 2.5 & 0.55 - 0.1\ (2.5 - 1.5) \\ \text{else} & \text{"NA"} \end{cases} = 0.55$$

$$\alpha_4 := \begin{cases} \text{if } \dfrac{s_{u4}}{p_a} \le 1.5 \\ \quad 0.55 \\ \text{else if } 1.5 \le \dfrac{s_{u4}}{p_a} \le 2.5 \\ \quad 0.55 - 0.1 \cdot \left(\dfrac{s_{u4}}{p_a} - 1.5\right) \\ \text{else if } \dfrac{s_{u4}}{p_a} \ge 2.5 \\ \quad 0.55 - 0.1\ (2.5 - 1.5) \\ \text{else} \\ \quad \text{“NA”} \end{cases} = 0.55$$

$$\alpha_5 := \begin{cases} \text{if } \dfrac{s_{u5}}{p_a} \le 1.5 \\ \quad 0.55 \\ \text{else if } 1.5 \le \dfrac{s_{u5}}{p_a} \le 2.5 \\ \quad 0.55 - 0.1 \cdot \left(\dfrac{s_{u5}}{p_a} - 1.5\right) \\ \text{else if } \dfrac{s_{u5}}{p_a} \ge 2.5 \\ \quad 0.55 - 0.1\ (2.5 - 1.5) \\ \text{else} \\ \quad \text{“NA”} \end{cases} = 0.55$$

Side resistance of drilled shaft in cohesive soil:

$$Q'_{s\_cohesive} := \begin{cases} \text{if } d_{embed} \le D_{1e} \\ \quad (\pi \cdot B) \cdot (\alpha_1 \cdot s_{u1}) \cdot (d_{embed} - B) \\ \text{also if } D_{1e} < d_{embed} \le D_{2e} \\ \quad (\pi \cdot B) \cdot \left((\alpha_1 \cdot s_{u1}) \cdot D_1 + (\alpha_2 \cdot s_{u2}) \cdot (d_{embed} - B - D_{1e})\right) \\ \text{also if } D_{2e} < d_{embed} \le D_{3e} \\ \quad (\pi \cdot B) \cdot \left((\alpha_1 \cdot s_{u1}) \cdot D_1 + (\alpha_2 \cdot s_{u2}) \cdot D_2 + (\alpha_3 \cdot s_{u3}) \cdot (d_{embed} - B - D_{2e})\right) \\ \text{also if } D_{3e} < d_{embed} \le D_{4e} \\ \quad (\pi \cdot B) \cdot \left((\alpha_1 \cdot s_{u1}) \cdot D_1 + (\alpha_2 \cdot s_{u2}) \cdot D_2 + (\alpha_3 \cdot s_{u3}) \cdot D_3 + (\alpha_4 \cdot s_{u4}) \cdot (d_{embed} - B - D_{3e})\right) \\ \text{also if } D_{4e} < d_{embed} \le D_{5e} \\ \quad (\pi \cdot B) \cdot \left((\alpha_1 \cdot s_{u1}) \cdot D_1 + (\alpha_2 \cdot s_{u2}) \cdot D_2 + (\alpha_3 \cdot s_{u3}) \cdot D_3 + (\alpha_3 \cdot s_{u3}) \cdot D_4 + (\alpha_5 \cdot s_{u5}) \cdot (d_{embed} - B - D_{4e})\right) \\ \text{else} \\ \quad \text{“ERROR”} \end{cases}$$

$$Q'_{s\_cohesive} = 0\ kip$$

The side resistance from top 5ft of drilled shaft shall not be considered (Section C10.8.3.5.1b)

Side resistance contribution from top 5ft of soil:

$$Q'_{s\_cohesive\_Top5ft} := \begin{cases} \text{if } 5 \cdot ft < D_{1e} \\ \quad \text{return } ((\pi \cdot B) \cdot 5 \cdot ft) \cdot (\alpha_1 \cdot s_{u1}) \\ \text{also if } D_{1e} \le 5 \cdot ft < D_{2e} \\ \quad (\pi \cdot B) \cdot ((\alpha_1 \cdot s_{u1}) \cdot D_1 + (\alpha_2 \cdot s_{u2}) \cdot (5 \cdot ft - D_{1e})) \\ \text{else} \\ \quad \text{"ERROR"} \end{cases}$$

$$Q'_{s\_cohesive\_Top5ft} = 0\ kip$$

Nominal side resistance of drilled shaft in cohesive soil:

$$Q_{s\_cohesive} := Q'_{s\_cohesive} - Q'_{s\_cohesive\_Top5ft}$$

$$Q_{s\_cohesive} = 0\ kip$$

Side resistance in cohesionless soil:

$q_s = \beta \cdot p'_m$ (AASHTO 10.8.3.5.2b-1)

Effective Friction angle for use in Equation 10.8.3.5.2b-2 to calculate β

$$\varphi'_1 := 27.5\ deg + 9.2\ deg \cdot \log(N_{1.160}) = 0.72$$

$$\varphi'_2 := 27.5\ deg + 9.2\ deg \cdot \log(N_{2.160}) = 0.78$$

$$\varphi'_3 := 27.5\ deg + 9.2\ deg \cdot \log(N_{3.160}) = 0.76$$

$$\varphi'_4 := 27.5\ deg + 9.2\ deg \cdot \log(N_{4.160}) = 0.48$$

$$\varphi'_5 := 27.5\ deg + 9.2\ deg \cdot \log(N_{5.160}) = 0.48$$

Preconsolidation pressure (Equation 10.8.3.5.2b-4)

$$\sigma'_{p1} := p_a \cdot (0.47 \cdot (N_{1.60})^{0.8}) = 11382\ psf$$

$$\sigma'_{p2} := p_a \cdot (0.47 \cdot (N_{2.60})^{0.8}) = 26361\ psf$$

$$\sigma'_{p3} := p_a \cdot (0.47 \cdot (N_{3.60})^{0.8}) = 19438\ psf$$

$$\sigma'_{p4} := p_a \cdot (0.47 \cdot (N_{4.60})^{0.8}) = 996\ psf$$

$$\sigma'_{p5} := p_a \cdot (0.47 \cdot (N_{5.60})^{0.8}) = 996\ psf$$

β factors as per Equation 10.8.3.5.2b-2:

$$\beta_1 := min\left(\left(\left(1-\sin\left(\varphi'_1\right)\right)\cdot\left(\frac{\sigma'_{p1}}{p'_{1m}}\right)^{\sin\left(\varphi'_1\right)}\cdot\tan\left(\varphi'_1\right)\right),\left(\left(\tan\left(45+\frac{\varphi'_1}{2}\right)\right)^2\cdot\tan\left(\varphi'_1\right)\right)\right)=1.75$$

$$\beta_2 := min\left(\left(\left(1-\sin\left(\varphi'_2\right)\right)\cdot\left(\frac{\sigma'_{p2}}{p'_{2m}}\right)^{\sin\left(\varphi'_2\right)}\cdot\tan\left(\varphi'_2\right)\right),\left(\left(\tan\left(45+\frac{\varphi'_2}{2}\right)\right)^2\cdot\tan\left(\varphi'_2\right)\right)\right)=1.74$$

$$\beta_3 := min\left(\left(\left(1-\sin\left(\varphi'_3\right)\right)\cdot\left(\frac{\sigma'_{p3}}{p'_{3m}}\right)^{\sin\left(\varphi'_3\right)}\cdot\tan\left(\varphi'_3\right)\right),\left(\left(\tan\left(45+\frac{\varphi'_3}{2}\right)\right)^2\cdot\tan\left(\varphi'_3\right)\right)\right)=1.17$$

$$\beta_4 := min\left(\left(\left(1-\sin\left(\varphi'_4\right)\right)\cdot\left(\frac{\sigma'_{p4}}{p'_{4m}}\right)^{\sin\left(\varphi'_4\right)}\cdot\tan\left(\varphi'_4\right)\right),\left(\left(\tan\left(45+\frac{\varphi'_4}{2}\right)\right)^2\cdot\tan\left(\varphi'_4\right)\right)\right)=0.18$$

$$\beta_5 := min\left(\left(\left(1-\sin\left(\varphi'_5\right)\right)\cdot\left(\frac{\sigma'_{p5}}{p'_{5m}}\right)^{\sin\left(\varphi'_5\right)}\cdot\tan\left(\varphi'_5\right)\right),\left(\left(\tan\left(45+\frac{\varphi'_5}{2}\right)\right)^2\cdot\tan\left(\varphi'_5\right)\right)\right)=0.18$$

Unit side resistances as per Equation 10.8.3.5.2b-1:

$$q_{s\_cohesionless\_1} := \begin{cases} \text{if } s_{u1} = 0 \\ \quad \beta_1 \cdot p'_{1m} \\ \text{else} \\ \quad 0\ ksf \end{cases}$$

$$q_{s\_cohesionless\_1} = 1.37\ ksf$$

$$q_{s\_cohesionless\_2} := \begin{cases} \text{if } s_{u2} = 0 \\ \quad \beta_2 \cdot p'_{2m} \\ \text{else} \\ \quad 0\ ksf \end{cases}$$

$$q_{s\_cohesionless\_2} = 3.66\ ksf$$

$q_{s\_cohesionless\_3} :=$ if $s_{u3} = 0$: $\beta_3 \cdot p'_{3m}$; else: $0\ ksf$

$q_{s\_cohesionless\_3} = 3.1\ ksf$

$q_{s\_cohesionless\_4} :=$ if $s_{u4} = 0$: $\beta_4 \cdot p'_{4m}$; else: $0\ ksf$

$q_{s\_cohesionless\_4} = 0.47\ ksf$

$q_{s\_cohesionless\_5} :=$ if $s_{u5} = 0$: $\beta_5 \cdot p'_{5m}$; else: $0\ ksf$

$q_{s\_cohesionless\_5} = 0.47\ ksf$

Nominal side resistance of drilled shaft in cohesionless soil:

$Q'_{s\_cohesionless} :=$

- if $d_{embed} \le D_{1e}$: $(\pi \cdot B) \cdot (q_{s\_cohesionless\_1}) \cdot d_{embed}$
- also if $D_{1e} < d_{embed} \le D_{2e}$: $(\pi \cdot B) \cdot (q_{s\_cohesionless\_1} \cdot D_1 + q_{s\_cohesionless\_2} \cdot (d_{embed} - D_{1e}))$
- also if $D_{2e} < d_{embed} \le D_{3e}$: $(\pi \cdot B) \cdot (q_{s\_cohesionless\_1} \cdot D_1 + q_{s\_cohesionless\_2} \cdot D_2 + q_{s\_cohesionless\_3} \cdot (d_{embed} - D_{2e}))$
- also if $D_{3e} < d_{embed} \le D_{4e}$: $(\pi \cdot B) \cdot (q_{s\_cohesionless\_1} \cdot D_1 + q_{s\_cohesionless\_2} \cdot D_2 + q_{s\_cohesionless\_3} \cdot D_3 + q_{s\_cohesionless\_4} \cdot (d_{embed} - D_{3e}))$
- also if $D_{4e} < d_{embed} \le D_{5e}$: $(\pi \cdot B) \cdot (q_{s\_cohesionless\_1} \cdot D_1 + q_{s\_cohesionless\_2} \cdot D_2 + q_{s\_cohesionless\_3} \cdot D_3 + q_{s\_cohesionless\_4} \cdot D_4 + q_{s\_cohesionless\_5} \cdot (d_{embed} - D_{4e}))$
- else: "ERROR"

$Q'_{s\_cohesionless} = 473.3\ kip$

The side resistance from top 5ft of drilled shaft shall not be considered (Section C10.8.3.5.1b)
Side resistance contribution from top 5ft of soil:

$$Q_{s\_cohesionless\_Top5ft} := \begin{cases} ((\pi \cdot B) \cdot 5 \cdot ft) \cdot (q_{s\_cohesionless\_1}) & \text{if } 5 \cdot ft < D_{1e} \\ (\pi \cdot B) \cdot (q_{s\_cohesionless\_1} \cdot D_1 + q_{s\_cohesionless\_2} \cdot (5 \cdot ft - D_{1e})) & \text{also if } D_{1e} \le 5 \cdot ft < D_{2e} \\ \text{"ERROR"} & \text{else} \end{cases}$$

$Q_{s\_cohesionless\_Top5ft} = 118\ kip$

Nominal side resistance of drilled shaft in cohesionless soil:

$$Q_{s\_cohesionless} := Q'_{s\_cohesionless} - Q_{s\_cohesionless\_Top5ft}$$

$Q_{s\_cohesionless} = 355\ kip$

Tip resistance

Corrected SPT Value of the soil at the tip of drilled shaft:

$$N_{60} := \begin{cases} N_{1.60} & \text{if } d_{embed} \le D_{1e} \\ N_{2.60} & \text{also if } D_{1e} < d_{embed} \le D_{2e} \\ N_{3.60} & \text{also if } D_{2e} < d_{embed} \le D_{3e} \\ N_{4.60} & \text{also if } D_{3e} < d_{embed} \le D_{4e} \\ N_{5.60} & \text{also if } D_{4e} < d_{embed} \le D_{5e} \\ \text{"ERROR. Extend the soil layer beyond the tip of drilled shaft"} & \text{else} \end{cases}$$

$N_{60} = 60$

Cohesion of the soil at the tip of drilled shaft:

$S_{ut} :=$ if $d_{embed} \le D_{1e}$
  s_{u1}
also if $D_{1e} < d_{embed} \le D_{2e}$
  s_{u2}
also if $D_{2e} < d_{embed} \le D_{3e}$
  s_{u3}
also if $D_{3e} < d_{embed} \le D_{4e}$
  s_{u4}
also if $D_{4e} < d_{embed} \le D_{5e}$
  s_{u5}
else
  "ERROR. Extend the soil layer beyond the tip of drilled shaft"

$S_{ut} = 0\ psf$

Tip resistance of drilled shaft in cohesionless soil (Section 10.8.3.5.2c)

$q_{T\_cohesionless} :=$ if $S_{ut} = 0$
  $min\left(\left(1.2 \cdot ksf \cdot N_{60}\right), 60 \cdot ksf\right)$
else
  $0\ ksf$

$q_{T\_cohesionless} = 60\ ksf$

Tip resistance of drilled shaft in cohesive soil (Section 10.8.3.5.1c)

$$N_c := min\left(6 \cdot \left(1 + 0.2 \cdot \left(\frac{d_{embed}}{B}\right)\right), 9\right) \qquad N_c = 9$$

$$q_{T\_cohesive} := \begin{cases} \min\left(N_c \cdot S_{ut}, 80 \cdot ksf\right) & \text{if } S_{ut} \neq 0 \\ 0 \cdot ksf & \text{else} \end{cases}$$

$q_{T\_cohesive} = 0\ psf$

Nominal geotechnical Tip resistance:

$$Q_{T\_cohesionless} := q_{T\_cohesionless} \cdot \left(\frac{\pi \cdot B^2}{4}\right)$$

$Q_{T\_cohesionless} = 1425\ kip$

$$Q_{T\_cohesive} := q_{T\_cohesive} \cdot \left(\frac{\pi \cdot B^2}{4}\right) = 0\ kip$$

Ultimate Axial capacity of shaft in compression (AASHTO 10.8.3.5):

$$Q_{ult} = Q_s + Q_T$$

$$Q_{ult\_Cohesive} := Q_{s\_cohesive} + Q_{T\_cohesive} = 0\ kip$$

$$Q_{ult\_Cohesionless} := Q_{s\_cohesionless} + Q_{T\_cohesionless} = 1781\ kip$$

$S := 0 \cdot ft$ (Drilled shaft spacing)

$$\eta := \begin{cases} 1.0 & \text{if } S > 3.\ B \\ 0.90 + \left(\frac{1 - 0.9}{3 \cdot B - 2 \cdot B}\right) \cdot (S - 2 \cdot B) & \text{else} \end{cases} = 0.7$$

(Group efficiency factor, Table 10.8.3.6.3-1)

$\eta := 1$ (Since it is a cantilever sign structure, there will be no group effect)

$$Q_{ult} := \eta \cdot \left(Q_{ult\_Cohesionless} + Q_{ult\_Cohesive}\right) = 1781\ kip$$

The allowable or working axial load

$FS := 2$ (Factor of Safety for design, NYSDOT GDM Section 11.12)

$$Q_{all} := \left(\frac{Q_{ult}}{FS}\right) = 890.3\ kip$$

$$DC := \frac{Q}{Q_{all}} = 0.1$$

Check := if $DC < 1.0$
  "Good. Axial load capacity of drilled shaft is sufficient"
else
  "Not Good. Axial load capacity of the drilled shaft isn't sufficient"

= "Good. Axial load capacity of drilled shaft is sufficient"

Uplift capacity

The allowable or working axial uplift load

$$U_{all} := \frac{\left(\eta \cdot \left(\left(0.75 \cdot Q_{s\_cohesionless}\right) + \left(0.7 \cdot Q_{s\_cohesive}\right)\right)\right)}{FS} = 133\ kip$$ (NYSDOT GDM Section 11.12)

$$DC_{uplift} := \frac{U}{U_{all}} = 0$$

Check := if $DC_{uplift} < 1.0$
  "Good. Uplift load capacity of drilled shaft is sufficient"
else
  "Not Good. Uplift load capacity of the drilled shaft isn't sufficient"

= "Good. Uplift load capacity of drilled shaft is sufficient"

Torsional capacity of drilled shaft:

Note - Due to lack of guidance from AASHTO and NYSDOT on the torsional resistance of drilled shaft, a research report titled 'Torsional Resistance of Drilled Shaft Foundations' by Auburn University is followed.

$$T_s := \left\| \begin{array}{l} \text{if } \left(d_{embed} - D_1\right) > 1.5 \cdot B \\ \quad \left\| \frac{1}{2} \cdot \pi \cdot B^2 \cdot \left(q_{s\_cohesionless\_1} \cdot D_1 + q_{s\_cohesionless\_2} \cdot \left(d_{embed} - D_{1e} - 1.5 \cdot B\right)\right) \right. \\ \text{else} \\ \quad \left\| \frac{1}{2} \cdot \pi \cdot B^2 \cdot q_{s\_cohesionless\_1} \cdot \left(d_{embed} - 1.5 \cdot B\right) \right. \end{array} \right\| = 439 \; kip \cdot ft$$

(Torsional capacity from side resistance)

$T_t := \frac{1}{12} \cdot \pi \cdot B^3 \cdot \left(q_{s\_cohesionless\_2}\right) = 159 \; kip \cdot ft$ (Torsional capacity from tip resistance)

$T_{ult} := T_s + T_t = 598 \; kip \cdot ft$ (Nominal torsional capacity)

$FS_t := 1.3$ (Conservative)

$T_{all} := \frac{T_{ult}}{FS_t} = 460 \; kip \cdot ft$ (Allowable torsional capacity)

$DC_T := \frac{T_{shaft}}{T_{all}} = 0.87$

Geotechnical Design of Drilled Shaft

References:

1. NYSDOT Geotechnical Design Manual
2. AASHTO LRFD Bridge Design, 9th Edition 2020

Legends

Input Intermediate results Recalling previously established value Final Result

Soil Profile:

$\gamma_w := 62.4 \cdot pcf$ (Unit weight of water)

$d := 12 \cdot ft$ (Depth of ground water)

Layer 1 Description: Silty SAND, Gravelly

$D_1 := 12 \cdot ft$ (Thickness of soil layer 1)

$\gamma_1 := 135 \cdot pcf$ (Moist Unit Weight of soil layer 1)

$\phi_1 := 36 \cdot deg$ (Friction angle of soil layer 1)

$\gamma'_1 := \gamma_1 - \gamma_w = 72.6\ pcf$ (Effective unit weight of soil layer 1)

$s_{u1} := 0 \cdot psf$ (Undrained shear strength of soil layer 1)

$N_{1.60} := 35$ (SPT Value at Soil layer 1 corrected for energy)

$N_{1.160} := 52$ (SPT Value at Soil layer 1 corrected for energy and overburden pressure)

Layer 2 Description: Silty GRAVEL, Sandy

$D_2 := 2 \cdot ft$ (Thickness of soil layer 2)

$\gamma_2 := 130 \cdot pcf$ (Moist Unit Weight of soil layer 2)

$\phi_2 := 34 \cdot deg$ (Friction angle of soil layer 1)

$\gamma'_2 := \gamma_2 - \gamma_w = 67.6\ pcf$ (Effective unit weight of soil layer 2)

$s_{u2} := 0 \cdot psf$ (Undrained shear strength of soil layer 2)

$N_{2.60} := 23$ (SPT Value at Soil layer 2 corrected for energy)

$N_{2.160} := 33$ (SPT Value at Soil layer 2 corrected for energy and overburden pressure)

Layer 3 Description: Sandy GRAVEL, Silty

$D_3 := 6 \cdot ft$ (Thickness of soil layer 3)

$\gamma_3 := 135 \cdot pcf$ (Moist Unit Weight of soil layer 3)

$\phi_3 := 36 \cdot deg$ (Friction angle of soil layer 1)

$\gamma'_3 := \gamma_3 - \gamma_w = 72.6\ pcf$ (Effective unit weight of soil layer 3)

$s_{u3} := 0 \cdot psf$ (Undrained shear strength of soil layer 3)

$N_{3.60} := 61$ (SPT Value at Soil layer 3 corrected for energy)

$N_{3.160} := 79$ (SPT Value at Soil layer 3 corrected for energy and overburden pressure)

Layer 4 Description: Silty SAND, Gravelly

$D_4 := 7 \cdot ft$ (Thickness of soil layer 4)

$\gamma_4 := 130 \cdot pcf$ (Moist Unit Weight of soil layer 4)

$\phi_4 := 34 \cdot deg$ (Friction angle of soil layer 1)

$\gamma'_4 := \gamma_4 - \gamma_w = 67.6\ pcf$ (Effective unit weight of soil layer 4)

$s_{u4} := 0 \cdot psf$ (Undrained shear strength of soil layer 4)

$N_{4.60} := 31$ (SPT Value at Soil layer 4 corrected for energy)

$N_{4.160} := 34$ (SPT Value at Soil layer 4 corrected for energy and overburden pressure)

Layer 5 Description: Sandy SILT NOT USED

$D_5 := 0 \cdot ft$ (Thickness of soil layer 5)

$\gamma_5 := 0 \cdot pcf$ (Moist Unit Weight of soil layer 5)

$\gamma'_5 := \gamma_5 - \gamma_w = -62.4\ pcf$ (Effective unit weight of soil layer 5)

$s_{u5} := 0 \cdot psf$ (Undrained shear strength of soil layer 5)

$N_{5.60} := 1$ (SPT Value at Soil layer 5 corrected for energy)

$N_{5.160} := 1$ (SPT Value at Soil layer 5 corrected for energy and overburden pressure)

KC Engineering and Land Surveying, P.C.

Subject: Axial Capacity of Drilled Shaft
Cantilever Sign Structure (Location 2 - S611.30)

Project: D214892 I-95 OHSS
Contract No:
Sheet No:
Calculated by: RG
Checked by: KR
Date: 2/24/2025

Depth to the bottom of each layer:

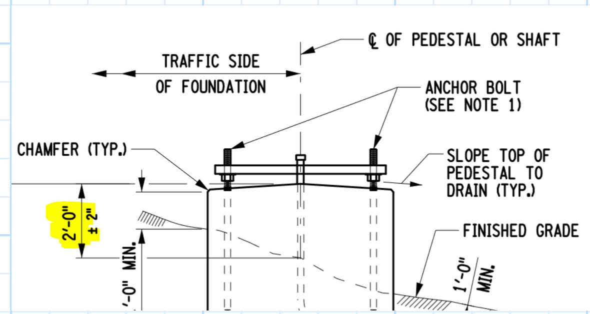
$D_{1e} := D_1$ $\quad D_{1e} = 12\ ft$

$D_{2e} := D_{1e} + D_2$ $\quad D_{2e} = 14\ ft$

$D_{3e} := D_{2e} + D_3$ $\quad D_{3e} = 20\ ft$

$D_{4e} := D_{3e} + D_4$ $\quad D_{4e} = 27\ ft$

$D_{5e} := D_{4e} + D_5$ $\quad D_{5e} = 27\ ft$



$L := 17 \cdot ft$ (Length of drilled shaft)

$d_{embed} := L - 2\ ft = 15\ ft$ (Embedment of drilled shaft)

$B := 5.5 \cdot ft$ (Diameter of drilled shaft)

$Q_{structure} := 26.3 \cdot kip$ (Maximum Vertical load, see foundation loads)

$U := 0\ kip$ (Maximum Uplift load, see foundation loads)

$W_{self\_wt} := \left(0.25 \cdot \pi \cdot B^2 \cdot L\right) \cdot (150 \cdot pcf)$ (Self weight of drilled shaft)

$W_{self\_wt} = 60.584\ kip$

$Q := Q_{structure} + W_{self\_wt} = 86.884\ kip$ (Total vertical load)

$T_{shaft} := 4824 \cdot kip \cdot in$ (Maximum Torsional load, see foundation loads)

Calculating effective vertical stresses at each soil layer:

Effective vertical stress at mid-point of Layer 1:

$D_{1m} := \frac{D_1}{2}$ (Depth of mid-point of layer 1 from ground surface)

$$p'_{1m} := \begin{cases} \gamma_1 \cdot \frac{D_1}{2} & \text{if } d > D_{1m} \\ \gamma_1 \cdot d + \gamma'_1 \cdot (D_{1m} - d) & \text{else} \end{cases}$$

$p'_{1m} = 810\ psf$

Effective vertical stress at Start of Layer 2:

$$p'_{2s} := \begin{cases} \gamma_1 \cdot D_1 & \text{if } d > D_{1e} \\ \gamma_1 \cdot d + \gamma'_1 \cdot (D_1 - d) & \text{else} \end{cases}$$

$p'_{2s} = 1620\ psf$

Effective vertical stress at mid-point of Layer 2:

$$D_{2m} := D_1 + \frac{D_2}{2}$$ (Depth of mid-point of layer 2 from ground surface)

$$p'_{2m} := \begin{cases} \gamma_1 \cdot D_1 + \gamma_2 \cdot \frac{D_2}{2} & \text{if } d > D_{2m} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot (d - D_{1e}) + \gamma'_2 \cdot (D_{2m} - d) & \text{also if } D_1 < d \le D_{2m} \\ \gamma_1 \cdot d + \gamma'_1 \cdot (D_1 - d) + \gamma'_2 \cdot \frac{D_2}{2} & \text{else} \end{cases}$$

$$p'_{2m} = 1688\ psf$$

Effective vertical stress at start of Layer 3:

$$p'_{3s} := \begin{cases} \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 & \text{if } d > D_{2e} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot (d - D_{1e}) + \gamma'_2 \cdot (D_{2e} - d) & \text{also if } D_{1e} < d \le D_{2e} \\ \gamma_1 \cdot d + \gamma'_1 \cdot (D_1 - d) + \gamma'_2 \cdot D_2 & \text{else} \end{cases}$$

$$p'_{3s} = 1755\ psf$$

Effective vertical stress at mid-point of Layer 3:

$$D_{3m} := D_{2e} + \frac{D_3}{2}$$ (Depth of mid-point of layer 3 from ground surface)

$$p'_{3m} := \begin{cases} \gamma_1 \cdot D_1 + D_2 \cdot \gamma_2 + \gamma_3 \cdot \frac{D_3}{2} & \text{if } d > D_{3m} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot (d - D_{2e}) + \gamma'_3 \cdot (D_{3m} - d) & \text{also if } D_{2e} < d \le D_{3m} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot (d - D_{1e}) + \gamma'_2 \cdot (D_{2e} - d) + \gamma'_3 \cdot \frac{D_3}{2} & \text{also if } D_{1e} < d \le D_{2e} \\ \gamma_1 \cdot d + \gamma'_1 \cdot (D_{1e} - d) + \gamma'_2 \cdot D_2 + \gamma'_3 \cdot \frac{D_3}{2} & \text{else} \end{cases}$$

$$p'_{3m} = 1973\ psf$$

Effective vertical stress at start of Layer 4:

$$p'_{4s} := \begin{cases} \gamma_1 \cdot D_1 + D_2 \cdot \gamma_2 + \gamma_3 \cdot D_3 & \text{if } d > D_{3e} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot (d - D_{2e}) + \gamma'_3 \cdot (D_{3e} - d) & \text{also if } D_{2e} < d \le D_{3e} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot (d - D_{1e}) + \gamma'_2 \cdot (D_{2e} - d) + \gamma'_3 \cdot D_3 & \text{also if } D_{1e} < d \le D_{2e} \\ \gamma_1 \cdot d + \gamma'_1 \cdot (D_{1e} - d) + \gamma'_2 \cdot D_2 + \gamma'_3 \cdot D_3 & \text{else} \end{cases}$$

$$p'_{4s} = 2191\ psf$$

Effective vertical stress at mid-point of Layer 4:

$$D_{4m} := D_1 + D_2 + D_3 + \frac{D_4}{2}$$ (Depth of mid-point of layer 4 from ground surface)

$$p'_{4m} := \begin{cases} \gamma_1 \cdot D_1 + D_2 \cdot \gamma_2 + \gamma_3 \cdot D_3 + \gamma_4 \cdot \frac{D_4}{2} & \text{if } d > D_{4m} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot D_3 + \gamma_4 \cdot (d - D_{3e}) + \gamma'_4 \cdot (D_{4m} - d) & \text{also if } D_{3e} < d \le D_{4m} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot (d - D_{2e}) + \gamma'_3 \cdot (D_{3e} - d) + \gamma'_4 \cdot \frac{D_4}{2} & \text{also if } D_{2e} < d \le D_{3e} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot (d - D_{1e}) + \gamma'_2 \cdot (D_{2e} - d) + \gamma'_3 \cdot D_3 + \gamma'_4 \cdot \frac{D_4}{2} & \text{also if } D_{1e} < d \le D_{2e} \\ \gamma_1 \cdot d + \gamma'_1 \cdot (D_{1e} - d) + \gamma'_2 \cdot D_2 + \gamma'_3 \cdot D_3 + \gamma'_4 \cdot \frac{D_4}{2} & \text{else} \end{cases}$$

$p'_{4m} = 2427\ psf$

Effective vertical stress at start of Layer 5:

$$p'_{5s} := \begin{cases} \gamma_1 \cdot D_1 + D_2 \cdot \gamma_2 + \gamma_3 \cdot D_3 + \gamma_4 \cdot D_4 & \text{if } d > D_{4e} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot D_3 + \gamma_4 \cdot (d - D_{3e}) + \gamma'_4 \cdot (D_{4e} - d) & \text{also if } D_{3e} < d \le D_{4e} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot (d - D_{2e}) + \gamma'_3 \cdot (D_{3e} - d) + \gamma'_4 \cdot D_4 & \text{also if } D_{2e} < d \le D_{3e} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot (d - D_{1e}) + \gamma'_2 \cdot (D_{2e} - d) + \gamma'_3 \cdot D_3 + \gamma'_4 \cdot D_4 & \text{also if } D_{1e} < d \le D_{2e} \\ \gamma_1 \cdot d + \gamma'_1 \cdot (D_{1e} - d) + \gamma'_2 \cdot D_2 + \gamma'_3 \cdot D_3 + \gamma'_4 \cdot D_4 & \text{else} \end{cases}$$

$p'_{5s} = 2664\ psf$

Effective vertical stress at mid-point of Layer 5:

$$D_{5m} := D_1 + D_2 + D_3 + D_4 + \frac{D_5}{2}$$ (Depth of mid-point of layer 5 from ground surface)

$$p'_{5m} := \begin{cases} \gamma_1 \cdot D_1 + D_2 \cdot \gamma_2 + \gamma_3 \cdot D_3 + \gamma_4 \cdot D_4 + \gamma_5 \cdot \frac{D_5}{2} & \text{if } d > D_{5m} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot D_3 + \gamma_4 \cdot D_4 + \gamma_5 \cdot (d - D_{4e}) + \gamma'_5 \cdot (D_{5m} - d) & \text{also if } D_{4e} < d \le D_{5m} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot D_3 + \gamma_4 \cdot (d - D_{3e}) + \gamma'_4 \cdot (D_{4e} - d) + \gamma'_5 \cdot \frac{D_5}{2} & \text{also if } D_{3e} < d \le D_{4e} \\ \gamma_1 \cdot D_1 + \gamma_2 \cdot D_2 + \gamma_3 \cdot (d - D_{2e}) + \gamma'_3 \cdot (D_{3e} - d) + \gamma'_4 \cdot D_4 + \gamma'_5 \cdot \frac{D_5}{2} & \text{also if } D_{2e} < d \le D_{3e} \end{cases}$$

$p'_{5m} = 2664\ psf$

also if $D_{1e} < d \le D_{2e}$

$$\gamma_1 \cdot D_1 + \gamma_2 \cdot (d - D_{1e}) + \gamma'_2 \cdot (D_{2e} - d) + \gamma'_3 \cdot D_3 + \gamma'_4 \cdot D_4 + \gamma'_5 \cdot \frac{D_5}{2}$$

else

$$\gamma_1 \cdot d + \gamma'_1 \cdot (D_1 - d) + \gamma'_2 \cdot D_2 + \gamma'_3 \cdot D_3 + \gamma'_4 \cdot D_4 + \gamma'_5 \cdot \frac{D_5}{2}$$

Side resistance

Side resistance in cohesive soil

Side resistance of drilled shaft in cohesive soil

$q_s = \alpha \cdot S_u$ (AASHTO 10.8.3.5.1b-1)

$p_a := 2.12\ ksf$ (Atmospheric pressure)

Determine adhesion factor α for each layers:

$$\alpha_1 := \begin{cases} \text{if } \frac{s_{u1}}{p_a} \le 1.5 & 0.55 \\ \text{else if } 1.5 \le \frac{s_{u1}}{p_a} \le 2.5 & 0.55 - 0.1 \cdot \left(\frac{s_{u1}}{p_a} - 1.5\right) \\ \text{else if } \frac{s_{u1}}{p_a} \ge 2.5 & 0.55 - 0.1\ (2.5 - 1.5) \\ \text{else} & \text{"NA"} \end{cases} = 0.55$$

$$\alpha_2 := \begin{cases} \text{if } \frac{s_{u2}}{p_a} \le 1.5 & 0.55 \\ \text{else if } 1.5 \le \frac{s_{u2}}{p_a} \le 2.5 & 0.55 - 0.1 \cdot \left(\frac{s_{u2}}{p_a} - 1.5\right) \\ \text{else if } \frac{s_{u2}}{p_a} \ge 2.5 & 0.55 - 0.1\ (2.5 - 1.5) \\ \text{else} & \text{"NA"} \end{cases} = 0.55$$

$$\alpha_3 := \begin{cases} \text{if } \frac{s_{u3}}{p_a} \le 1.5 & 0.55 \\ \text{else if } 1.5 \le \frac{s_{u3}}{p_a} \le 2.5 & 0.55 - 0.1 \cdot \left(\frac{s_{u3}}{p_a} - 1.5\right) \\ \text{else if } \frac{s_{u3}}{p_a} \ge 2.5 & 0.55 - 0.1\ (2.5 - 1.5) \\ \text{else} & \text{"NA"} \end{cases} = 0.55$$

$\alpha_4 :=$ if $\frac{s_{u4}}{p_a} \le 1.5$
  0.55
else if $1.5 \le \frac{s_{u4}}{p_a} \le 2.5$
  $0.55 - 0.1 \cdot \left(\frac{s_{u4}}{p_a} - 1.5\right)$
else if $\frac{s_{u4}}{p_a} \ge 2.5$
  $0.55 - 0.1\ (2.5 - 1.5)$
else
  "NA"

$\alpha_4 = 0.55$

$\alpha_5 :=$ if $\frac{s_{u5}}{p_a} \le 1.5$
  0.55
else if $1.5 \le \frac{s_{u5}}{p_a} \le 2.5$
  $0.55 - 0.1 \cdot \left(\frac{s_{u5}}{p_a} - 1.5\right)$
else if $\frac{s_{u5}}{p_a} \ge 2.5$
  $0.55 - 0.1\ (2.5 - 1.5)$
else
  "NA"

$\alpha_5 = 0.55$

Side resistance of drilled shaft in cohesive soil:

$Q'_{s\_cohesive} :=$ if $d_{embed} \le D_{1e}$
  $(\pi \cdot B) \cdot (\alpha_1 \cdot s_{u1}) \cdot (d_{embed} - B)$
also if $D_{1e} < d_{embed} \le D_{2e}$
  $(\pi \cdot B) \cdot ((\alpha_1 \cdot s_{u1}) \cdot D_1 + (\alpha_2 \cdot s_{u2}) \cdot (d_{embed} - B - D_{1e}))$
also if $D_{2e} < d_{embed} \le D_{3e}$
  $(\pi \cdot B) \cdot ((\alpha_1 \cdot s_{u1}) \cdot D_1 + (\alpha_2 \cdot s_{u2}) \cdot D_2 + (\alpha_3 \cdot s_{u3}) \cdot (d_{embed} - B - D_{2e}))$
also if $D_{3e} < d_{embed} \le D_{4e}$
  $(\pi \cdot B) \cdot \left((\alpha_1 \cdot s_{u1}) \cdot D_1 + (\alpha_2 \cdot s_{u2}) \cdot D_2 + (\alpha_3 \cdot s_{u3}) \cdot D_3 + (\alpha_4 \cdot s_{u4}) \cdot (d_{embed} - B - D_{3e})\right)$
also if $D_{4e} < d_{embed} \le D_{5e}$
  $(\pi \cdot B) \cdot \left((\alpha_1 \cdot s_{u1}) \cdot D_1 + (\alpha_2 \cdot s_{u2}) \cdot D_2 + (\alpha_3 \cdot s_{u3}) \cdot D_3 + (\alpha_3 \cdot s_{u3}) \cdot D_4 + (\alpha_5 \cdot s_{u5}) \cdot (d_{embed} - B - D_{4e})\right)$
else
  "ERROR"

$Q'_{s\_cohesive} = 0\ kip$

The side resistance from top 5ft of drilled shaft shall not be considered (Section C10.8.3.5.1b)

Side resistance contribution from top 5ft of soil:

$Q'_{s\_cohesive\_Top5ft} :=$
if $5 \cdot ft < D_{1e}$
  return $((\pi \cdot B) \cdot 5 \cdot ft) \cdot (\alpha_1 \cdot s_{u1})$
also if $D_{1e} \le 5 \cdot ft < D_{2e}$
  $(\pi \cdot B) \cdot ((\alpha_1 \cdot s_{u1}) \cdot D_1 + (\alpha_2 \cdot s_{u2}) \cdot (5 \cdot ft - D_{1e}))$
else
  "ERROR"

$Q'_{s\_cohesive\_Top5ft} = 0\ kip$

Nominal side resistance of drilled shaft in cohesive soil:

$Q_{s\_cohesive} := Q'_{s\_cohesive} - Q'_{s\_cohesive\_Top5ft}$

$Q_{s\_cohesive} = 0\ kip$

Side resistance in cohesionless soil:

$q_s = \beta \cdot p'_m$ (AASHTO 10.8.3.5.2b-1)

Effective Friction angle for use in Equation 10.8.3.5.2b-2 to calculate β

$\varphi'_1 := 27.5\ deg + 9.2\ deg \cdot \log(N_{1.160}) = 0.76$

$\varphi'_2 := 27.5\ deg + 9.2\ deg \cdot \log(N_{2.160}) = 0.72$

$\varphi'_3 := 27.5\ deg + 9.2\ deg \cdot \log(N_{3.160}) = 0.78$

$\varphi'_4 := 27.5\ deg + 9.2\ deg \cdot \log(N_{4.160}) = 0.73$

$\varphi'_5 := 27.5\ deg + 9.2\ deg \cdot \log(N_{5.160}) = 0.48$

Preconsolidation pressure (Equation 10.8.3.5.2b-4)

$\sigma'_{p1} := p_a \cdot (0.47 \cdot (N_{1.60})^{0.8}) = 17127\ psf$

$\sigma'_{p2} := p_a \cdot (0.47 \cdot (N_{2.60})^{0.8}) = 12241\ psf$

$\sigma'_{p3} := p_a \cdot (0.47 \cdot (N_{3.60})^{0.8}) = 26711\ psf$

$\sigma'_{p4} := p_a \cdot (0.47 \cdot (N_{4.60})^{0.8}) = 15543\ psf$

$\sigma'_{p5} := p_a \cdot (0.47 \cdot (N_{5.60})^{0.8}) = 996\ psf$

β factors as per Equation 10.8.3.5.2b-2:

$$\beta_1 := min\left(\left(\left(1-\sin\left(\varphi'_1\right)\right)\cdot\left(\frac{\sigma'_{p1}}{p'_{1m}}\right)^{\sin\left(\varphi'_1\right)}\cdot\tan\left(\varphi'_1\right)\right),\left(\left(\tan\left(45+\frac{\varphi'_1}{2}\right)\right)^2\cdot\tan\left(\varphi'_1\right)\right)\right)=2.4$$

$$\beta_2 := min\left(\left(\left(1-\sin\left(\varphi'_2\right)\right)\cdot\left(\frac{\sigma'_{p2}}{p'_{2m}}\right)^{\sin\left(\varphi'_2\right)}\cdot\tan\left(\varphi'_2\right)\right),\left(\left(\tan\left(45+\frac{\varphi'_2}{2}\right)\right)^2\cdot\tan\left(\varphi'_2\right)\right)\right)=1.11$$

$$\beta_3 := min\left(\left(\left(1-\sin\left(\varphi'_3\right)\right)\cdot\left(\frac{\sigma'_{p3}}{p'_{3m}}\right)^{\sin\left(\varphi'_3\right)}\cdot\tan\left(\varphi'_3\right)\right),\left(\left(\tan\left(45+\frac{\varphi'_3}{2}\right)\right)^2\cdot\tan\left(\varphi'_3\right)\right)\right)=1.85$$

$$\beta_4 := min\left(\left(\left(1-\sin\left(\varphi'_4\right)\right)\cdot\left(\frac{\sigma'_{p4}}{p'_{4m}}\right)^{\sin\left(\varphi'_4\right)}\cdot\tan\left(\varphi'_4\right)\right),\left(\left(\tan\left(45+\frac{\varphi'_4}{2}\right)\right)^2\cdot\tan\left(\varphi'_4\right)\right)\right)=1.02$$

$$\beta_5 := min\left(\left(\left(1-\sin\left(\varphi'_5\right)\right)\cdot\left(\frac{\sigma'_{p5}}{p'_{5m}}\right)^{\sin\left(\varphi'_5\right)}\cdot\tan\left(\varphi'_5\right)\right),\left(\left(\tan\left(45+\frac{\varphi'_5}{2}\right)\right)^2\cdot\tan\left(\varphi'_5\right)\right)\right)=0.18$$

Unit side resistances as per Equation 10.8.3.5.2b-1:

$$q_{s\_cohesionless\_1} := \begin{cases} \text{if } s_{u1}=0 & \beta_1\cdot p'_{1m} \\ \text{else} & 0\ ksf \end{cases}$$

$q_{s\_cohesionless\_1}=1.94\ ksf$

$$q_{s\_cohesionless\_2} := \begin{cases} \text{if } s_{u2}=0 & \beta_2\cdot p'_{2m} \\ \text{else} & 0\ ksf \end{cases}$$

$q_{s\_cohesionless\_2}=1.87\ ksf$

$q_{s\_cohesionless\_3} :=$ if $s_{u3} = 0$: $\beta_3 \cdot p'_{3m}$; else: $0\ ksf$

$q_{s\_cohesionless\_3} = 3.64\ ksf$

$q_{s\_cohesionless\_4} :=$ if $s_{u4} = 0$: $\beta_4 \cdot p'_{4m}$; else: $0\ ksf$

$q_{s\_cohesionless\_4} = 2.48\ ksf$

$q_{s\_cohesionless\_5} :=$ if $s_{u5} = 0$: $\beta_5 \cdot p'_{5m}$; else: $0\ ksf$

$q_{s\_cohesionless\_5} = 0.47\ ksf$

Nominal side resistance of drilled shaft in cohesionless soil:

$Q'_{s\_cohesionless} :=$

- if $d_{embed} \le D_{1e}$: $(\pi \cdot B) \cdot (q_{s\_cohesionless\_1}) \cdot d_{embed}$
- also if $D_{1e} < d_{embed} \le D_{2e}$: $(\pi \cdot B) \cdot (q_{s\_cohesionless\_1} \cdot D_1 + q_{s\_cohesionless\_2} \cdot (d_{embed} - D_{1e}))$
- also if $D_{2e} < d_{embed} \le D_{3e}$: $(\pi \cdot B) \cdot (q_{s\_cohesionless\_1} \cdot D_1 + q_{s\_cohesionless\_2} \cdot D_2 + q_{s\_cohesionless\_3} \cdot (d_{embed} - D_{2e}))$
- also if $D_{3e} < d_{embed} \le D_{4e}$: $(\pi \cdot B) \cdot (q_{s\_cohesionless\_1} \cdot D_1 + q_{s\_cohesionless\_2} \cdot D_2 + q_{s\_cohesionless\_3} \cdot D_3 + q_{s\_cohesionless\_4} \cdot (d_{embed} - D_{3e}))$
- also if $D_{4e} < d_{embed} \le D_{5e}$: $(\pi \cdot B) \cdot (q_{s\_cohesionless\_1} \cdot D_1 + q_{s\_cohesionless\_2} \cdot D_2 + q_{s\_cohesionless\_3} \cdot D_3 + q_{s\_cohesionless\_4} \cdot D_4 + q_{s\_cohesionless\_5} \cdot (d_{embed} - D_{4e}))$
- else: "ERROR"

$Q'_{s\_cohesionless} = 530.6\ kip$

The side resistance from top 5ft of drilled shaft shall not be considered (Section C10.8.3.5.1b)
Side resistance contribution from top 5ft of soil:

$$Q_{s\_cohesionless\_Top5ft} := \begin{cases} ((\pi \cdot B) \cdot 5 \cdot ft) \cdot (q_{s\_cohesionless\_1}) & \text{if } 5 \cdot ft < D_{1e} \\ (\pi \cdot B) \cdot (q_{s\_cohesionless\_1} \cdot D_1 + q_{s\_cohesionless\_2} \cdot (5 \cdot ft - D_{1e})) & \text{also if } D_{1e} \le 5 \cdot ft < D_{2e} \\ \text{"ERROR"} & \text{else} \end{cases}$$

$$Q_{s\_cohesionless\_Top5ft} = 168\ kip$$

Nominal side resistance of drilled shaft in cohesionless soil:

$$Q_{s\_cohesionless} := Q'_{s\_cohesionless} - Q_{s\_cohesionless\_Top5ft}$$

$$Q_{s\_cohesionless} = 363\ kip$$

Tip resistance

Corrected SPT Value of the soil at the tip of drilled shaft:

$$N_{60} := \begin{cases} N_{1.60} & \text{if } d_{embed} \le D_{1e} \\ N_{2.60} & \text{also if } D_{1e} < d_{embed} \le D_{2e} \\ N_{3.60} & \text{also if } D_{2e} < d_{embed} \le D_{3e} \\ N_{4.60} & \text{also if } D_{3e} < d_{embed} \le D_{4e} \\ N_{5.60} & \text{also if } D_{4e} < d_{embed} \le D_{5e} \\ \text{"ERROR. Extend the soil layer beyond the tip of drilled shaft"} & \text{else} \end{cases}$$

$$N_{60} = 61$$

Cohesion of the soil at the tip of drilled shaft:

$$S_{ut} := \begin{cases} s_{u1} & \text{if } d_{embed} \le D_{1e} \\ s_{u2} & \text{also if } D_{1e} < d_{embed} \le D_{2e} \\ s_{u3} & \text{also if } D_{2e} < d_{embed} \le D_{3e} \\ s_{u4} & \text{also if } D_{3e} < d_{embed} \le D_{4e} \\ s_{u5} & \text{also if } D_{4e} < d_{embed} \le D_{5e} \\ \text{“ERROR. Extend the soil layer beyond the tip of drilled shaft”} & \text{else} \end{cases}$$

$S_{ut} = 0\ psf$

Tip resistance of drilled shaft in cohesionless soil (Section 10.8.3.5.2c)

$$q_{T\_cohesionless} := \begin{cases} min\left(\left(1.2 \cdot ksf \cdot N_{60}\right), 60 \cdot ksf\right) & \text{if } S_{ut} = 0 \\ 0\ ksf & \text{else} \end{cases}$$

$q_{T\_cohesionless} = 60\ ksf$

Tip resistance of drilled shaft in cohesive soil (Section 10.8.3.5.1c)

$$N_c := min\left(6 \cdot \left(1 + 0.2 \cdot \left(\frac{d_{embed}}{B}\right)\right), 9\right)$$

$N_c = 9$

$$q_{T\_cohesive} := \begin{cases} \min(N_c \cdot S_{ut}, 80 \cdot ksf) & \text{if } S_{ut} \neq 0 \\ 0 \cdot ksf & \text{else} \end{cases}$$

$q_{T\_cohesive} = 0\ psf$

Nominal geotechnical Tip resistance:

$$Q_{T\_cohesionless} := q_{T\_cohesionless} \cdot \left(\frac{\pi \cdot B^2}{4}\right)$$

$Q_{T\_cohesionless} = 1425\ kip$

$$Q_{T\_cohesive} := q_{T\_cohesive} \cdot \left(\frac{\pi \cdot B^2}{4}\right) = 0\ kip$$

Ultimate Axial capacity of shaft in compression (AASHTO 10.8.3.5):

$$Q_{ult} = Q_s + Q_T$$

$$Q_{ult\_Cohesive} := Q_{s\_cohesive} + Q_{T\_cohesive} = 0\ kip$$

$$Q_{ult\_Cohesionless} := Q_{s\_cohesionless} + Q_{T\_cohesionless} = 1788\ kip$$

$S := 0 \cdot ft$ (Drilled shaft spacing)

$$\eta := \begin{cases} 1.0 & \text{if } S > 3.\ B \\ 0.90 + \left(\frac{1 - 0.9}{3 \cdot B - 2 \cdot B}\right) \cdot (S - 2 \cdot B) & \text{else} \end{cases} = 0.7$$

(Group efficiency factor, Table 10.8.3.6.3-1)

$\eta := 1$ (Since it is a cantilever sign structure, there will be no group effect)

$$Q_{ult} := \eta \cdot \left(Q_{ult\_Cohesionless} + Q_{ult\_Cohesive}\right) = 1788\ kip$$

The allowable or working axial load

$FS := 2$ (Factor of Safety for design, NYSDOT GDM Section 11.12)

$$Q_{all} := \left(\frac{Q_{ult}}{FS}\right) = 894.1\ kip$$

$$DC := \frac{Q}{Q_{all}} = 0.1$$

$Check :=$ if $DC < 1.0$
  "Good. Axial load capacity of drilled shaft is sufficient"
else
  "Not Good. Axial load capacity of the drilled shaft isn't sufficient"

= "Good. Axial load capacity of drilled shaft is sufficient"

Uplift capacity

The allowable or working axial uplift load

$$U_{all} := \frac{\left(\eta \cdot \left(\left(0.75 \cdot Q_{s\_cohesionless}\right) + \left(0.7 \cdot Q_{s\_cohesive}\right)\right)\right)}{FS} = 136\ kip$$ (NYSDOT GDM Section 11.12)

$$DC_{uplift} := \frac{U}{U_{all}} = 0$$

$Check :=$ if $DC_{uplift} < 1.0$
  "Good. Uplift load capacity of drilled shaft is sufficient"
else
  "Not Good. Uplift load capacity of the drilled shaft isn't sufficient"

= "Good. Uplift load capacity of drilled shaft is sufficient"

Torsional capacity of drilled shaft:

Note - Due to lack of guidance from AASHTO AND NYSDOT on the torsional resistance of drilled shaft, a research report titled 'Torsional Resistance of Drilled Shaft Foundations' by Auburn University is followed.

$$T_s := \begin{cases} \text{if } (d_{embed} - D_{2e}) > 1.5 \cdot B \\ \quad \frac{1}{2} \cdot \pi \cdot B^2 \cdot \left(q_{s\_cohesionless\_1} \cdot D_1 + q_{s\_cohesionless\_2} \cdot D_2 + q_{s\_cohesionless\_3} \cdot \left(d_{embed} - D_{2e} - 1.5 \cdot B\right)\right) \\ \text{else} \\ \quad \text{if } (d_{embed} - D_{1e}) > 1.5 \cdot B \\ \quad\quad \frac{1}{2} \cdot \pi \cdot B^2 \cdot \left(q_{s\_cohesionless\_1} \cdot D_1 + q_{s\_cohesionless\_2} \cdot \left(d_{embed} - D_{1e} - 1.5 \cdot B\right)\right) \\ \quad \text{else} \\ \quad\quad \frac{1}{2} \cdot \pi \cdot B^2 \cdot \left(q_{s\_cohesionless\_1} \cdot \left(d_{embed} - 1.5 \cdot B\right)\right) \end{cases} = 623\ kip \cdot ft$$

(Torsional capacity from side resistance)

$T_t := \frac{1}{12} \cdot \pi \cdot B^3 \cdot \left(q_{s\_cohesionless\_3}\right) = 159\ kip \cdot ft$ (Torsional capacity from tip resistance)

$T_{ult} := T_s + T_t = 782\ kip \cdot ft$ (Nominal torsional capacity)

$FS_t := 1.3$ (Conservative)

$T_{all} := \frac{T_{ult}}{FS_t} = 602\ kip \cdot ft$ (Allowable torsional capacity)

$DC_T := \frac{T_{shaft}}{T_{all}} = 0.67$

LATERAL GEOTECHNICAL DESIGN

SUMMARY OF LATERAL DESIGN

Drilled shaft responses from different LPILE Models have been summarized below:

1. Location 1 - S610.90

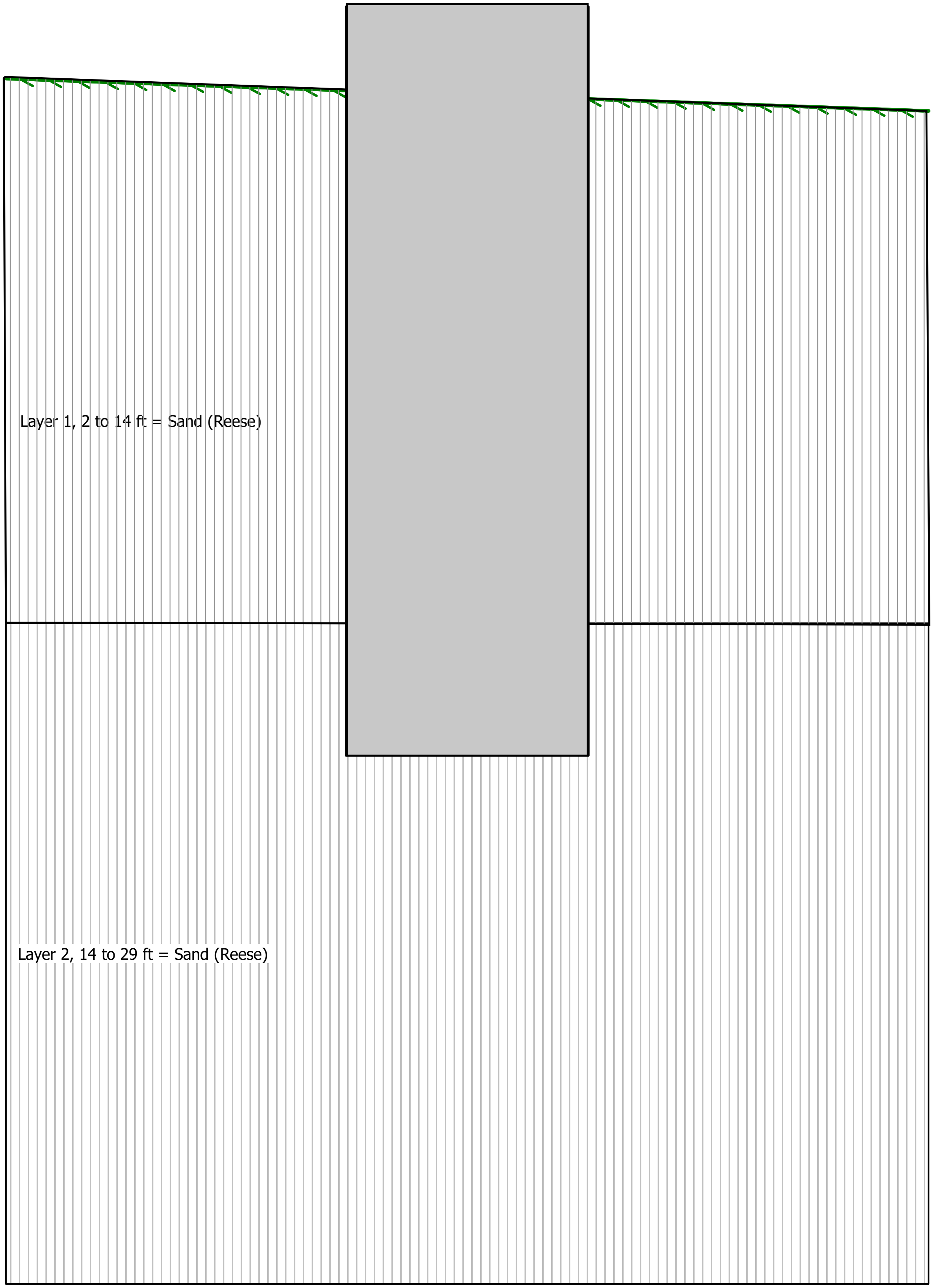
$V_1 := 93.76\ kip$	(Maximum shear force)
$M_1 := 658.07\ kip \cdot ft$	(Maximum moment)
$\delta_1 := 0.35\ in$	(Lateral displacement at top)

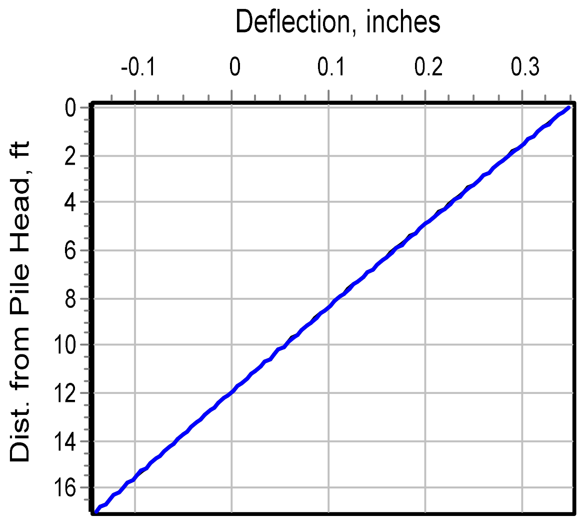
2. Location 2 - S611.30

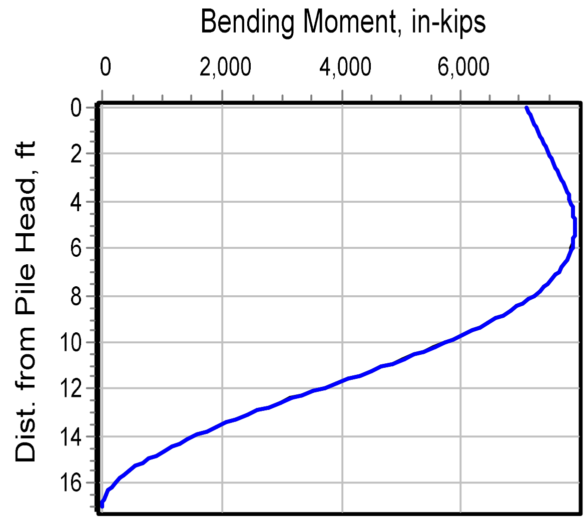
$V_2 := 101.05\ kip$	(Maximum shear force)
$M_2 := 661.35\ kip \cdot ft$	(Maximum moment)
$\delta_2 := 0.54\ in$	(Lateral displacement at top)

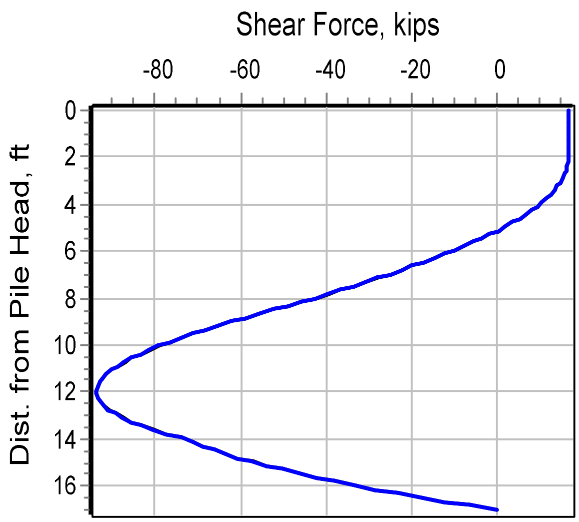
LPILE ANALYSIS

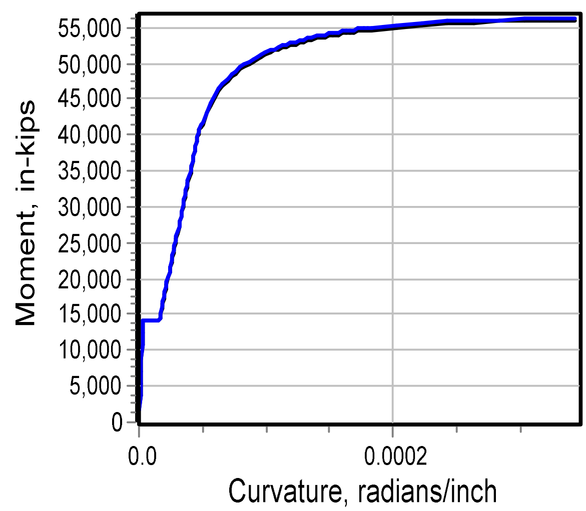
LOCATION 1 - S610.90

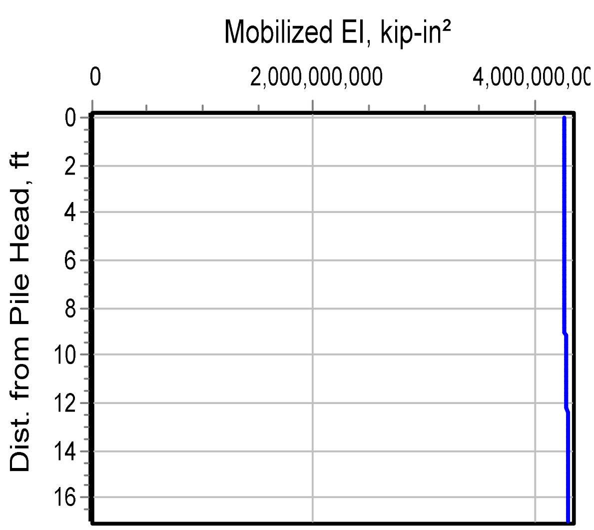


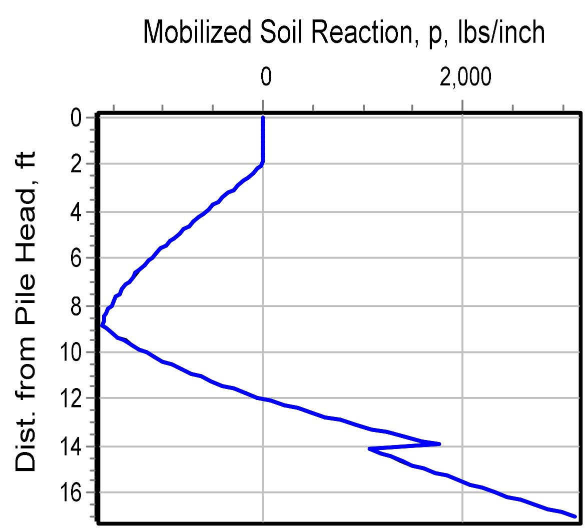

Deflection, inches
-0.1
0
0.1
0.2
0.3
Dist. from Pile Head, ft
0
2
4
6
8
10
12
14
16


Bending Moment, in-kips
0
2,000
4,000
6,000
Dist. from Pile Head, ft
0
2
4
6
8
10
12
14
16


Shear Force, kips
-80
-60
-40
-20
0
Dist. from Pile Head, ft
0
2
4
6
8
10
12
14
16


55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Moment, in-kips
0.0
0.0002
Curvature, radians/inch


Mobilized EI, kip-in²
0
2,000,000,000
4,000,000,0C
Dist. from Pile Head, ft
0
2
4
6
8
10
12
14
16


Mobilized Soil Reaction, p, lbs/inch
0
2,000
Dist. from Pile Head, ft
0
2
4
6
8
10
12
14
16

==

LPile for Windows, Version 2022-12.011

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:
\120186 - D214892, Assignment #1, H371.1, I-95 Pavement
Resurfacing\70_Design_Documents\Geotechnical\Geotechnical_Design\LPILE_Model\

Name of input data file:
I-95 Cantilever Sign Structure (Location 1).lp12d

Name of output report file:
I-95 Cantilever Sign Structure (Location 1).lp12o

Name of plot output file:
I-95 Cantilever Sign Structure (Location 1).lp12p

Name of runtime message file:
I-95 Cantilever Sign Structure (Location 1).lp12r

Date and Time of Analysis

Date: May 22, 2025   Time: 16:02:40

Problem Title

Project Name: I-95 Pavement Resurfacing

Job Number: 120186 - D214892

Client: NYSTA

Engineer: Kamal R./ Rohan G.

Description: Cantilever Sign Structures (Location 1)

Program Options and Settings

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:

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

Loading Type and Number of Cycles of Loading:

- Static loading specified

- Use of p-y modification factors for p-y curves not selected
- Analysis uses layering correction (Method of Georgiadis)
- Analysis includes loading by one distributed lateral load acting on pile
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

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

Pile Structural Properties and Geometry

```
Number of pile sections defined                        =            1
Total length of pile                                   =       17.000 ft
Depth of ground surface below top of pile              =       2.0000 ft
```

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	66.0000
2	17.000	66.0000

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                                         =    17.000000 ft
   Shaft Diameter                                            =    66.000000 in
```

```
--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                           =        2.320 degrees
                                                             =        0.040 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                 =     2.000000 ft
   Distance from top of pile to bottom of layer              =    14.000000 ft
   Effective unit weight at top of layer                     =   130.000000 pcf
   Effective unit weight at bottom of layer                  =   130.000000 pcf
   Friction angle at top of layer                            =    34.000000 deg.
   Friction angle at bottom of layer                         =    34.000000 deg.
   Subgrade k at top of layer                                =   225.000000 pci
   Subgrade k at bottom of layer                             =   225.000000 pci


Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer                 =    14.000000 ft
   Distance from top of pile to bottom of layer              =    29.000000 ft
   Effective unit weight at top of layer                     =    67.600000 pcf
   Effective unit weight at bottom of layer                  =    67.600000 pcf
   Friction angle at top of layer                            =    36.000000 deg.
   Friction angle at bottom of layer                         =    36.000000 deg.
   Subgrade k at top of layer                                =   125.000000 pci
   Subgrade k at bottom of layer                             =   125.000000 pci


 (Depth of the lowest soil layer extends 12.000 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	Angle of Friction deg.	kpy pci
1	Sand	2.0000	130.0000	34.0000	225.0000
	(Reese, et al.)	14.0000	130.0000	34.0000	225.0000
2	Sand	14.0000	67.6000	36.0000	125.0000
	(Reese, et al.)	29.0000	67.6000	36.0000	125.0000

Static Loading Type

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

Distributed Lateral Loading Used For All Load Cases

Distributed lateral load intensity defined using 1 points

Point No.	Depth X ft	Dist. Load lb/in
1	0.000	0.000

Concentrated Loads Applied to All Load Cases

Concentrated loads along depth defined using 1 points

Point No.	Depth X ft	Shear Force lbs	Moment in-lbs
1	0.00000	0.00000	0.00000

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 2

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 16600. lbs	M = 7080000. in-lbs	12100.	No	Yes
2	1	V = 16600. lbs	M = 7080000. in-lbs	26300.	No	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	=	17.000000 ft
Shaft Diameter	=	66.000000 in
Concrete Cover Thickness (to edge of long. rebar)	=	3.000000 in
Number of Reinforcing Bars	=	44 bars
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	3421. sq. in.

```
Total Area of Reinforcing Steel                          =    34.760000 sq. in.
Area Ratio of Steel Reinforcement                        =         1.02 percent
Edge-to-Edge Bar Spacing                                 =     3.137673 in
Maximum Concrete Aggregate Size                          =     0.750000 in
Ratio of Bar Spacing to Aggregate Size                   =         4.18
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    =    13599.477 kips
Tensile Load for Cracking of Concrete                    =    -1524.748 kips
Nominal Axial Tensile Capacity                           =    -2085.600 kips
```

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	1.000000	0.790000	29.000000	0.00000
2	1.000000	0.790000	28.704822	4.127130
3	1.000000	0.790000	27.825296	8.170244
4	1.000000	0.790000	26.379328	12.047035
5	1.000000	0.790000	24.396352	15.678584
6	1.000000	0.790000	21.916738	18.990961
7	1.000000	0.790000	18.990961	21.916738
8	1.000000	0.790000	15.678584	24.396352
9	1.000000	0.790000	12.047035	26.379328
10	1.000000	0.790000	8.170244	27.825296
11	1.000000	0.790000	4.127130	28.704822
12	1.000000	0.790000	0.00000	29.000000
13	1.000000	0.790000	-4.12713	28.704822
14	1.000000	0.790000	-8.17024	27.825296
15	1.000000	0.790000	-12.04704	26.379328
16	1.000000	0.790000	-15.67858	24.396352
17	1.000000	0.790000	-18.99096	21.916738
18	1.000000	0.790000	-21.91674	18.990961
19	1.000000	0.790000	-24.39635	15.678584
20	1.000000	0.790000	-26.37933	12.047035
21	1.000000	0.790000	-27.82530	8.170244
22	1.000000	0.790000	-28.70482	4.127130
23	1.000000	0.790000	-29.00000	0.00000
24	1.000000	0.790000	-28.70482	-4.12713
25	1.000000	0.790000	-27.82530	-8.17024
26	1.000000	0.790000	-26.37933	-12.04704
27	1.000000	0.790000	-24.39635	-15.67858
28	1.000000	0.790000	-21.91674	-18.99096
29	1.000000	0.790000	-18.99096	-21.91674
30	1.000000	0.790000	-15.67858	-24.39635

31	1.000000	0.790000	-12.04704	-26.37933
32	1.000000	0.790000	-8.17024	-27.82530
33	1.000000	0.790000	-4.12713	-28.70482
34	1.000000	0.790000	0.00000	-29.00000
35	1.000000	0.790000	4.127130	-28.70482
36	1.000000	0.790000	8.170244	-27.82530
37	1.000000	0.790000	12.047035	-26.37933
38	1.000000	0.790000	15.678584	-24.39635
39	1.000000	0.790000	18.990961	-21.91674
40	1.000000	0.790000	21.916738	-18.99096
41	1.000000	0.790000	24.396352	-15.67858
42	1.000000	0.790000	26.379328	-12.04704
43	1.000000	0.790000	27.825296	-8.17024
44	1.000000	0.790000	28.704822	-4.12713

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

Minimum spacing between any two bars not equal to zero = 3.138 inches
between bars 15 and 16.

Ratio of bar spacing to maximum aggregate size = 4.18

Concrete Properties:

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

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 2

Number	Axial Thrust Force kips
1	12.100
2	26.300

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in

reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.

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

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

Axial Thrust Force = 12.100 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
4.16667E-07	1793.	4302995505.	34.8948795	0.00001454	-0.00001296	0.0608483	0.3777840	
8.33333E-07	3578.	4293425448.	33.9502217	0.00002829	-0.00002671	0.1179418	0.7327387	
0.00000125	5355.	4283828357.	33.6353475	0.00004204	-0.00004046	0.1746186	1.0876938	
0.00000167	7124.	4274224500.	33.4779188	0.00005580	-0.00005420	0.2308787	1.4426494	
0.00000208	8885.	4264617935.	33.3834683	0.00006955	-0.00006795	0.2867221	1.7976054	
0.00000250	10638.	4255010017.	33.3205069	0.00008330	-0.00008170	0.3421487	2.1525618	
0.00000292	12382.	4245401325.	33.2755393	0.00009705	-0.00009545	0.3971586	2.5075185	
0.00000333	14119.	4235792149.	33.2418179	0.0001108	-0.000109	0.4517518	2.8624757	
0.00000375	14119.	3765148577.	16.8216796	0.00006308	-0.000184	0.2579905	-4.953380	C
0.00000417	14119.	3388633719.	16.7414633	0.00006976	-0.000205	0.2847592	-5.513448	C
0.00000458	14119.	3080576108.	16.6767000	0.00007643	-0.000226	0.3114480	-6.073401	C
0.00000500	14119.	2823861433.	16.6235291	0.00008312	-0.000247	0.3380569	-6.633238	C
0.00000542	14119.	2606641323.	16.5792775	0.00008980	-0.000268	0.3645856	-7.192959	C
0.00000583	14119.	2420452657.	16.5420362	0.00009650	-0.000289	0.3910341	-7.752564	C
0.00000625	14119.	2259089146.	16.5104051	0.0001032	-0.000309			

0.4174021 -8.312052 C
0.00000667 14119. 2117896075. 16.4833341 0.0001099 -0.000330
0.4436897 -8.871422 C
0.00000708 14119. 1993313953. 16.4600204 0.0001166 -0.000351
0.4698966 -9.430675 C
0.00000750 14119. 1882574288. 16.4398394 0.0001233 -0.000372
0.4960227 -9.989810 C
0.00000792 14119. 1783491431. 16.4222982 0.0001300 -0.000392
0.5220679 -10.548827 C
0.00000833 14119. 1694316860. 16.4070022 0.0001367 -0.000413
0.5480321 -11.107725 C
0.00000875 14119. 1613635104. 16.3934802 0.0001434 -0.000434
0.5739152 -11.666503 C
0.00000917 14119. 1540288054. 16.3817664 0.0001502 -0.000455
0.5997169 -12.225163 C
0.00000958 14119. 1473319008. 16.3715017 0.0001569 -0.000476
0.6254372 -12.783702 C
0.00001000 14119. 1411930716. 16.3625063 0.0001636 -0.000496
0.6510760 -13.342122 C
0.00001042 14119. 1355453488. 16.3546292 0.0001704 -0.000517
0.6766331 -13.900420 C
0.00001083 14119. 1303320661. 16.3477426 0.0001771 -0.000538
0.7021083 -14.458598 C
0.00001125 14119. 1255049526. 16.3417376 0.0001838 -0.000559
0.7275016 -15.016655 C
0.00001167 14119. 1210226328. 16.3365209 0.0001906 -0.000579
0.7528128 -15.574589 C
0.00001208 14119. 1168494386. 16.3320122 0.0001973 -0.000600
0.7780417 -16.132402 C
0.00001250 14119. 1129544573. 16.3281417 0.0002041 -0.000621
0.8031883 -16.690091 C
0.00001292 14119. 1093107651. 16.3248487 0.0002109 -0.000642
0.8282524 -17.247658 C
0.00001333 14119. 1058948037. 16.3220802 0.0002176 -0.000662
0.8532338 -17.805102 C
0.00001375 14119. 1026858703. 16.3197895 0.0002244 -0.000683
0.8781325 -18.362422 C
0.00001417 14119. 996656976. 16.3179354 0.0002312 -0.000704
0.9029482 -18.919617 C
0.00001458 14119. 968181063. 16.3164814 0.0002379 -0.000725
0.9276809 -19.476689 C
0.00001500 14119. 941287144. 16.3153952 0.0002447 -0.000745
0.9523304 -20.033635 C
0.00001542 14119. 915846951. 16.3146479 0.0002515 -0.000766
0.9768965 -20.590455 C
0.00001583 14119. 891745716. 16.3142136 0.0002583 -0.000787
1.0013792 -21.147150 C
0.00001625 14328. 881721714. 16.3140692 0.0002651 -0.000807
1.0257782 -21.703719 C
0.00001708 15045. 880696329. 16.3145684 0.0002787 -0.000849

1.0743249	-22.816476 C				
0.00001792	15762.	879727102.	16.3160018	0.0002923	-0.000890
1.1225354	-23.928723 C				
0.00001875	16478.	878806326.	16.3182511	0.0003060	-0.000932
1.1704084	-25.040456 C				
0.00001958	17193.	877927608.	16.3212183	0.0003196	-0.000973
1.2179430	-26.151673 C				
0.00002042	17907.	877085592.	16.3248215	0.0003333	-0.001014
1.2651378	-27.262369 C				
0.00002125	18621.	876275763.	16.3289916	0.0003470	-0.001056
1.3119917	-28.372541 C				
0.00002208	19334.	875494284.	16.3336701	0.0003607	-0.001097
1.3585035	-29.482185 C				
0.00002292	20046.	874737875.	16.3388071	0.0003744	-0.001138
1.4046720	-30.591299 C				
0.00002375	20758.	874003713.	16.3443597	0.0003882	-0.001179
1.4504959	-31.699877 C				
0.00002458	21468.	873289356.	16.3502909	0.0004019	-0.001221
1.4959739	-32.807916 C				
0.00002542	22178.	872592681.	16.3565686	0.0004157	-0.001262
1.5411049	-33.915413 C				
0.00002625	22888.	871911832.	16.3631648	0.0004295	-0.001303
1.5858876	-35.022364 C				
0.00002708	23596.	871245179.	16.3700551	0.0004434	-0.001344
1.6303206	-36.128764 C				
0.00002792	24304.	870591285.	16.3772181	0.0004572	-0.001385
1.6744027	-37.234611 C				
0.00002875	25011.	869948879.	16.3846348	0.0004711	-0.001426
1.7181326	-38.339899 C				
0.00002958	25717.	869316830.	16.3922885	0.0004849	-0.001468
1.7615090	-39.444624 C				
0.00003042	26423.	868694128.	16.4001644	0.0004988	-0.001509
1.8045305	-40.548784 C				
0.00003125	27127.	868079871.	16.4082492	0.0005128	-0.001550
1.8471957	-41.652373 C				
0.00003208	27831.	867473248.	16.4165312	0.0005267	-0.001591
1.8895034	-42.755387 C				
0.00003292	28535.	866873529.	16.4253117	0.0005407	-0.001632
1.9314521	-43.857822 C				
0.00003375	29237.	866280051.	16.4339651	0.0005546	-0.001673
1.9730404	-44.959674 C				
0.00003458	29939.	865692218.	16.4427874	0.0005686	-0.001714
2.0142670	-46.060938 C				
0.00003542	30639.	865109485.	16.4517708	0.0005827	-0.001755
2.0551304	-47.161611 C				
0.00003625	31339.	864531355.	16.4609086	0.0005967	-0.001796
2.0956291	-48.261686 C				
0.00003708	32038.	863957377.	16.4701946	0.0006108	-0.001837
2.1357618	-49.361161 C				
0.00003792	32737.	863387135.	16.4796232	0.0006249	-0.001878

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2.1755269    -50.460029 C
0.00003875        33434.    862820248.    16.4891893    0.0006390    -0.001919
2.2149229    -51.558287 C
0.00003958        34131.    862256365.    16.4988885    0.0006531    -0.001959
2.2539484    -52.655930 C
0.00004042        34827.    861695163.    16.5087166    0.0006672    -0.002000
2.2926019    -53.752953 C
0.00004125        35522.    861136342.    16.5186697    0.0006814    -0.002041
2.3308817    -54.849351 C
0.00004208        36216.    860579625.    16.5287447    0.0006956    -0.002082
2.3687864    -55.945119 C
0.00004292        36909.    860024755.    16.5389384    0.0007098    -0.002123
2.4063143    -57.040252 C
0.00004375        37602.    859471491.    16.5492479    0.0007240    -0.002163
2.4434639    -58.134745 C
0.00004458        38293.    858919610.    16.5596709    0.0007383    -0.002204
2.4802335    -59.228592 C
0.00004542        38977.    858198183.    16.5690719    0.0007525    -0.002245
2.5164891    -60.000000 CY
0.00004625        39600.    856212807.    16.5700715    0.0007664    -0.002286
2.5513584    -60.000000 CY
0.00004708        40142.    852568511.    16.5597887    0.0007797    -0.002328
2.5844812    -60.000000 CY
0.00004792        40641.    848151116.    16.5445389    0.0007928    -0.002370
2.6165328    -60.000000 CY
0.00004875        41094.    842957561.    16.5233073    0.0008055    -0.002412
2.6474789    -60.000000 CY
0.00004958        41514.    837260777.    16.4977715    0.0008180    -0.002454
2.6775319    -60.000000 CY
0.00005292        42992.    812446560.    16.3806487    0.0008668    -0.002626
2.7912471    -60.000000 CY
0.00005625        44188.    785568707.    16.2421578    0.0009136    -0.002799
2.8954834    -60.000000 CY
0.00005958        45194.    758507594.    16.0924132    0.0009588    -0.002974
2.9915884    -60.000000 CY
0.00006292        46083.    732446974.    15.9410975    0.0010030    -0.003150
3.0811207    -60.000000 CY
0.00006625        46806.    706512984.    15.7820455    0.0010456    -0.003327
3.1636392    -60.000000 CY
0.00006958        47503.    682681993.    15.6384620    0.0010882    -0.003504
3.2421483    -60.000000 CY
0.00007292        48071.    659263424.    15.4889970    0.0011294    -0.003683
3.3143963    -60.000000 CY
0.00007625        48595.    637306792.    15.3408249    0.0011697    -0.003863
3.3815850    -60.000000 CY
0.00007958        49108.    617060588.    15.2062146    0.0012102    -0.004042
3.4453916    -60.000000 CY
0.00008292        49507.    597073115.    15.0649530    0.0012491    -0.004223
3.5036159    -60.000000 CY
0.00008625        49892.    578455976.    14.9344853    0.0012881    -0.004404
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3.5585563    -60.000000 CY
0.00008958        50272.    561178509.    14.8127939    0.0013270    -0.004586
3.6101774    -60.000000 CY
0.00009292        50621.    544795717.    14.6908543    0.0013650    -0.004767
3.6575733    -60.000000 CY
0.00009625        50902.    528846794.    14.5668786    0.0014021    -0.004950
3.7007076    -60.000000 CY
0.00009958        51170.    513842011.    14.4505605    0.0014390    -0.005133
3.7408795    -60.000000 CY
 0.0001029        51437.    499789992.    14.3416241    0.0014760    -0.005317
3.7782920    -60.000000 CY
 0.0001063        51701.    486600760.    14.2437212    0.0015134    -0.005499
3.8129144    -60.000000 CY
 0.0001096        51945.    474020957.    14.1451049    0.0015501    -0.005682
3.8441210    -60.000000 CY
 0.0001129        52145.    461801223.    14.0417347    0.0015855    -0.005867
3.8715740    -60.000000 CY
 0.0001163        52324.    450099332.    13.9413560    0.0016207    -0.006052
3.8961377    -60.000000 CY
 0.0001196        52501.    439036674.    13.8476440    0.0016559    -0.006237
3.9181741    -60.000000 CY
 0.0001229        52677.    428560987.    13.7575833    0.0016910    -0.006421
3.9376548    -60.000000 CY
 0.0001263        52851.    418625652.    13.6780816    0.0017269    -0.006606
3.9545508    -60.000000 CY
 0.0001296        53024.    409188635.    13.6014721    0.0017625    -0.006790
3.9688320    -60.000000 CY
 0.0001329        53186.    400141950.    13.5274871    0.0017980    -0.006974
3.9803804    -60.000000 CY
 0.0001363        53329.    391402305.    13.4491317    0.0018324    -0.007160
3.9890306    -60.000000 CY
 0.0001396        53440.    382850385.    13.3683771    0.0018660    -0.007346
3.9950542    -60.000000 CY
 0.0001429        53549.    374688195.    13.2917455    0.0018996    -0.007533
3.9987193    -60.000000 CY
 0.0001462        53658.    366889051.    13.2203454    0.0019335    -0.007719
3.9999988    -60.000000 CY
 0.0001496        53764.    359425239.    13.1517324    0.0019673    -0.007905
3.9949673    -60.000000 CY
 0.0001529        53869.    352278737.    13.0876815    0.0020013    -0.008091
3.9985335    -60.000000 CY
 0.0001562        53973.    345429230.    13.0284197    0.0020357    -0.008277
3.9999696    -60.000000 CY
 0.0001596        54075.    338853381.    12.9707258    0.0020699    -0.008463
3.9929061    -60.000000 CY
 0.0001629        54176.    332538997.    12.9186660    0.0021047    -0.008648
3.9971423    -60.000000 CY
 0.0001662        54273.    326456868.    12.8671461    0.0021392    -0.008833
3.9994842    -60.000000 CY
 0.0001696        54362.    320559498.    12.8123436    0.0021728    -0.009020
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   3.9979067    -60.000000 CY
    0.0001729        54446.    314867603.    12.7600198     0.0022064     -0.009206
   3.9929324    -60.000000 CY
    0.0001762        54506.    309255706.    12.7037491     0.0022390     -0.009393
   3.9966765    -60.000000 CY
    0.0001796        54566.    303848525.    12.6501057     0.0022717     -0.009581
   3.9990309    -60.000000 CY
    0.0001829        54624.    298629566.    12.5983912     0.0023045     -0.009768
   3.9999792    -60.000000 CY
    0.0002029        54953.    270817526.    12.3366422     0.0025033     -0.010889
   3.9954925    -60.000000 CY
    0.0002229        55254.    247866442.    12.1268049     0.0027033     -0.012009
   3.9975518    -60.000000 CY
    0.0002429        55466.    228331852.    11.9287643     0.0028977     -0.013135
   3.9989436    -60.000000 CY
    0.0002629        55612.    211519850.    11.7570130     0.0030911     -0.014261
   3.9895378    60.0000000 CYT
    0.0002829        55746.    197039785.    11.6203405     0.0032876     -0.015385
   3.9997242    60.0000000 CYT
    0.0003029        55839.    184338966.    11.5229265     0.0034905     -0.016502
   3.9898225    60.0000000 CYT
    0.0003229        55920.    173170857.    11.4353745     0.0036927     -0.017620
   3.9999701    60.0000000 CYT
    0.0003429        55920.    163070977.    11.4594909     0.0039297     -0.018703
   3.9871990    60.0000000 CYT


Axial Thrust Force =     26.300 kips

    Bending       Bending       Bending      Depth to      Max Comp      Max Tens
  Max Conc      Max Steel  Run
   Curvature      Moment      Stiffness       N Axis        Strain        Strain
   Stress        Stress    Msg
    rad/in.       in-kip       kip-in2          in          in/in         in/in
     ksi           ksi
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------------- ------------- ---
  4.16667E-07         1793.   4302698182.    37.1186068    0.00001547   -0.00001203
   0.0647470     0.4046540
  8.33333E-07         3578.   4293275394.    35.0652869    0.00002922   -0.00002578
   0.1218233     0.7596861
   0.00000125         5355.   4283727672.    34.3808805    0.00004298   -0.00003952
   0.1784829     1.1147194
   0.00000167         7124.   4274148526.    34.0386968    0.00005673   -0.00005327
   0.2347256     1.4697537
   0.00000208         8884.   4264556795.    33.8334016    0.00007049   -0.00006701
   0.2905515     1.8247889
   0.00000250        10637.   4254958764.    33.6965502    0.00008424   -0.00008076
   0.3459606     2.1798249
   0.00000292        12382.   4245357132.    33.5988096    0.00009800   -0.00009450
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0.00000500	14119.	2823835500.	17.3589093	0.00008679	-0.000243
0.3529626	-6.526608 C				
0.00000542	14119.	2606617385.	17.2612147	0.00009350	-0.000264
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0.4059670	-7.644956 C				
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0.4323472	-8.203960 C				
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0.4586458	-8.762850 C				
0.00000708	14119.	1993295647.	16.9907577	0.0001204	-0.000347
0.4848628	-9.321626 C				
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0.5630224	-10.997268 C				
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0.5889114	-11.555585 C				
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0.00001042	14119.	1355441040.	16.7235870	0.0001742	-0.000513
0.6914666	-13.789021 C				
0.00001083	14119.	1303308692.	16.7029057	0.0001809	-0.000534
0.7169007	-14.347079 C				
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0.7422527	-14.905015 C				
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0.7675225	-15.462829 C				
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0.7927099	-16.020521 C				
0.00001250	14119.	1129534200.	16.6373392	0.0002080	-0.000617
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0.8926337 -18.250053 C
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0.9667053 -19.920895 C
0.00001542 14119. 915838541. 16.5673729 0.0002554 -0.000762
0.9912291 -20.477591 C
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1.2789541 -27.147972 C
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0.00004042        35054.    867318164.    16.6124814    0.0006714    -0.001996
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   0.0001529        54192.    354391088.    13.1460356     0.0020102     -0.008082
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  3.9944257    -60.000000 CY
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  3.9946595    -60.000000 CY
   0.0001762        54836.    311124375.    12.7637128     0.0022496     -0.009383
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   0.0001796        54895.    305680243.    12.7092157     0.0022824     -0.009570
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   0.0001829        54953.    300426059.    12.6571402     0.0023152     -0.009757
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  3.9920333    -60.000000 CY
   0.0002229        55582.    249341482.    12.1847833     0.0027162     -0.011996
  3.9934997    -60.000000 CY
   0.0002429        55798.    229701662.    11.9848749     0.0029113     -0.013121
  3.9996748    -60.000000 CY
   0.0002629        55942.    212774461.    11.8111635     0.0031054     -0.014247
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  3.9949300    60.0000000 CYT
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  3.9931069    60.0000000 CYT
   0.0003229        56241.    174165119.    11.4971081     0.0037126     -0.017600
  3.9953677    60.0000000 CYT
   0.0003429        56241.    164007251.    11.5204145     0.0039505     -0.018682
  3.9917208    60.0000000 CYT


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   Summary of Results for Nominal Moment Capacity for Section 1
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Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.
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Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max. Tens. Strain
1	12.100	55543.090	0.00300000	-0.01373068
2	26.300	55863.986	0.00300000	-0.01363577

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

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

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

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

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	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	12.100000	55543.	7.865000	36103.	860670288.
2	0.65	26.300000	55864.	17.095000	36312.	866089646.
1	0.75	12.100000	55543.	9.075000	41657.	834857281.
2	0.75	26.300000	55864.	19.725000	41898.	840233138.
1	0.90	12.100000	55543.	10.890000	49989.	574052587.
2	0.90	26.300000	55864.	23.670000	50278.	578154063.

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	2.0000	0.00	N.A.	No	0.00	642999.
2	14.0000	11.2051	Yes	No	642999.	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 = 16600.0 lbs
Applied moment at pile head = 7080000.0 in-lbs
Axial thrust load on pile head = 12100.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.3484	7080000.	16600.	-0.00255	0.00	4.27E+12	0.00	0.00	0.00
0.1700	0.3432	7113927.	16600.	-0.00255	0.00	4.27E+12	0.00	0.00	0.00
0.3400	0.3380	7147854.	16600.	-0.00254	0.00	4.27E+12	0.00	0.00	0.00
0.5100	0.3328	7181781.	16600.	-0.00254	0.00	4.27E+12	0.00	0.00	0.00
0.6800	0.3277	7215707.	16600.	-0.00254	0.00	4.27E+12			

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0.00       0.00       0.00
    0.8500     0.3225   7249634.     16600.   -0.00253       0.00   4.27E+12
0.00       0.00       0.00
    1.0200     0.3173   7283560.     16600.   -0.00253       0.00   4.27E+12
0.00       0.00       0.00
    1.1900     0.3122   7317487.     16600.   -0.00253       0.00   4.27E+12
0.00       0.00       0.00
    1.3600     0.3070   7351413.     16600.   -0.00252       0.00   4.27E+12
0.00       0.00       0.00
    1.5300     0.3019   7385339.     16600.   -0.00252       0.00   4.27E+12
0.00       0.00       0.00
    1.7000     0.2967   7419266.     16600.   -0.00252       0.00   4.27E+12
0.00       0.00       0.00
    1.8700     0.2916   7453192.     16600.   -0.00251       0.00   4.27E+12
0.00       0.00       0.00
    2.0400     0.2865   7487118.     16589.   -0.00251       0.00   4.27E+12
-10.863    77.3541       0.00
    2.2100     0.2814   7520998.     16519.   -0.00251       0.00   4.27E+12
-57.546   417.2343       0.00
    2.3800     0.2763   7554639.     16353.   -0.00250       0.00   4.27E+12
-104.985   775.2649       0.00
    2.5500     0.2712   7587844.     16090.   -0.00250       0.00   4.27E+12
-153.073      1152.       0.00
    2.7200     0.2661   7620411.     15728.   -0.00250       0.00   4.27E+12
-201.703      1547.       0.00
    2.8900     0.2610   7652138.     15267.   -0.00249       0.00   4.27E+12
-250.769      1960.       0.00
    3.0600     0.2559   7682822.     14705.   -0.00249       0.00   4.27E+12
-300.164      2393.       0.00
    3.2300     0.2508   7712256.     14042.   -0.00248       0.00   4.27E+12
-349.781      2845.       0.00
    3.4000     0.2458   7740235.     13278.   -0.00248       0.00   4.27E+12
-399.513      3316.       0.00
    3.5700     0.2407   7766551.     12412.   -0.00248       0.00   4.27E+12
-449.253      3808.       0.00
    3.7400     0.2357   7790998.     11445.   -0.00247       0.00   4.27E+12
-498.894      4319.       0.00
    3.9100     0.2306   7813368.     10377.   -0.00247       0.00   4.27E+12
-548.329      4851.       0.00
    4.0800     0.2256   7833456.      9208.   -0.00247       0.00   4.27E+12
-597.451      5403.       0.00
    4.2500     0.2206   7851058.      7939.   -0.00246       0.00   4.27E+12
-646.152      5977.       0.00
    4.4200     0.2155   7865970.      6572.   -0.00246       0.00   4.27E+12
-694.327      6572.       0.00
    4.5900     0.2105   7877993.      5107.   -0.00245       0.00   4.27E+12
-741.867      7189.       0.00
    4.7600     0.2055   7886929.      3546.   -0.00245       0.00   4.27E+12
-788.795      7830.       0.00
    4.9300     0.2005   7892582.      1887.   -0.00245       0.00   4.27E+12
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-837.158	8517.	0.00				
5.1000	0.1955	7894750.	130.8907	-0.00244	0.00	4.27E+12
-884.943	9232.	0.00				
5.2700	0.1906	7893236.	-1722.	-0.00244	0.00	4.27E+12
-932.060	9978.	0.00				
5.4400	0.1856	7887843.	-3671.	-0.00244	0.00	4.27E+12
-978.416	10755.	0.00				
5.6100	0.1806	7878378.	-5714.	-0.00243	0.00	4.27E+12
-1024.	11565.	0.00				
5.7800	0.1757	7864652.	-7848.	-0.00243	0.00	4.27E+12
-1068.	12408.	0.00				
5.9500	0.1707	7846479.	-10072.	-0.00242	0.00	4.27E+12
-1112.	13288.	0.00				
6.1200	0.1658	7823679.	-12384.	-0.00242	0.00	4.27E+12
-1154.	14206.	0.00				
6.2900	0.1608	7796074.	-14780.	-0.00242	0.00	4.27E+12
-1196.	15164.	0.00				
6.4600	0.1559	7763494.	-17260.	-0.00241	0.00	4.27E+12
-1235.	16164.	0.00				
6.6300	0.1510	7725772.	-19819.	-0.00241	0.00	4.27E+12
-1274.	17209.	0.00				
6.8000	0.1461	7682750.	-22455.	-0.00241	0.00	4.27E+12
-1311.	18303.	0.00				
6.9700	0.1412	7634273.	-25165.	-0.00240	0.00	4.27E+12
-1346.	19448.	0.00				
7.1400	0.1363	7580195.	-27945.	-0.00240	0.00	4.27E+12
-1379.	20649.	0.00				
7.3100	0.1314	7520376.	-30791.	-0.00239	0.00	4.27E+12
-1411.	21909.	0.00				
7.4800	0.1265	7454685.	-33700.	-0.00239	0.00	4.27E+12
-1441.	23234.	0.00				
7.6500	0.1216	7382997.	-36670.	-0.00239	0.00	4.27E+12
-1470.	24659.	0.00				
7.8200	0.1168	7305190.	-39697.	-0.00238	0.00	4.27E+12
-1498.	26169.	0.00				
7.9900	0.1119	7221149.	-42779.	-0.00238	0.00	4.27E+12
-1523.	27770.	0.00				
8.1600	0.1071	7130769.	-45911.	-0.00238	0.00	4.27E+12
-1547.	29472.	0.00				
8.3300	0.1022	7033951.	-49087.	-0.00237	0.00	4.27E+12
-1567.	31285.	0.00				
8.5000	0.09737	6930610.	-52303.	-0.00237	0.00	4.28E+12
-1586.	33223.	0.00				
8.6700	0.09254	6820670.	-55554.	-0.00237	0.00	4.28E+12
-1601.	35301.	0.00				
8.8400	0.08771	6704066.	-58834.	-0.00236	0.00	4.28E+12
-1614.	37539.	0.00				
9.0100	0.08289	6580744.	-62081.	-0.00236	0.00	4.28E+12
-1569.	38611.	0.00				
9.1800	0.07808	6450893.	-65225.	-0.00236	0.00	4.28E+12

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-1514.     39547.       0.00
    9.3500   0.07328   6314743.    -68252.   -0.00235       0.00   4.28E+12
-1454.     40484.       0.00
    9.5200   0.06848   6172540.    -71154.   -0.00235       0.00   4.28E+12
-1390.     41420.       0.00
    9.6900   0.06368   6024552.    -73920.   -0.00235       0.00   4.28E+12
-1322.     42357.       0.00
    9.8600   0.05889   5871061.    -76544.   -0.00235       0.00   4.28E+12
-1250.     43293.       0.00
   10.0300   0.05411   5712369.    -79015.   -0.00234       0.00   4.28E+12
-1173.     44229.       0.00
   10.2000   0.04933   5548795.    -81326.   -0.00234       0.00   4.28E+12
-1092.     45166.       0.00
   10.3700   0.04456   5380675.    -83467.   -0.00234       0.00   4.28E+12
-1007.     46102.       0.00
   10.5400   0.03979   5208365.    -85430.   -0.00234       0.00   4.28E+12
-917.555     47038.       0.00
   10.7100   0.03503   5032236.    -87206.   -0.00233       0.00   4.29E+12
-823.841     47975.       0.00
   10.8800   0.03027   4852678.    -88787.   -0.00233       0.00   4.29E+12
-725.873     48911.       0.00
   11.0500   0.02552   4670100.    -90164.   -0.00233       0.00   4.29E+12
-623.654     49847.       0.00
   11.2200   0.02078   4484926.    -91327.   -0.00233       0.00   4.29E+12
-517.185     50784.       0.00
   11.3900   0.01603   4297599.    -92269.   -0.00232       0.00   4.29E+12
-406.468     51720.       0.00
   11.5600   0.01129   4108581.    -92981.   -0.00232       0.00   4.29E+12
-291.505     52656.       0.00
   11.7300   0.00656   3918350.    -93454.   -0.00232       0.00   4.29E+12
-172.296     53593.       0.00
   11.9000   0.00183   3727402.    -93680.   -0.00232       0.00   4.29E+12
-48.842     54529.       0.00
   12.0700  -0.00290   3536251.    -93649.   -0.00232       0.00   4.29E+12
78.8576     55466.       0.00
   12.2400  -0.00762   3345427.    -93354.   -0.00231       0.00   4.29E+12
210.8018     56402.       0.00
   12.4100  -0.01235   3155481.    -92785.   -0.00231       0.00   4.29E+12
346.9917     57338.       0.00
   12.5800  -0.01706   2966979.    -91934.   -0.00231       0.00   4.30E+12
487.4280     58275.       0.00
   12.7500  -0.02178   2780505.    -90792.   -0.00231       0.00   4.30E+12
632.1119     59211.       0.00
   12.9200  -0.02649   2596662.    -89350.   -0.00231       0.00   4.30E+12
781.0446     60147.       0.00
   13.0900  -0.03120   2416070.    -87601.   -0.00231       0.00   4.30E+12
934.2280     61084.       0.00
   13.2600  -0.03591   2239365.    -85534.   -0.00231       0.00   4.30E+12
1092.     62020.       0.00
   13.4300  -0.04061   2067203.    -83143.   -0.00231       0.00   4.30E+12
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1253.     62956.       0.00
   13.6000   -0.04532   1900257.    -80416.   -0.00231       0.00   4.30E+12
1419.     63893.       0.00
   13.7700   -0.05002   1739218.    -77347.   -0.00230       0.00   4.30E+12
1590.     64829.       0.00
   13.9400   -0.05472   1584793.    -73927.   -0.00230       0.00   4.30E+12
1764.     65766.       0.00
   14.1100   -0.05942   1437709.    -71027.   -0.00230       0.00   4.30E+12
1079.     37057.       0.00
   14.2800   -0.06411   1295117.    -68721.   -0.00230       0.00   4.30E+12
1181.     37577.       0.00
   14.4500   -0.06881   1157440.    -66206.   -0.00230       0.00   4.30E+12
1285.     38097.       0.00
   14.6200   -0.07350   1025110.    -63476.   -0.00230       0.00   4.30E+12
1391.     38617.       0.00
   14.7900   -0.07820    898571.    -60527.   -0.00230       0.00   4.30E+12
1500.     39137.       0.00
   14.9600   -0.08289    778275.    -57353.   -0.00230       0.00   4.30E+12
1611.     39658.       0.00
   15.1300   -0.08758    664684.    -53950.   -0.00230       0.00   4.30E+12
1725.     40178.       0.00
   15.3000   -0.09227    558272.    -50313.   -0.00230       0.00   4.30E+12
1841.     40698.       0.00
   15.4700   -0.09696    459521.    -46437.   -0.00230       0.00   4.30E+12
1959.     41218.       0.00
   15.6400     -0.102    368922.    -42317.   -0.00230       0.00   4.30E+12
2080.     41738.       0.00
   15.8100     -0.106    286979.    -37949.   -0.00230       0.00   4.30E+12
2203.     42259.       0.00
   15.9800     -0.111    214203.    -33327.   -0.00230       0.00   4.30E+12
2328.     42779.       0.00
   16.1500     -0.116    151117.    -28447.   -0.00230       0.00   4.30E+12
2456.     43299.       0.00
   16.3200     -0.120     98253.    -23304.   -0.00230       0.00   4.30E+12
2586.     43819.       0.00
   16.4900     -0.125     56152.    -17892.   -0.00230       0.00   4.30E+12
2719.     44339.       0.00
   16.6600     -0.130     25367.    -12208.   -0.00230       0.00   4.30E+12
2854.     44860.       0.00
   16.8300     -0.134      6459.     -6245.   -0.00230       0.00   4.30E+12
2991.     45380.       0.00
   17.0000     -0.139       0.00       0.00   -0.00230       0.00   4.30E+12
3131.     22950.       0.00
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* 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 = 0.34842677 inches
Computed slope at pile head = -0.0025513 radians
Maximum bending moment = 7894750. inch-lbs
Maximum shear force = -93680. lbs
Depth of maximum bending moment = 5.10000000 feet below pile head
Depth of maximum shear force = 11.90000000 feet below pile head
Number of iterations = 14
Number of zero deflection points = 1
Pile deflection at ground = 0.28768239 inches

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

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

Shear force at pile head	=	16600.0 lbs
Applied moment at pile head	=	7080000.0 in-lbs
Axial thrust load on pile head	=	26300.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.3489	7080000.	16600.	-0.00255	0.00	4.27E+12	0.00	0.00	0.00
0.1700	0.3437	7114001.	16600.	-0.00255	0.00	4.27E+12	0.00	0.00	0.00
0.3400	0.3385	7148002.	16600.	-0.00255	0.00	4.27E+12	0.00	0.00	0.00
0.5100	0.3333	7182002.	16600.	-0.00254	0.00	4.27E+12	0.00	0.00	0.00
0.6800	0.3281	7216003.	16600.	-0.00254	0.00	4.27E+12	0.00	0.00	0.00
0.8500	0.3229	7250003.	16600.	-0.00254	0.00	4.27E+12	0.00	0.00	0.00
1.0200	0.3177	7284003.	16600.	-0.00253	0.00	4.27E+12	0.00	0.00	0.00
1.1900	0.3126	7318003.	16600.	-0.00253	0.00	4.27E+12			

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0.00       0.00       0.00
    1.3600     0.3074   7352002.     16600.   -0.00253       0.00   4.27E+12
0.00       0.00       0.00
    1.5300     0.3023   7386002.     16600.   -0.00252       0.00   4.27E+12
0.00       0.00       0.00
    1.7000     0.2971   7420001.     16600.   -0.00252       0.00   4.27E+12
0.00       0.00       0.00
    1.8700     0.2920   7454000.     16600.   -0.00252       0.00   4.27E+12
0.00       0.00       0.00
    2.0400     0.2868   7487999.     16589.   -0.00251       0.00   4.27E+12
-10.866    77.2810       0.00
    2.2100     0.2817   7521953.     16519.   -0.00251       0.00   4.27E+12
-57.565   416.8406       0.00
    2.3800     0.2766   7555666.     16353.   -0.00251       0.00   4.27E+12
-105.020   774.5336       0.00
    2.5500     0.2715   7588943.     16090.   -0.00250       0.00   4.27E+12
-153.124      1151.       0.00
    2.7200     0.2664   7621582.     15728.   -0.00250       0.00   4.27E+12
-201.772      1545.       0.00
    2.8900     0.2613   7653381.     15266.   -0.00249       0.00   4.27E+12
-250.855      1958.       0.00
    3.0600     0.2562   7684136.     14704.   -0.00249       0.00   4.27E+12
-300.267      2391.       0.00
    3.2300     0.2511   7713641.     14041.   -0.00249       0.00   4.27E+12
-349.902      2842.       0.00
    3.4000     0.2461   7741690.     13276.   -0.00248       0.00   4.27E+12
-399.652      3313.       0.00
    3.5700     0.2410   7768076.     12410.   -0.00248       0.00   4.27E+12
-449.411      3804.       0.00
    3.7400     0.2360   7792591.     11443.   -0.00248       0.00   4.27E+12
-499.070      4315.       0.00
    3.9100     0.2309   7815029.     10374.   -0.00247       0.00   4.27E+12
-548.525      4846.       0.00
    4.0800     0.2259   7835183.      9205.   -0.00247       0.00   4.27E+12
-597.666      5398.       0.00
    4.2500     0.2208   7852851.      7936.   -0.00246       0.00   4.27E+12
-646.387      5971.       0.00
    4.4200     0.2158   7867828.      6569.   -0.00246       0.00   4.27E+12
-694.581      6566.       0.00
    4.5900     0.2108   7879915.      5103.   -0.00246       0.00   4.27E+12
-742.141      7182.       0.00
    4.7600     0.2058   7888913.      3541.   -0.00245       0.00   4.27E+12
-789.089      7822.       0.00
    4.9300     0.2008   7894626.      1882.   -0.00245       0.00   4.27E+12
-837.471      8509.       0.00
    5.1000     0.1958   7896855.   124.9527   -0.00245       0.00   4.27E+12
-885.276      9224.       0.00
    5.2700     0.1908   7895399.     -1729.   -0.00244       0.00   4.27E+12
-932.412      9969.       0.00
    5.4400     0.1858   7890062.     -3679.   -0.00244       0.00   4.27E+12
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-978.788	10745.	0.00				
5.6100	0.1809	7880652.	-5722.	-0.00243	0.00	4.27E+12
-1024.	11554.	0.00				
5.7800	0.1759	7866979.	-7857.	-0.00243	0.00	4.27E+12
-1069.	12397.	0.00				
5.9500	0.1709	7848857.	-10082.	-0.00243	0.00	4.27E+12
-1112.	13276.	0.00				
6.1200	0.1660	7826106.	-12394.	-0.00242	0.00	4.27E+12
-1155.	14192.	0.00				
6.2900	0.1611	7798549.	-14792.	-0.00242	0.00	4.27E+12
-1196.	15149.	0.00				
6.4600	0.1561	7766014.	-17273.	-0.00242	0.00	4.27E+12
-1236.	16148.	0.00				
6.6300	0.1512	7728336.	-19833.	-0.00241	0.00	4.27E+12
-1274.	17193.	0.00				
6.8000	0.1463	7685354.	-22470.	-0.00241	0.00	4.27E+12
-1311.	18285.	0.00				
6.9700	0.1414	7636916.	-25181.	-0.00240	0.00	4.27E+12
-1346.	19429.	0.00				
7.1400	0.1365	7582874.	-27962.	-0.00240	0.00	4.27E+12
-1380.	20629.	0.00				
7.3100	0.1316	7523090.	-30809.	-0.00240	0.00	4.27E+12
-1412.	21888.	0.00				
7.4800	0.1267	7457430.	-33720.	-0.00239	0.00	4.27E+12
-1441.	23211.	0.00				
7.6500	0.1218	7385771.	-36690.	-0.00239	0.00	4.27E+12
-1471.	24635.	0.00				
7.8200	0.1169	7307990.	-39719.	-0.00239	0.00	4.27E+12
-1499.	26144.	0.00				
7.9900	0.1121	7223973.	-42802.	-0.00238	0.00	4.27E+12
-1524.	27743.	0.00				
8.1600	0.1072	7133614.	-45935.	-0.00238	0.00	4.27E+12
-1547.	29443.	0.00				
8.3300	0.1024	7036814.	-49113.	-0.00238	0.00	4.27E+12
-1568.	31254.	0.00				
8.5000	0.09751	6933489.	-52330.	-0.00237	0.00	4.27E+12
-1586.	33190.	0.00				
8.6700	0.09267	6823561.	-55583.	-0.00237	0.00	4.28E+12
-1602.	35266.	0.00				
8.8400	0.08784	6706966.	-58864.	-0.00237	0.00	4.28E+12
-1615.	37501.	0.00				
9.0100	0.08302	6583651.	-62114.	-0.00236	0.00	4.28E+12
-1571.	38611.	0.00				
9.1800	0.07820	6453796.	-65263.	-0.00236	0.00	4.28E+12
-1516.	39547.	0.00				
9.3500	0.07339	6317633.	-68294.	-0.00236	0.00	4.28E+12
-1456.	40484.	0.00				
9.5200	0.06858	6175409.	-71200.	-0.00235	0.00	4.28E+12
-1392.	41420.	0.00				
9.6900	0.06378	6027390.	-73971.	-0.00235	0.00	4.28E+12

-1324.	42357.	0.00				
9.8600	0.05898	5873859.	-76598.	-0.00235	0.00	4.28E+12
-1252.	43293.	0.00				
10.0300	0.05420	5715120.	-79074.	-0.00235	0.00	4.28E+12
-1175.	44229.	0.00				
10.2000	0.04941	5551490.	-81388.	-0.00234	0.00	4.28E+12
-1094.	45166.	0.00				
10.3700	0.04463	5383307.	-83533.	-0.00234	0.00	4.28E+12
-1009.	46102.	0.00				
10.5400	0.03986	5210927.	-85499.	-0.00234	0.00	4.28E+12
-919.137	47038.	0.00				
10.7100	0.03509	5034721.	-87279.	-0.00234	0.00	4.28E+12
-825.317	47975.	0.00				
10.8800	0.03033	4855081.	-88862.	-0.00233	0.00	4.29E+12
-727.237	48911.	0.00				
11.0500	0.02557	4672414.	-90241.	-0.00233	0.00	4.29E+12
-624.901	49847.	0.00				
11.2200	0.02082	4487146.	-91408.	-0.00233	0.00	4.29E+12
-518.309	50784.	0.00				
11.3900	0.01607	4299721.	-92352.	-0.00233	0.00	4.29E+12
-407.465	51720.	0.00				
11.5600	0.01133	4110600.	-93066.	-0.00232	0.00	4.29E+12
-292.369	52656.	0.00				
11.7300	0.00659	3920263.	-93540.	-0.00232	0.00	4.29E+12
-173.021	53593.	0.00				
11.9000	0.00185	3729205.	-93767.	-0.00232	0.00	4.29E+12
-49.424	54529.	0.00				
12.0700	-0.00288	3537941.	-93738.	-0.00232	0.00	4.29E+12
78.4244	55466.	0.00				
12.2400	-0.00761	3347004.	-93443.	-0.00232	0.00	4.29E+12
210.5228	56402.	0.00				
12.4100	-0.01234	3156943.	-92874.	-0.00232	0.00	4.29E+12
346.8722	57338.	0.00				
12.5800	-0.01706	2968325.	-92023.	-0.00231	0.00	4.30E+12
487.4734	58275.	0.00				
12.7500	-0.02179	2781736.	-90881.	-0.00231	0.00	4.30E+12
632.3275	59211.	0.00				
12.9200	-0.02650	2597779.	-89439.	-0.00231	0.00	4.30E+12
781.4357	60147.	0.00				
13.0900	-0.03122	2417073.	-87689.	-0.00231	0.00	4.30E+12
934.7999	61084.	0.00				
13.2600	-0.03593	2240257.	-85621.	-0.00231	0.00	4.30E+12
1092.	62020.	0.00				
13.4300	-0.04064	2067988.	-83227.	-0.00231	0.00	4.30E+12
1254.	62956.	0.00				
13.6000	-0.04535	1900938.	-80499.	-0.00231	0.00	4.30E+12
1420.	63893.	0.00				
13.7700	-0.05006	1739800.	-77427.	-0.00231	0.00	4.30E+12
1591.	64829.	0.00				
13.9400	-0.05477	1585282.	-74004.	-0.00231	0.00	4.30E+12

```
1766.     65766.       0.00
   14.1100   -0.05947   1438112.    -71101.   -0.00231       0.00   4.30E+12
1080.     37057.       0.00
   14.2800   -0.06417   1295437.    -68794.   -0.00230       0.00   4.30E+12
1182.     37577.       0.00
   14.4500   -0.06887   1157682.    -66276.   -0.00230       0.00   4.30E+12
1286.     38097.       0.00
   14.6200   -0.07357   1025279.    -63543.   -0.00230       0.00   4.30E+12
1393.     38617.       0.00
   14.7900   -0.07827    898672.    -60591.   -0.00230       0.00   4.30E+12
1502.     39137.       0.00
   14.9600   -0.08297    778314.    -57414.   -0.00230       0.00   4.30E+12
1613.     39658.       0.00
   15.1300   -0.08767    664669.    -54008.   -0.00230       0.00   4.30E+12
1727.     40178.       0.00
   15.3000   -0.09237    558210.    -50367.   -0.00230       0.00   4.30E+12
1843.     40698.       0.00
   15.4700   -0.09706    459419.    -46487.   -0.00230       0.00   4.30E+12
1961.     41218.       0.00
   15.6400     -0.102    368790.    -42363.   -0.00230       0.00   4.30E+12
2082.     41738.       0.00
   15.8100     -0.106    286825.    -37990.   -0.00230       0.00   4.30E+12
2205.     42259.       0.00
   15.9800     -0.111    214037.    -33363.   -0.00230       0.00   4.30E+12
2331.     42779.       0.00
   16.1500     -0.116    150949.    -28478.   -0.00230       0.00   4.30E+12
2459.     43299.       0.00
   16.3200     -0.121     98094.    -23329.   -0.00230       0.00   4.30E+12
2589.     43819.       0.00
   16.4900     -0.125     56014.    -17912.   -0.00230       0.00   4.30E+12
2722.     44339.       0.00
   16.6600     -0.130     25261.    -12221.   -0.00230       0.00   4.30E+12
2857.     44860.       0.00
   16.8300     -0.135      6399.     -6252.   -0.00230       0.00   4.30E+12
2995.     45380.       0.00
   17.0000     -0.139       0.00       0.00   -0.00230       0.00   4.30E+12
3135.     22950.       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. 2:

```
Pile-head deflection              =     0.34886372 inches
Computed slope at pile head       =     -0.0025542 radians
```

Maximum bending moment = 7896855. inch-lbs
Maximum shear force = -93767. lbs
Depth of maximum bending moment = 5.10000000 feet below pile head
Depth of maximum shear force = 11.90000000 feet below pile head
Number of iterations = 14
Number of zero deflection points = 1
Pile deflection at ground = 0.28804893 inches

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

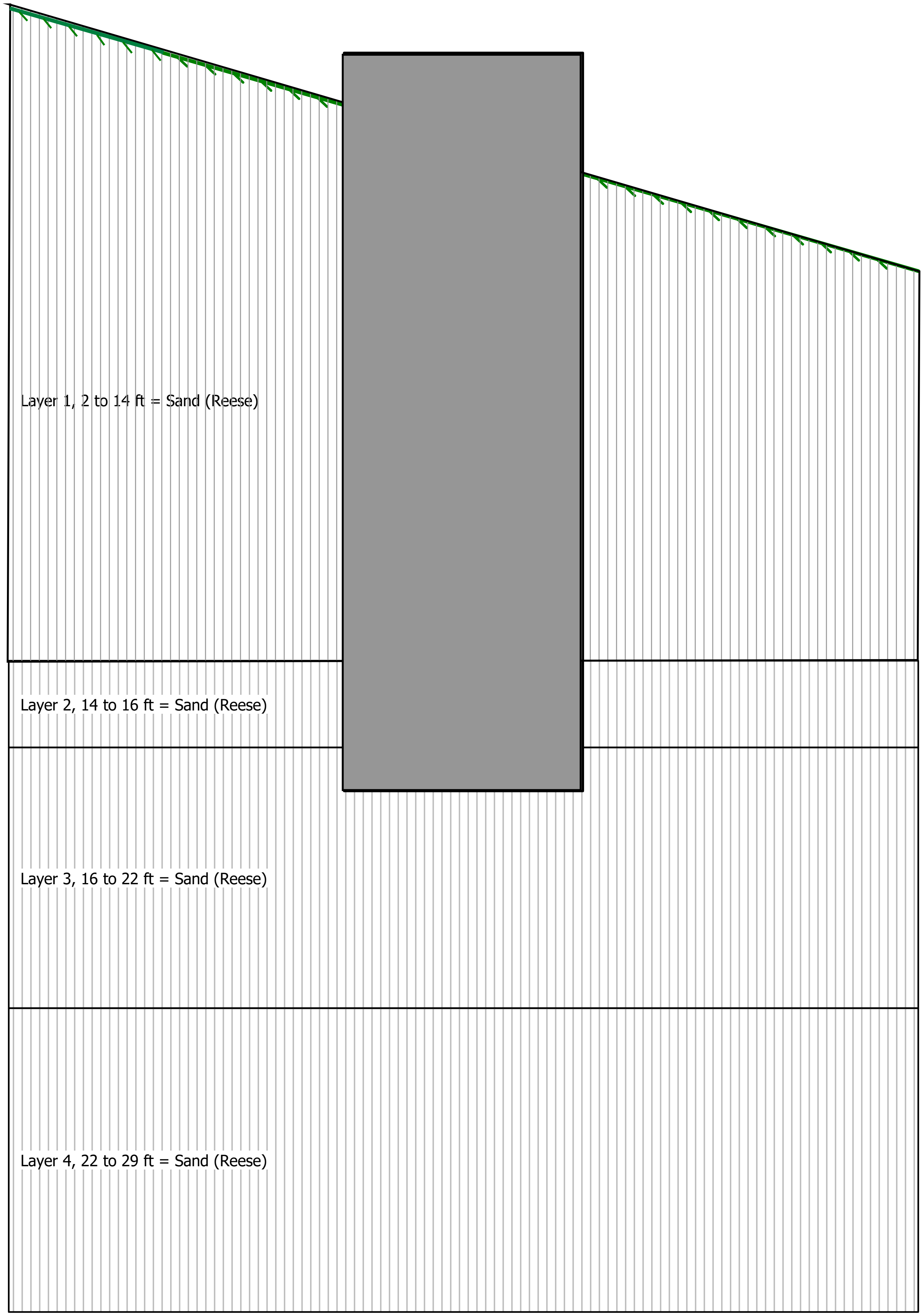
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load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

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	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	16600.	M, in-lb	7080000.	12100.	0.3484	-0.00255	-93680.	7894750.
2	V, lb	16600.	M, in-lb	7080000.	26300.	0.3489	-0.00255	-93767.	7896855.

Maximum pile-head deflection = 0.3488637194 inches
Maximum pile-head rotation = -0.0025542291 radians = -0.146347 deg.

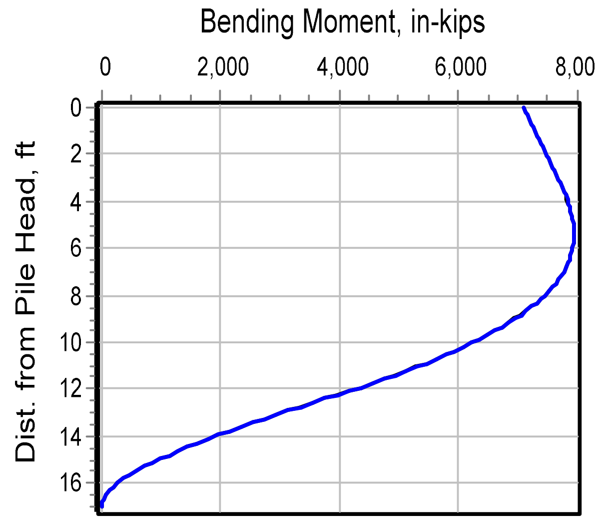
The analysis ended normally.

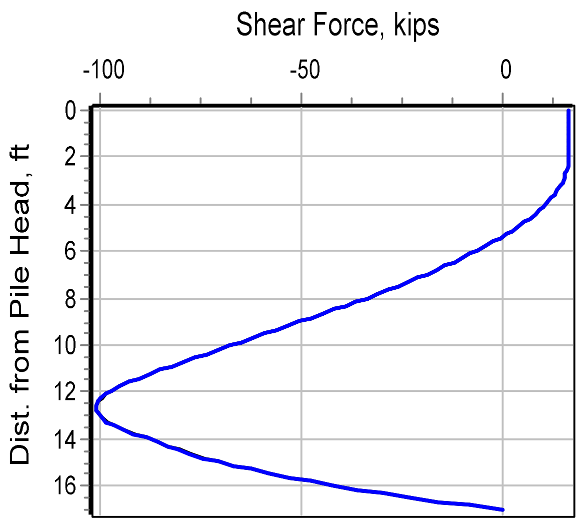
LOCATION 2 - S611.30

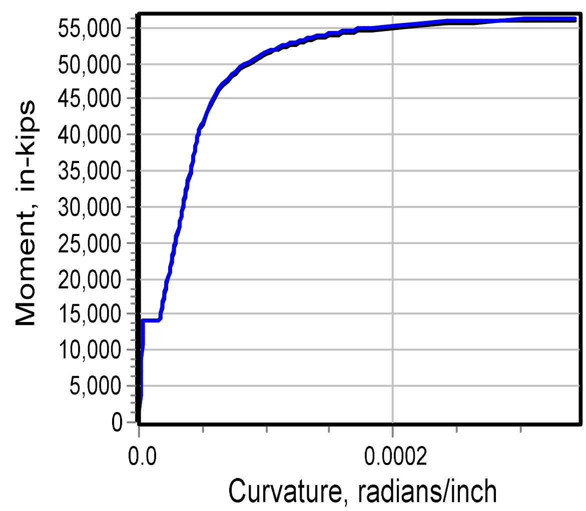


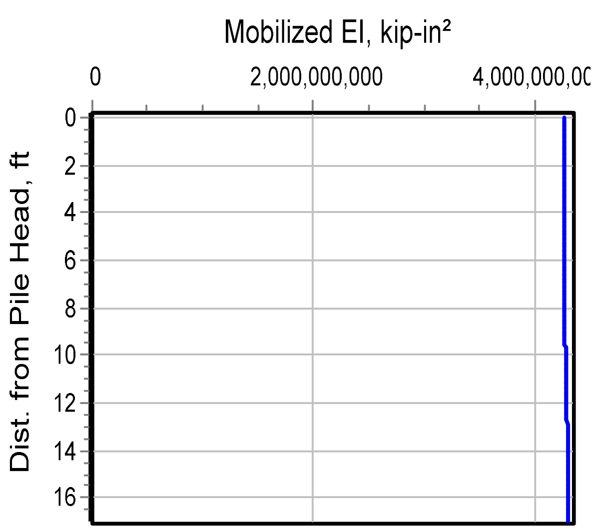
LPile 2022.12.11, © 2022 by Ensoft, Inc.

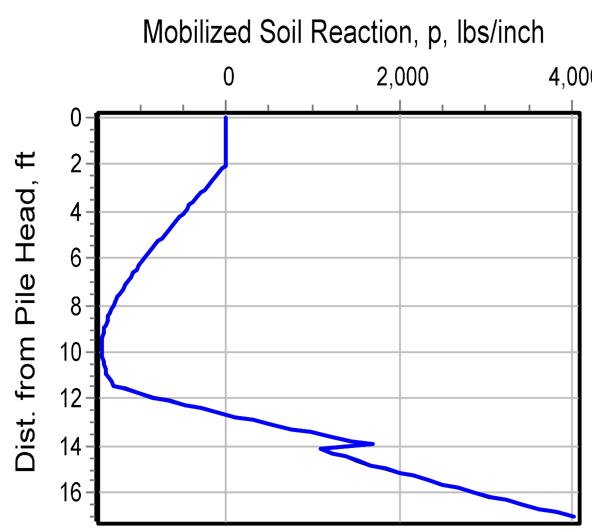

Deflection, inches
0
0.2
0.4
Dist. from Pile Head, ft
0
2
4
6
8
10
12
14
16


Bending Moment, in-kips
0
2,000
4,000
6,000
8,00
Dist. from Pile Head, ft
0
2
4
6
8
10
12
14
16


Shear Force, kips
-100
-50
0
Dist. from Pile Head, ft
0
2
4
6
8
10
12
14
16


Moment, in-kips
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0.0
0.0002
Curvature, radians/inch


Mobilized EI, kip-in²
0
2,000,000,000
4,000,000,0(
Dist. from Pile Head, ft
0
2
4
6
8
10
12
14
16


Mobilized Soil Reaction, p, lbs/inch
0
2,000
4,00(
Dist. from Pile Head, ft
0
2
4
6
8
10
12
14
16

==

LPile for Windows, Version 2022-12.011

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

==

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KC Engineering and Land Surveyin, New York, NY, USA

Files Used for Analysis

Path to file locations:
\120186 - D214892, Assignment #1, H371.1, I-95 Pavement
Resurfacing\70_Design_Documents\Geotechnical\Geotechnical_Design\LPILE_Model\

Name of input data file:
I-95 Cantilever Sign Structure (Location 2).lp12d

Name of output report file:
I-95 Cantilever Sign Structure (Location 2).lp12o

Name of plot output file:
I-95 Cantilever Sign Structure (Location 2).lp12p

Name of runtime message file:
I-95 Cantilever Sign Structure (Location 2).lp12r

Date and Time of Analysis

Date: May 22, 2025   Time: 16:09:54

Problem Title

Project Name: I-95 Pavement Resurfacing

Job Number: 120186 - D214892

Client: NYSTA

Engineer: Kamal R./ Rohan G.

Description: Cantilever Sign Structures (Location 2)

Program Options and Settings

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:

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

Loading Type and Number of Cycles of Loading:

- Static loading specified

- Use of p-y modification factors for p-y curves not selected
- Analysis uses layering correction (Method of Georgiadis)
- Analysis includes loading by one distributed lateral load acting on pile
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

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

Pile Structural Properties and Geometry

Number of pile sections defined	=	1
Total length of pile	=	17.000 ft
Depth of ground surface below top of pile	=	2.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	66.0000
2	17.000	66.0000

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                                          =    17.000000 ft
   Shaft Diameter                                             =    66.000000 in
```

Ground Slope and Pile Batter Angles

```
Ground Slope Angle                                            =       16.120 degrees
                                                              =        0.281 radians

Pile Batter Angle                                             =        0.000 degrees
                                                              =        0.000 radians
```

Soil and Rock Layering Information

The soil profile is modelled using 4 layers

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

```
   Distance from top of pile to top of layer                  =     2.000000 ft
   Distance from top of pile to bottom of layer               =    14.000000 ft
   Effective unit weight at top of layer                      =   135.000000 pcf
   Effective unit weight at bottom of layer                   =   135.000000 pcf
   Friction angle at top of layer                             =    36.000000 deg.
   Friction angle at bottom of layer                          =    36.000000 deg.
   Subgrade k at top of layer                                 =   225.000000 pci
   Subgrade k at bottom of layer                              =   225.000000 pci
```

Layer 2 is sand, p-y criteria by Reese et al., 1974

```
   Distance from top of pile to top of layer                  =    14.000000 ft
   Distance from top of pile to bottom of layer               =    16.000000 ft
   Effective unit weight at top of layer                      =    67.600000 pcf
   Effective unit weight at bottom of layer                   =    67.600000 pcf
   Friction angle at top of layer                             =    34.000000 deg.
   Friction angle at bottom of layer                          =    34.000000 deg.
   Subgrade k at top of layer                                 =   125.000000 pci
   Subgrade k at bottom of layer                              =   125.000000 pci
```

Layer 3 is sand, p-y criteria by Reese et al., 1974

```
   Distance from top of pile to top of layer                  =    16.000000 ft
```

Distance from top of pile to bottom of layer = 22.000000 ft
Effective unit weight at top of layer = 72.600000 pcf
Effective unit weight at bottom of layer = 72.600000 pcf
Friction angle at top of layer = 36.000000 deg.
Friction angle at bottom of layer = 36.000000 deg.
Subgrade k at top of layer = 125.000000 pci
Subgrade k at bottom of layer = 125.000000 pci

Layer 4 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 22.000000 ft
Distance from top of pile to bottom of layer = 29.000000 ft
Effective unit weight at top of layer = 67.600000 pcf
Effective unit weight at bottom of layer = 67.600000 pcf
Friction angle at top of layer = 34.000000 deg.
Friction angle at bottom of layer = 34.000000 deg.
Subgrade k at top of layer = 125.000000 pci
Subgrade k at bottom of layer = 125.000000 pci

(Depth of the lowest soil layer extends 12.000 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	Angle of Friction deg.	kpy pci
1	Sand	2.0000	135.0000	36.0000	225.0000
	(Reese, et al.)	14.0000	135.0000	36.0000	225.0000
2	Sand	14.0000	67.6000	34.0000	125.0000
	(Reese, et al.)	16.0000	67.6000	34.0000	125.0000
3	Sand	16.0000	72.6000	36.0000	125.0000
	(Reese, et al.)	22.0000	72.6000	36.0000	125.0000
4	Sand	22.0000	67.6000	34.0000	125.0000
	(Reese, et al.)	29.0000	67.6000	34.0000	125.0000

Static Loading Type

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

Distributed Lateral Loading Used For All Load Cases

Distributed lateral load intensity defined using 1 points

Point No.	Depth X ft	Dist. Load lb/in
1	0.000	0.000

Concentrated Loads Applied to All Load Cases

Concentrated loads along depth defined using 1 points

Point No.	Depth X ft	Shear Force lbs	Moment in-lbs
1	0.00000	0.00000	0.00000

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 2

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 16600. lbs	M = 7080000. in-lbs	12100.	No	Yes
2	1	V = 16600. lbs	M = 7080000. in-lbs	26300.	No	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	=	17.000000 ft
Shaft Diameter	=	66.000000 in
Concrete Cover Thickness (to edge of long. rebar)	=	3.000000 in
Number of Reinforcing Bars	=	44 bars
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	3421. sq. in.
Total Area of Reinforcing Steel	=	34.760000 sq. in.
Area Ratio of Steel Reinforcement	=	1.02 percent
Edge-to-Edge Bar Spacing	=	3.137673 in
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	4.18
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	=	13599.477 kips
Tensile Load for Cracking of Concrete	=	-1524.748 kips
Nominal Axial Tensile Capacity	=	-2085.600 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	1.000000	0.790000	29.000000	0.00000
2	1.000000	0.790000	28.704822	4.127130

3	1.000000	0.790000	27.825296	8.170244
4	1.000000	0.790000	26.379328	12.047035
5	1.000000	0.790000	24.396352	15.678584
6	1.000000	0.790000	21.916738	18.990961
7	1.000000	0.790000	18.990961	21.916738
8	1.000000	0.790000	15.678584	24.396352
9	1.000000	0.790000	12.047035	26.379328
10	1.000000	0.790000	8.170244	27.825296
11	1.000000	0.790000	4.127130	28.704822
12	1.000000	0.790000	0.00000	29.000000
13	1.000000	0.790000	-4.12713	28.704822
14	1.000000	0.790000	-8.17024	27.825296
15	1.000000	0.790000	-12.04704	26.379328
16	1.000000	0.790000	-15.67858	24.396352
17	1.000000	0.790000	-18.99096	21.916738
18	1.000000	0.790000	-21.91674	18.990961
19	1.000000	0.790000	-24.39635	15.678584
20	1.000000	0.790000	-26.37933	12.047035
21	1.000000	0.790000	-27.82530	8.170244
22	1.000000	0.790000	-28.70482	4.127130
23	1.000000	0.790000	-29.00000	0.00000
24	1.000000	0.790000	-28.70482	-4.12713
25	1.000000	0.790000	-27.82530	-8.17024
26	1.000000	0.790000	-26.37933	-12.04704
27	1.000000	0.790000	-24.39635	-15.67858
28	1.000000	0.790000	-21.91674	-18.99096
29	1.000000	0.790000	-18.99096	-21.91674
30	1.000000	0.790000	-15.67858	-24.39635
31	1.000000	0.790000	-12.04704	-26.37933
32	1.000000	0.790000	-8.17024	-27.82530
33	1.000000	0.790000	-4.12713	-28.70482
34	1.000000	0.790000	0.00000	-29.00000
35	1.000000	0.790000	4.127130	-28.70482
36	1.000000	0.790000	8.170244	-27.82530
37	1.000000	0.790000	12.047035	-26.37933
38	1.000000	0.790000	15.678584	-24.39635
39	1.000000	0.790000	18.990961	-21.91674
40	1.000000	0.790000	21.916738	-18.99096
41	1.000000	0.790000	24.396352	-15.67858
42	1.000000	0.790000	26.379328	-12.04704
43	1.000000	0.790000	27.825296	-8.17024
44	1.000000	0.790000	28.704822	-4.12713

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

Minimum spacing between any two bars not equal to zero = 3.138 inches
between bars 15 and 16.

Ratio of bar spacing to maximum aggregate size = 4.18

Concrete Properties:

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

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 2

Number	Axial Thrust Force kips
1	12.100
2	26.300

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

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

Axial Thrust Force = 12.100 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
4.16667E-07	1793.	4302995505.	34.8948795	0.00001454	-0.00001296			

0.0608483	0.3777840				
8.33333E-07	3578.	4293425448.	33.9502217	0.00002829	-0.00002671
0.1179418	0.7327387				
0.00000125	5355.	4283828357.	33.6353475	0.00004204	-0.00004046
0.1746186	1.0876938				
0.00000167	7124.	4274224500.	33.4779188	0.00005580	-0.00005420
0.2308787	1.4426494				
0.00000208	8885.	4264617935.	33.3834683	0.00006955	-0.00006795
0.2867221	1.7976054				
0.00000250	10638.	4255010017.	33.3205069	0.00008330	-0.00008170
0.3421487	2.1525618				
0.00000292	12382.	4245401325.	33.2755393	0.00009705	-0.00009545
0.3971586	2.5075185				
0.00000333	14119.	4235792149.	33.2418179	0.0001108	-0.000109
0.4517518	2.8624757				
0.00000375	14119.	3765148577.	16.8216796	0.00006308	-0.000184
0.2579905	-4.953380 C				
0.00000417	14119.	3388633719.	16.7414633	0.00006976	-0.000205
0.2847592	-5.513448 C				
0.00000458	14119.	3080576108.	16.6767000	0.00007643	-0.000226
0.3114480	-6.073401 C				
0.00000500	14119.	2823861433.	16.6235291	0.00008312	-0.000247
0.3380569	-6.633238 C				
0.00000542	14119.	2606641323.	16.5792775	0.00008980	-0.000268
0.3645856	-7.192959 C				
0.00000583	14119.	2420452657.	16.5420362	0.00009650	-0.000289
0.3910341	-7.752564 C				
0.00000625	14119.	2259089146.	16.5104051	0.0001032	-0.000309
0.4174021	-8.312052 C				
0.00000667	14119.	2117896075.	16.4833341	0.0001099	-0.000330
0.4436897	-8.871422 C				
0.00000708	14119.	1993313953.	16.4600204	0.0001166	-0.000351
0.4698966	-9.430675 C				
0.00000750	14119.	1882574288.	16.4398394	0.0001233	-0.000372
0.4960227	-9.989810 C				
0.00000792	14119.	1783491431.	16.4222982	0.0001300	-0.000392
0.5220679	-10.548827 C				
0.00000833	14119.	1694316860.	16.4070022	0.0001367	-0.000413
0.5480321	-11.107725 C				
0.00000875	14119.	1613635104.	16.3934802	0.0001434	-0.000434
0.5739152	-11.666503 C				
0.00000917	14119.	1540288054.	16.3817664	0.0001502	-0.000455
0.5997169	-12.225163 C				
0.00000958	14119.	1473319008.	16.3715017	0.0001569	-0.000476
0.6254372	-12.783702 C				
0.00001000	14119.	1411930716.	16.3625063	0.0001636	-0.000496
0.6510760	-13.342122 C				
0.00001042	14119.	1355453488.	16.3546292	0.0001704	-0.000517
0.6766331	-13.900420 C				
0.00001083	14119.	1303320661.	16.3477426	0.0001771	-0.000538

0.7021083 -14.458598 C
0.00001125 14119. 1255049526. 16.3417376 0.0001838 -0.000559
0.7275016 -15.016655 C
0.00001167 14119. 1210226328. 16.3365209 0.0001906 -0.000579
0.7528128 -15.574589 C
0.00001208 14119. 1168494386. 16.3320122 0.0001973 -0.000600
0.7780417 -16.132402 C
0.00001250 14119. 1129544573. 16.3281417 0.0002041 -0.000621
0.8031883 -16.690091 C
0.00001292 14119. 1093107651. 16.3248487 0.0002109 -0.000642
0.8282524 -17.247658 C
0.00001333 14119. 1058948037. 16.3220802 0.0002176 -0.000662
0.8532338 -17.805102 C
0.00001375 14119. 1026858703. 16.3197895 0.0002244 -0.000683
0.8781325 -18.362422 C
0.00001417 14119. 996656976. 16.3179354 0.0002312 -0.000704
0.9029482 -18.919617 C
0.00001458 14119. 968181063. 16.3164814 0.0002379 -0.000725
0.9276809 -19.476689 C
0.00001500 14119. 941287144. 16.3153952 0.0002447 -0.000745
0.9523304 -20.033635 C
0.00001542 14119. 915846951. 16.3146479 0.0002515 -0.000766
0.9768965 -20.590455 C
0.00001583 14119. 891745716. 16.3142136 0.0002583 -0.000787
1.0013792 -21.147150 C
0.00001625 14328. 881721714. 16.3140692 0.0002651 -0.000807
1.0257782 -21.703719 C
0.00001708 15045. 880696329. 16.3145684 0.0002787 -0.000849
1.0743249 -22.816476 C
0.00001792 15762. 879727102. 16.3160018 0.0002923 -0.000890
1.1225354 -23.928723 C
0.00001875 16478. 878806326. 16.3182511 0.0003060 -0.000932
1.1704084 -25.040456 C
0.00001958 17193. 877927608. 16.3212183 0.0003196 -0.000973
1.2179430 -26.151673 C
0.00002042 17907. 877085592. 16.3248215 0.0003333 -0.001014
1.2651378 -27.262369 C
0.00002125 18621. 876275763. 16.3289916 0.0003470 -0.001056
1.3119917 -28.372541 C
0.00002208 19334. 875494284. 16.3336701 0.0003607 -0.001097
1.3585035 -29.482185 C
0.00002292 20046. 874737875. 16.3388071 0.0003744 -0.001138
1.4046720 -30.591299 C
0.00002375 20758. 874003713. 16.3443597 0.0003882 -0.001179
1.4504959 -31.699877 C
0.00002458 21468. 873289356. 16.3502909 0.0004019 -0.001221
1.4959739 -32.807916 C
0.00002542 22178. 872592681. 16.3565686 0.0004157 -0.001262
1.5411049 -33.915413 C
0.00002625 22888. 871911832. 16.3631648 0.0004295 -0.001303

1.5858876	-35.022364 C				
0.00002708	23596.	871245179.	16.3700551	0.0004434	-0.001344
1.6303206	-36.128764 C				
0.00002792	24304.	870591285.	16.3772181	0.0004572	-0.001385
1.6744027	-37.234611 C				
0.00002875	25011.	869948879.	16.3846348	0.0004711	-0.001426
1.7181326	-38.339899 C				
0.00002958	25717.	869316830.	16.3922885	0.0004849	-0.001468
1.7615090	-39.444624 C				
0.00003042	26423.	868694128.	16.4001644	0.0004988	-0.001509
1.8045305	-40.548784 C				
0.00003125	27127.	868079871.	16.4082492	0.0005128	-0.001550
1.8471957	-41.652373 C				
0.00003208	27831.	867473248.	16.4165312	0.0005267	-0.001591
1.8895034	-42.755387 C				
0.00003292	28535.	866873529.	16.4253117	0.0005407	-0.001632
1.9314521	-43.857822 C				
0.00003375	29237.	866280051.	16.4339651	0.0005546	-0.001673
1.9730404	-44.959674 C				
0.00003458	29939.	865692218.	16.4427874	0.0005686	-0.001714
2.0142670	-46.060938 C				
0.00003542	30639.	865109485.	16.4517708	0.0005827	-0.001755
2.0551304	-47.161611 C				
0.00003625	31339.	864531355.	16.4609086	0.0005967	-0.001796
2.0956291	-48.261686 C				
0.00003708	32038.	863957377.	16.4701946	0.0006108	-0.001837
2.1357618	-49.361161 C				
0.00003792	32737.	863387135.	16.4796232	0.0006249	-0.001878
2.1755269	-50.460029 C				
0.00003875	33434.	862820248.	16.4891893	0.0006390	-0.001919
2.2149229	-51.558287 C				
0.00003958	34131.	862256365.	16.4988885	0.0006531	-0.001959
2.2539484	-52.655930 C				
0.00004042	34827.	861695163.	16.5087166	0.0006672	-0.002000
2.2926019	-53.752953 C				
0.00004125	35522.	861136342.	16.5186697	0.0006814	-0.002041
2.3308817	-54.849351 C				
0.00004208	36216.	860579625.	16.5287447	0.0006956	-0.002082
2.3687864	-55.945119 C				
0.00004292	36909.	860024755.	16.5389384	0.0007098	-0.002123
2.4063143	-57.040252 C				
0.00004375	37602.	859471491.	16.5492479	0.0007240	-0.002163
2.4434639	-58.134745 C				
0.00004458	38293.	858919610.	16.5596709	0.0007383	-0.002204
2.4802335	-59.228592 C				
0.00004542	38977.	858198183.	16.5690719	0.0007525	-0.002245
2.5164891	-60.000000 CY				
0.00004625	39600.	856212807.	16.5700715	0.0007664	-0.002286
2.5513584	-60.000000 CY				
0.00004708	40142.	852568511.	16.5597887	0.0007797	-0.002328

2.5844812	-60.000000	CY			
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2.6165328	-60.000000	CY			
0.00004875	41094.	842957561.	16.5233073	0.0008055	-0.002412
2.6474789	-60.000000	CY			
0.00004958	41514.	837260777.	16.4977715	0.0008180	-0.002454
2.6775319	-60.000000	CY			
0.00005292	42992.	812446560.	16.3806487	0.0008668	-0.002626
2.7912471	-60.000000	CY			
0.00005625	44188.	785568707.	16.2421578	0.0009136	-0.002799
2.8954834	-60.000000	CY			
0.00005958	45194.	758507594.	16.0924132	0.0009588	-0.002974
2.9915884	-60.000000	CY			
0.00006292	46083.	732446974.	15.9410975	0.0010030	-0.003150
3.0811207	-60.000000	CY			
0.00006625	46806.	706512984.	15.7820455	0.0010456	-0.003327
3.1636392	-60.000000	CY			
0.00006958	47503.	682681993.	15.6384620	0.0010882	-0.003504
3.2421483	-60.000000	CY			
0.00007292	48071.	659263424.	15.4889970	0.0011294	-0.003683
3.3143963	-60.000000	CY			
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3.3815850	-60.000000	CY			
0.00007958	49108.	617060588.	15.2062146	0.0012102	-0.004042
3.4453916	-60.000000	CY			
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0.00008958	50272.	561178509.	14.8127939	0.0013270	-0.004586
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3.7782920	-60.000000	CY			
0.0001063	51701.	486600760.	14.2437212	0.0015134	-0.005499
3.8129144	-60.000000	CY			
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3.8715740	-60.000000	CY			
0.0001163	52324.	450099332.	13.9413560	0.0016207	-0.006052
3.8961377	-60.000000	CY			
0.0001196	52501.	439036674.	13.8476440	0.0016559	-0.006237
3.9181741	-60.000000	CY			
0.0001229	52677.	428560987.	13.7575833	0.0016910	-0.006421

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3.9376548    -60.000000 CY
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3.9545508    -60.000000 CY
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3.9688320    -60.000000 CY
 0.0001329        53186.   400141950.    13.5274871     0.0017980     -0.006974
3.9803804    -60.000000 CY
 0.0001363        53329.   391402305.    13.4491317     0.0018324     -0.007160
3.9890306    -60.000000 CY
 0.0001396        53440.   382850385.    13.3683771     0.0018660     -0.007346
3.9950542    -60.000000 CY
 0.0001429        53549.   374688195.    13.2917455     0.0018996     -0.007533
3.9987193    -60.000000 CY
 0.0001462        53658.   366889051.    13.2203454     0.0019335     -0.007719
3.9999988    -60.000000 CY
 0.0001496        53764.   359425239.    13.1517324     0.0019673     -0.007905
3.9949673    -60.000000 CY
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3.9985335    -60.000000 CY
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3.9929061    -60.000000 CY
 0.0001629        54176.   332538997.    12.9186660     0.0021047     -0.008648
3.9971423    -60.000000 CY
 0.0001662        54273.   326456868.    12.8671461     0.0021392     -0.008833
3.9994842    -60.000000 CY
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3.9979067    -60.000000 CY
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3.9929324    -60.000000 CY
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3.9966765    -60.000000 CY
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3.9990309    -60.000000 CY
 0.0001829        54624.   298629566.    12.5983912     0.0023045     -0.009768
3.9999792    -60.000000 CY
 0.0002029        54953.   270817526.    12.3366422     0.0025033     -0.010889
3.9954925    -60.000000 CY
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3.9975518    -60.000000 CY
 0.0002429        55466.   228331852.    11.9287643     0.0028977     -0.013135
3.9989436    -60.000000 CY
 0.0002629        55612.   211519850.    11.7570130     0.0030911     -0.014261
3.9895378    60.0000000 CYT
 0.0002829        55746.   197039785.    11.6203405     0.0032876     -0.015385
3.9997242    60.0000000 CYT
 0.0003029        55839.   184338966.    11.5229265     0.0034905     -0.016502
3.9898225    60.0000000 CYT
 0.0003229        55920.   173170857.    11.4353745     0.0036927     -0.017620
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						3.9999701	60.0000000	CYT
0.0003429	55920.	163070977.	11.4594909	0.0039297	-0.018703	3.9871990	60.0000000	CYT

Axial Thrust Force =   26.300 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
4.16667E-07	1793.	4302698182.	37.1186068	0.00001547	-0.00001203	0.0647470	0.4046540	
8.33333E-07	3578.	4293275394.	35.0652869	0.00002922	-0.00002578	0.1218233	0.7596861	
0.00000125	5355.	4283727672.	34.3808805	0.00004298	-0.00003952	0.1784829	1.1147194	
0.00000167	7124.	4274148526.	34.0386968	0.00005673	-0.00005327	0.2347256	1.4697537	
0.00000208	8884.	4264556795.	33.8334016	0.00007049	-0.00006701	0.2905515	1.8247889	
0.00000250	10637.	4254958764.	33.6965502	0.00008424	-0.00008076	0.3459606	2.1798249	
0.00000292	12382.	4245357132.	33.5988096	0.00009800	-0.00009450	0.4009528	2.5348618	
0.00000333	14119.	4235753250.	33.5255134	0.0001118	-0.000108	0.4555282	2.8898996	
0.00000375	14119.	3765114000.	17.7768544	0.00006666	-0.000181	0.2726694	-4.849505	C
0.00000417	14119.	3388602600.	17.6107403	0.00007338	-0.000202	0.2995503	-5.408401	C
0.00000458	14119.	3080547818.	17.4752136	0.00008009	-0.000222	0.3263385	-5.967265	C
0.00000500	14119.	2823835500.	17.3589093	0.00008679	-0.000243	0.3529626	-6.526608	C
0.00000542	14119.	2606617385.	17.2612147	0.00009350	-0.000264	0.3795054	-7.085838	C
0.00000583	14119.	2420430429.	17.1781441	0.0001002	-0.000285	0.4059670	-7.644956	C
0.00000625	14119.	2259068400.	17.1067747	0.0001069	-0.000306	0.4323472	-8.203960	C
0.00000667	14119.	2117876625.	17.0447993	0.0001136	-0.000326	0.4586458	-8.762850	C
0.00000708	14119.	1993295647.	16.9907577	0.0001204	-0.000347	0.4848628	-9.321626	C
0.00000750	14119.	1882557000.	16.9432448	0.0001271	-0.000368			

0.5109979 -9.880288 C
0.00000792 14119. 1783475053. 16.9012312 0.0001338 -0.000389
0.5370512 -10.438836 C
0.00000833 14119. 1694301300. 16.8638935 0.0001405 -0.000409
0.5630224 -10.997268 C
0.00000875 14119. 1613620286. 16.8305650 0.0001473 -0.000430
0.5889114 -11.555585 C
0.00000917 14119. 1540273909. 16.7996469 0.0001540 -0.000451
0.6146735 -12.114119 C
0.00000958 14119. 1473305478. 16.7716544 0.0001607 -0.000472
0.6403529 -12.672540 C
0.00001000 14119. 1411917750. 16.7464106 0.0001675 -0.000493
0.6659507 -13.230841 C
0.00001042 14119. 1355441040. 16.7235870 0.0001742 -0.000513
0.6914666 -13.789021 C
0.00001083 14119. 1303308692. 16.7029057 0.0001809 -0.000534
0.7169007 -14.347079 C
0.00001125 14119. 1255038000. 16.6841296 0.0001877 -0.000555
0.7422527 -14.905015 C
0.00001167 14119. 1210215214. 16.6670560 0.0001944 -0.000576
0.7675225 -15.462829 C
0.00001208 14119. 1168483655. 16.6515097 0.0002012 -0.000596
0.7927099 -16.020521 C
0.00001250 14119. 1129534200. 16.6373392 0.0002080 -0.000617
0.8178149 -16.578090 C
0.00001292 14119. 1093097613. 16.6244124 0.0002147 -0.000638
0.8428373 -17.135535 C
0.00001333 14119. 1058938313. 16.6126137 0.0002215 -0.000658
0.8677769 -17.692856 C
0.00001375 14119. 1026849273. 16.6018416 0.0002283 -0.000679
0.8926337 -18.250053 C
0.00001417 14119. 996647824. 16.5920065 0.0002351 -0.000700
0.9174074 -18.807126 C
0.00001458 14119. 968172171. 16.5830291 0.0002418 -0.000721
0.9420980 -19.364073 C
0.00001500 14119. 941278500. 16.5748389 0.0002486 -0.000741
0.9667053 -19.920895 C
0.00001542 14119. 915838541. 16.5673729 0.0002554 -0.000762
0.9912291 -20.477591 C
0.00001583 14206. 897227397. 16.5605749 0.0002622 -0.000783
1.0156693 -21.034161 C
0.00001625 14565. 896297809. 16.5543944 0.0002690 -0.000803
1.0400259 -21.590604 C
0.00001708 15282. 894543874. 16.5437085 0.0002826 -0.000845
1.0884871 -22.703109 C
0.00001792 15998. 892913756. 16.5350020 0.0002963 -0.000886
1.1366117 -23.815101 C
0.00001875 16714. 891390727. 16.5280173 0.0003099 -0.000928
1.1843986 -24.926578 C
0.00001958 17428. 889960905. 16.5225408 0.0003236 -0.000969

1.2318464	-26.037537 C				
0.00002042	18143.	888612671.	16.5183938	0.0003373	-0.001010
1.2789541	-27.147972 C				
0.00002125	18856.	887336229.	16.5154256	0.0003510	-0.001052
1.3257203	-28.257882 C				
0.00002208	19569.	886123255.	16.5135086	0.0003647	-0.001093
1.3721440	-29.367262 C				
0.00002292	20280.	884966638.	16.5125335	0.0003784	-0.001134
1.4182239	-30.476108 C				
0.00002375	20992.	883860260.	16.5124067	0.0003922	-0.001175
1.4639588	-31.584418 C				
0.00002458	21702.	882798833.	16.5130472	0.0004059	-0.001217
1.5093473	-32.692186 C				
0.00002542	22412.	881777757.	16.5143847	0.0004197	-0.001258
1.5543883	-33.799410 C				
0.00002625	23121.	880793017.	16.5163578	0.0004336	-0.001299
1.5990805	-34.906086 C				
0.00002708	23829.	879841090.	16.5189130	0.0004474	-0.001340
1.6434225	-36.012209 C				
0.00002792	24536.	878918870.	16.5220030	0.0004612	-0.001381
1.6874132	-37.117775 C				
0.00002875	25243.	878023609.	16.5255861	0.0004751	-0.001422
1.7310511	-38.222781 C				
0.00002958	25949.	877152870.	16.5296254	0.0004890	-0.001463
1.7743349	-39.327222 C				
0.00003042	26654.	876304478.	16.5340881	0.0005029	-0.001505
1.8172634	-40.431095 C				
0.00003125	27359.	875476489.	16.5389449	0.0005168	-0.001546
1.8598350	-41.534394 C				
0.00003208	28062.	874667159.	16.5441698	0.0005308	-0.001587
1.9020486	-42.637117 C				
0.00003292	28765.	873874918.	16.5497391	0.0005448	-0.001628
1.9439026	-43.739258 C				
0.00003375	29467.	873098352.	16.5556320	0.0005588	-0.001669
1.9853958	-44.840814 C				
0.00003458	30168.	872336179.	16.5618293	0.0005728	-0.001710
2.0265266	-45.941779 C				
0.00003542	30869.	871587283.	16.5681201	0.0005868	-0.001751
2.0672937	-47.042148 C				
0.00003625	31568.	870850510.	16.5748736	0.0006008	-0.001792
2.1076956	-48.141920 C				
0.00003708	32267.	870124946.	16.5818848	0.0006149	-0.001833
2.1477308	-49.241087 C				
0.00003792	32965.	869409708.	16.5891411	0.0006290	-0.001873
2.1873978	-50.339646 C				
0.00003875	33662.	868703989.	16.5966308	0.0006431	-0.001914
2.2266952	-51.437592 C				
0.00003958	34359.	868007049.	16.6043433	0.0006573	-0.001955
2.2656214	-52.534920 C				
0.00004042	35054.	867318164.	16.6124814	0.0006714	-0.001996

2.3041749	-53.631626	C			
0.00004125	35749.	866636791.	16.6206147	0.0006856	-0.002037
2.3423542	-54.727703	C			
0.00004208	36443.	865962306.	16.6289444	0.0006998	-0.002078
2.3801577	-55.823147	C			
0.00004292	37136.	865294171.	16.6374631	0.0007140	-0.002118
2.4175839	-56.917954	C			
0.00004375	37828.	864631889.	16.6461641	0.0007283	-0.002159
2.4546311	-58.012117	C			
0.00004458	38519.	863974996.	16.6550412	0.0007425	-0.002200
2.4912976	-59.105633	C			
0.00004542	39204.	863217780.	16.6633908	0.0007568	-0.002241
2.5275004	-60.000000	CY			
0.00004625	39837.	861335784.	16.6643246	0.0007707	-0.002282
2.5624270	-60.000000	CY			
0.00004708	40385.	857737942.	16.6536507	0.0007841	-0.002323
2.5955651	-60.000000	CY			
0.00004792	40887.	853300144.	16.6371414	0.0007972	-0.002365
2.6275781	-60.000000	CY			
0.00004875	41349.	848191401.	16.6158031	0.0008100	-0.002407
2.6585765	-60.000000	CY			
0.00004958	41769.	842401394.	16.5894281	0.0008226	-0.002450
2.6885279	-60.000000	CY			
0.00005292	43255.	817413521.	16.4676393	0.0008714	-0.002621
2.8019975	-60.000000	CY			
0.00005625	44459.	790380539.	16.3261847	0.0009183	-0.002794
2.9059875	-60.000000	CY			
0.00005958	45475.	763211764.	16.1773598	0.0009639	-0.002969
3.0023746	-60.000000	CY			
0.00006292	46365.	736933415.	16.0231730	0.0010081	-0.003144
3.0915874	-60.000000	CY			
0.00006625	47094.	710852528.	15.8614629	0.0010508	-0.003322
3.1738007	-60.000000	CY			
0.00006958	47790.	686803607.	15.7144739	0.0010935	-0.003499
3.2518768	-60.000000	CY			
0.00007292	48366.	663306896.	15.5639221	0.0011349	-0.003678
3.3240173	-60.000000	CY			
0.00007625	48891.	641192768.	15.4169201	0.0011755	-0.003857
3.3911904	-60.000000	CY			
0.00007958	49407.	620827042.	15.2799480	0.0012160	-0.004036
3.4546275	-60.000000	CY			
0.00008292	49810.	600726303.	15.1368187	0.0012551	-0.004217
3.5124747	-60.000000	CY			
0.00008625	50194.	581960909.	15.0038952	0.0012941	-0.004398
3.5669497	-60.000000	CY			
0.00008958	50576.	564564019.	14.8823368	0.0013332	-0.004579
3.6183878	-60.000000	CY			
0.00009292	50930.	548128150.	14.7615793	0.0013716	-0.004761
3.6656760	-60.000000	CY			
0.00009625	51213.	532081140.	14.6358939	0.0014087	-0.004944

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3.7083629    -60.000000 CY
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3.7480332    -60.000000 CY
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3.7849378    -60.000000 CY
 0.0001063        52011.    489514342.    14.3066559     0.0015201     -0.005492
3.8190457    -60.000000 CY
 0.0001096        52260.    476893425.    14.2107919     0.0015573     -0.005675
3.8500888    -60.000000 CY
 0.0001129        52464.    464627309.    14.1081329     0.0015930     -0.005859
3.8772084    -60.000000 CY
 0.0001163        52643.    452839705.    14.0061572     0.0016282     -0.006044
3.9012221    -60.000000 CY
 0.0001196        52819.    441696058.    13.9097120     0.0016634     -0.006229
3.9227014    -60.000000 CY
 0.0001229        52995.    431143715.    13.8219585     0.0016989     -0.006414
3.9416177    -60.000000 CY
 0.0001263        53168.    421135689.    13.7386615     0.0017345     -0.006598
3.9579416    -60.000000 CY
 0.0001296        53340.    411629658.    13.6607916     0.0017702     -0.006782
3.9716428    -60.000000 CY
 0.0001329        53503.    402533145.    13.5858352     0.0018058     -0.006967
3.9826313    -60.000000 CY
 0.0001363        53654.    393793837.    13.5129005     0.0018411     -0.007151
3.9908734    -60.000000 CY
 0.0001396        53765.    385180977.    13.4308737     0.0018747     -0.007338
3.9962693    -60.000000 CY
 0.0001429        53874.    376960682.    13.3531997     0.0019084     -0.007524
3.9992982    -60.000000 CY
 0.0001462        53982.    369105049.    13.2806910     0.0019423     -0.007710
3.9975635    -60.000000 CY
 0.0001496        54088.    361588225.    13.2112309     0.0019762     -0.007896
3.9962125    -60.000000 CY
 0.0001529        54192.    354391088.    13.1460356     0.0020102     -0.008082
3.9991678    -60.000000 CY
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3.9988205    -60.000000 CY
 0.0001596        54397.    340869285.    13.0275867     0.0020790     -0.008454
3.9944257    -60.000000 CY
 0.0001629        54497.    334510588.    12.9743114     0.0021137     -0.008639
3.9980776    -60.000000 CY
 0.0001662        54596.    328394413.    12.9206377     0.0021481     -0.008824
3.9998324    -60.000000 CY
 0.0001696        54686.    322474203.    12.8722869     0.0021829     -0.009010
3.9947196    -60.000000 CY
 0.0001729        54772.    316756397.    12.8199556     0.0022168     -0.009196
3.9946595    -60.000000 CY
 0.0001762        54836.    311124375.    12.7637128     0.0022496     -0.009383
3.9978429    -60.000000 CY
 0.0001796        54895.    305680243.    12.7092157     0.0022824     -0.009570
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   3.9996050    -60.000000 CY
    0.0001829        54953.    300426059.    12.6571402     0.0023152     -0.009757
   3.9979936    -60.000000 CY
    0.0002029        55279.    272423702.    12.3910159     0.0025143     -0.010878
   3.9920333    -60.000000 CY
    0.0002229        55582.    249341482.    12.1847833     0.0027162     -0.011996
   3.9934997    -60.000000 CY
    0.0002429        55798.    229701662.    11.9848749     0.0029113     -0.013121
   3.9996748    -60.000000 CY
    0.0002629        55942.    212774461.    11.8111635     0.0031054     -0.014247
   3.9923867    60.0000000 CYT
    0.0002829        56070.    198185359.    11.6743893     0.0033029     -0.015370
   3.9949300    60.0000000 CYT
    0.0003029        56164.    185410121.    11.5784460     0.0035073     -0.016485
   3.9931069    60.0000000 CYT
    0.0003229        56241.    174165119.    11.4971081     0.0037126     -0.017600
   3.9953677    60.0000000 CYT
    0.0003429        56241.    164007251.    11.5204145     0.0039505     -0.018682
   3.9917208    60.0000000 CYT
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Summary of Results for Nominal Moment Capacity for Section 1

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

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max. Tens. Strain
1	12.100	55543.090	0.00300000	-0.01373068
2	26.300	55863.986	0.00300000	-0.01363577

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

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

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

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

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	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	12.100000	55543.	7.865000	36103.	860670288.
2	0.65	26.300000	55864.	17.095000	36312.	866089646.
1	0.75	12.100000	55543.	9.075000	41657.	834857281.
2	0.75	26.300000	55864.	19.725000	41898.	840233138.
1	0.90	12.100000	55543.	10.890000	49989.	574052587.
2	0.90	26.300000	55864.	23.670000	50278.	578154063.

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	2.0000	0.00	N.A.	No	0.00	767729.
2	14.0000	12.8673	Yes	No	767729.	244408.
3	16.0000	14.2811	Yes	No	1012138.	142852.
4	22.0000	20.0000	No	No	1154989.	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 = 16600.0 lbs
Applied moment at pile head = 7080000.0 in-lbs
Axial thrust load on pile head = 12100.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.5406	7080000.	16600.	-0.00369	0.00	4.27E+12	0.00	0.00	0.00
0.1700	0.5330	7113955.	16600.	-0.00369	0.00	4.27E+12	0.00	0.00	0.00
0.3400	0.5255	7147910.	16600.	-0.00368	0.00	4.27E+12	0.00	0.00	0.00
0.5100	0.5180	7181865.	16600.	-0.00368	0.00	4.27E+12	0.00	0.00	0.00
0.6800	0.5105	7215820.	16600.	-0.00368	0.00	4.27E+12	0.00	0.00	0.00
0.8500	0.5030	7249774.	16600.	-0.00367	0.00	4.27E+12	0.00	0.00	0.00
1.0200	0.4955	7283729.	16600.	-0.00367	0.00	4.27E+12	0.00	0.00	0.00
1.1900	0.4880	7317684.	16600.	-0.00367	0.00	4.27E+12	0.00	0.00	0.00
1.3600	0.4806	7351638.	16600.	-0.00366	0.00	4.27E+12	0.00	0.00	0.00
1.5300	0.4731	7385592.	16600.	-0.00366	0.00	4.27E+12	0.00	0.00	0.00
1.7000	0.4656	7419547.	16600.	-0.00366	0.00	4.27E+12	0.00	0.00	0.00
1.8700	0.4582	7453501.	16600.	-0.00365	0.00	4.27E+12	0.00	0.00	0.00
2.0400	0.4507	7487455.	16591.	-0.00365	0.00	4.27E+12	-9.159	41.4557	0.00
2.2100	0.4433	7521371.	16532.	-0.00364	0.00	4.27E+12	-48.483	223.1175	0.00
2.3800	0.4359	7555085.	16392.	-0.00364	0.00	4.27E+12			

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-88.389   413.7004       0.00
    2.5500     0.4284   7588431.     16171.   -0.00364        0.00   4.27E+12
-128.799   613.2839       0.00
    2.7200     0.4210   7621241.     15866.   -0.00363        0.00   4.27E+12
-169.634   821.9519       0.00
    2.8900     0.4136   7653345.     15478.   -0.00363        0.00   4.27E+12
-210.815      1040.       0.00
    3.0600     0.4062   7684571.     15006.   -0.00363        0.00   4.27E+12
-252.263      1267.       0.00
    3.2300     0.3988   7714748.     14449.   -0.00362        0.00   4.27E+12
-293.900      1503.       0.00
    3.4000     0.3914   7743702.     13807.   -0.00362        0.00   4.27E+12
-335.645      1749.       0.00
    3.5700     0.3840   7771258.     13079.   -0.00362        0.00   4.27E+12
-377.420      2005.       0.00
    3.7400     0.3767   7797244.     12267.   -0.00361        0.00   4.27E+12
-419.146      2270.       0.00
    3.9100     0.3693   7821485.     11369.   -0.00361        0.00   4.27E+12
-460.742      2545.       0.00
    4.0800     0.3619   7843809.     10387.   -0.00360        0.00   4.27E+12
-502.129      2830.       0.00
    4.2500     0.3546   7864043.      9321.   -0.00360        0.00   4.27E+12
-543.227      3125.       0.00
    4.4200     0.3473   7882017.      8171.   -0.00360        0.00   4.27E+12
-583.956      3431.       0.00
    4.5900     0.3399   7897560.      6939.   -0.00359        0.00   4.27E+12
-624.237      3746.       0.00
    4.7600     0.3326   7910505.      5625.   -0.00359        0.00   4.27E+12
-664.075      4073.       0.00
    4.9300     0.3253   7920686.      4229.   -0.00359        0.00   4.27E+12
-704.810      4420.       0.00
    5.1000     0.3180   7927934.      2750.   -0.00358        0.00   4.27E+12
-745.113      4780.       0.00
    5.2700     0.3107   7932082.      1189.   -0.00358        0.00   4.27E+12
-784.916      5154.       0.00
    5.4400     0.3034   7932962.   -452.228   -0.00357        0.00   4.27E+12
-824.151      5542.       0.00
    5.6100     0.2961   7930413.     -2173.   -0.00357        0.00   4.27E+12
-862.749      5944.       0.00
    5.7800     0.2888   7924273.     -3972.   -0.00357        0.00   4.27E+12
-900.641      6362.       0.00
    5.9500     0.2815   7914385.     -5847.   -0.00356        0.00   4.27E+12
-937.759      6795.       0.00
    6.1200     0.2743   7900595.     -7797.   -0.00356        0.00   4.27E+12
-974.033      7245.       0.00
    6.2900     0.2670   7882750.     -9820.   -0.00356        0.00   4.27E+12
-1009.     7712.      0.00
    6.4600     0.2598   7860705.    -11914.   -0.00355        0.00   4.27E+12
-1044.     8197.      0.00
    6.6300     0.2525   7834316.    -14077.   -0.00355        0.00   4.27E+12
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-1077.	8701.	0.00				
6.8000	0.2453	7803445.	-16307.	-0.00354	0.00	4.27E+12
-1109.	9226.	0.00				
6.9700	0.2381	7767957.	-18602.	-0.00354	0.00	4.27E+12
-1140.	9771.	0.00				
7.1400	0.2308	7727724.	-20958.	-0.00354	0.00	4.27E+12
-1170.	10339.	0.00				
7.3100	0.2236	7682621.	-23374.	-0.00353	0.00	4.27E+12
-1198.	10932.	0.00				
7.4800	0.2164	7632531.	-25846.	-0.00353	0.00	4.27E+12
-1225.	11549.	0.00				
7.6500	0.2092	7577342.	-28373.	-0.00353	0.00	4.27E+12
-1252.	12208.	0.00				
7.8200	0.2020	7516942.	-30954.	-0.00352	0.00	4.27E+12
-1278.	12900.	0.00				
7.9900	0.1949	7451225.	-33584.	-0.00352	0.00	4.27E+12
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8.1600	0.1877	7380091.	-36262.	-0.00351	0.00	4.27E+12
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8.3300	0.1805	7303448.	-38984.	-0.00351	0.00	4.27E+12
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-1363.	16043.	0.00				
8.6700	0.1662	7133297.	-44545.	-0.00350	0.00	4.27E+12
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8.8400	0.1591	7039640.	-47376.	-0.00350	0.00	4.27E+12
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9.1800	0.1448	6834853.	-53119.	-0.00349	0.00	4.28E+12
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9.8600	0.1163	6354222.	-64795.	-0.00348	0.00	4.28E+12
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10.0300	0.1092	6219136.	-67723.	-0.00348	0.00	4.28E+12
-1434.	26785.	0.00				
10.2000	0.1021	6078082.	-70644.	-0.00348	0.00	4.28E+12
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10.3700	0.09505	5931082.	-73551.	-0.00347	0.00	4.28E+12
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   11.0500   0.06676   5284361.    -84948.   -0.00346        0.00   4.28E+12
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   11.2200   0.05970   5108321.    -87695.   -0.00346        0.00   4.28E+12
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   11.3900   0.05264   4926736.    -90379.   -0.00346        0.00   4.29E+12
-1298.     50318.       0.00
   11.5600   0.04559   4739747.    -92903.   -0.00346        0.00   4.29E+12
-1177.     52656.       0.00
   11.7300   0.03854   4547861.    -95137.   -0.00345        0.00   4.29E+12
-1013.     53593.       0.00
   11.9000   0.03150   4351761.    -97028.   -0.00345        0.00   4.29E+12
-842.074     54529.       0.00
   12.0700   0.02447   4152156.    -98566.   -0.00345        0.00   4.29E+12
-665.188     55466.       0.00
   12.2400   0.01743   3949783.    -99736.   -0.00345        0.00   4.29E+12
-481.952     56402.       0.00
   12.4100   0.01040   3745404.   -100526.   -0.00345        0.00   4.29E+12
-292.368     57338.       0.00
   12.5800   0.00338   3539808.   -100922.   -0.00344        0.00   4.29E+12
-96.434     58275.       0.00
   12.7500  -0.00365   3333811.   -100913.   -0.00344        0.00   4.29E+12
105.8507     59211.       0.00
   12.9200  -0.01067   3128255.   -100484.   -0.00344        0.00   4.29E+12
314.4868     60147.       0.00
   13.0900  -0.01768   2924007.    -99623.   -0.00344        0.00   4.30E+12
529.4759     61084.       0.00
   13.2600  -0.02470   2721962.    -98317.   -0.00344        0.00   4.30E+12
750.8200     62020.       0.00
   13.4300  -0.03171   2523043.    -96553.   -0.00344        0.00   4.30E+12
978.5212     62956.       0.00
   13.6000  -0.03872   2328195.    -94318.   -0.00344        0.00   4.30E+12
1213.     63893.       0.00
   13.7700  -0.04572   2138394.    -91599.   -0.00343        0.00   4.30E+12
1453.     64829.       0.00
   13.9400  -0.05273   1954639.    -88384.   -0.00343        0.00   4.30E+12
1700.     65766.       0.00
   14.1100  -0.05973   1777958.    -85543.   -0.00343        0.00   4.30E+12
1085.     37057.       0.00
   14.2800  -0.06673   1605793.    -83183.   -0.00343        0.00   4.30E+12
1229.     37577.       0.00
   14.4500  -0.07373   1438743.    -80524.   -0.00343        0.00   4.30E+12
1377.     38097.       0.00
   14.6200  -0.08073   1277422.    -77561.   -0.00343        0.00   4.30E+12
1528.     38617.       0.00
   14.7900  -0.08772   1122462.    -74286.   -0.00343        0.00   4.30E+12
1683.     39137.       0.00
   14.9600  -0.09472    974505.    -70691.   -0.00343        0.00   4.30E+12
1841.     39658.       0.00
   15.1300    -0.102    834210.    -66770.   -0.00343        0.00   4.30E+12
```

							2003.	40178.	0.00
15.3000	-0.109	702253.	-62515.	-0.00343	0.00	4.30E+12	2169.	40698.	0.00
15.4700	-0.116	579320.	-57918.	-0.00343	0.00	4.30E+12	2338.	41218.	0.00
15.6400	-0.123	466116.	-52973.	-0.00343	0.00	4.30E+12	2510.	41738.	0.00
15.8100	-0.130	363359.	-47673.	-0.00343	0.00	4.30E+12	2686.	42259.	0.00
15.9800	-0.137	271781.	-42009.	-0.00343	0.00	4.30E+12	2866.	42779.	0.00
16.1500	-0.144	192131.	-35975.	-0.00343	0.00	4.30E+12	3049.	43299.	0.00
16.3200	-0.151	125171.	-29564.	-0.00343	0.00	4.30E+12	3236.	43819.	0.00
16.4900	-0.158	71678.	-22768.	-0.00343	0.00	4.30E+12	3426.	44339.	0.00
16.6600	-0.165	32445.	-15581.	-0.00343	0.00	4.30E+12	3620.	44860.	0.00
16.8300	-0.172	8278.	-7994.	-0.00343	0.00	4.30E+12	3818.	45380.	0.00
17.0000	-0.179	0.00	0.00	-0.00343	0.00	4.30E+12	4019.	22950.	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             =     0.54055181 inches
Computed slope at pile head      =     -0.0036900 radians
Maximum bending moment           =       7932962. inch-lbs
Maximum shear force              =       -100922. lbs
Depth of maximum bending moment  =     5.44000000 feet below pile head
Depth of maximum shear force     =    12.58000000 feet below pile head
Number of iterations             =             21
Number of zero deflection points =              1
Pile deflection at ground        =     0.45247734 inches
```

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

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

Shear force at pile head = 16600.0 lbs
Applied moment at pile head = 7080000.0 in-lbs
Axial thrust load on pile head = 26300.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.5418	7080000.	16600.	-0.00370	0.00	4.27E+12	0.00	0.00	0.00
0.1700	0.5342	7114062.	16600.	-0.00369	0.00	4.27E+12	0.00	0.00	0.00
0.3400	0.5267	7148124.	16600.	-0.00369	0.00	4.27E+12	0.00	0.00	0.00
0.5100	0.5192	7182186.	16600.	-0.00369	0.00	4.27E+12	0.00	0.00	0.00
0.6800	0.5116	7216248.	16600.	-0.00368	0.00	4.27E+12	0.00	0.00	0.00
0.8500	0.5041	7250310.	16600.	-0.00368	0.00	4.27E+12	0.00	0.00	0.00
1.0200	0.4966	7284371.	16600.	-0.00368	0.00	4.27E+12	0.00	0.00	0.00
1.1900	0.4891	7318432.	16600.	-0.00367	0.00	4.27E+12	0.00	0.00	0.00
1.3600	0.4816	7352493.	16600.	-0.00367	0.00	4.27E+12	0.00	0.00	0.00
1.5300	0.4742	7386554.	16600.	-0.00367	0.00	4.27E+12	0.00	0.00	0.00
1.7000	0.4667	7420615.	16600.	-0.00366	0.00	4.27E+12	0.00	0.00	0.00
1.8700	0.4592	7454675.	16600.	-0.00366	0.00	4.27E+12	0.00	0.00	0.00
2.0400	0.4518	7488735.	16591.	-0.00366	0.00	4.27E+12	-9.165	41.3857	0.00
2.2100	0.4443	7522757.	16532.	-0.00365	0.00	4.27E+12	-48.512	222.7405	0.00
2.3800	0.4369	7556577.	16392.	-0.00365	0.00	4.27E+12	-88.442	413.0015	0.00
2.5500	0.4294	7590029.	16170.	-0.00365	0.00	4.27E+12	-128.876	612.2483	0.00
2.7200	0.4220	7622944.	15866.	-0.00364	0.00	4.27E+12	-169.737	820.5644	0.00
2.8900	0.4146	7655152.	15478.	-0.00364	0.00	4.27E+12			

-210.944	1038.	0.00				
3.0600	0.4071	7686483.	15005.	-0.00363	0.00	4.27E+12
-252.419	1265.	0.00				
3.2300	0.3997	7716762.	14448.	-0.00363	0.00	4.27E+12
-294.082	1501.	0.00				
3.4000	0.3923	7745818.	13805.	-0.00363	0.00	4.27E+12
-335.855	1746.	0.00				
3.5700	0.3849	7773476.	13077.	-0.00362	0.00	4.27E+12
-377.658	2001.	0.00				
3.7400	0.3775	7799562.	12264.	-0.00362	0.00	4.27E+12
-419.412	2266.	0.00				
3.9100	0.3702	7823902.	11366.	-0.00362	0.00	4.27E+12
-461.037	2541.	0.00				
4.0800	0.3628	7846324.	10383.	-0.00361	0.00	4.27E+12
-502.453	2825.	0.00				
4.2500	0.3554	7866654.	9316.	-0.00361	0.00	4.27E+12
-543.581	3120.	0.00				
4.4200	0.3481	7884722.	8166.	-0.00360	0.00	4.27E+12
-584.340	3425.	0.00				
4.5900	0.3407	7900358.	6933.	-0.00360	0.00	4.27E+12
-624.651	3740.	0.00				
4.7600	0.3334	7913394.	5618.	-0.00360	0.00	4.27E+12
-664.519	4066.	0.00				
4.9300	0.3260	7923664.	4221.	-0.00359	0.00	4.27E+12
-705.283	4413.	0.00				
5.1000	0.3187	7931000.	2741.	-0.00359	0.00	4.27E+12
-745.616	4772.	0.00				
5.2700	0.3114	7935232.	1179.	-0.00359	0.00	4.27E+12
-785.448	5145.	0.00				
5.4400	0.3041	7936195.	-463.346	-0.00358	0.00	4.27E+12
-824.713	5533.	0.00				
5.6100	0.2968	7933725.	-2185.	-0.00358	0.00	4.27E+12
-863.340	5934.	0.00				
5.7800	0.2895	7927663.	-3985.	-0.00357	0.00	4.27E+12
-901.261	6351.	0.00				
5.9500	0.2822	7917850.	-5862.	-0.00357	0.00	4.27E+12
-938.408	6783.	0.00				
6.1200	0.2749	7904131.	-7813.	-0.00357	0.00	4.27E+12
-974.711	7232.	0.00				
6.2900	0.2677	7886356.	-9837.	-0.00356	0.00	4.27E+12
-1010.	7699.	0.00				
6.4600	0.2604	7864377.	-11933.	-0.00356	0.00	4.27E+12
-1045.	8183.	0.00				
6.6300	0.2531	7838051.	-14098.	-0.00356	0.00	4.27E+12
-1078.	8686.	0.00				
6.8000	0.2459	7807239.	-16330.	-0.00355	0.00	4.27E+12
-1110.	9210.	0.00				
6.9700	0.2386	7771807.	-18626.	-0.00355	0.00	4.27E+12
-1141.	9754.	0.00				
7.1400	0.2314	7731627.	-20984.	-0.00354	0.00	4.27E+12

-1171.	10321.	0.00				
7.3100	0.2242	7686573.	-23401.	-0.00354	0.00	4.27E+12
-1199.	10913.	0.00				
7.4800	0.2170	7636528.	-25875.	-0.00354	0.00	4.27E+12
-1226.	11529.	0.00				
7.6500	0.2098	7581381.	-28404.	-0.00353	0.00	4.27E+12
-1253.	12186.	0.00				
7.8200	0.2026	7521018.	-30986.	-0.00353	0.00	4.27E+12
-1279.	12877.	0.00				
7.9900	0.1954	7455335.	-33619.	-0.00353	0.00	4.27E+12
-1303.	13602.	0.00				
8.1600	0.1882	7384230.	-36299.	-0.00352	0.00	4.27E+12
-1325.	14364.	0.00				
8.3300	0.1810	7307612.	-39023.	-0.00352	0.00	4.27E+12
-1346.	15167.	0.00				
8.5000	0.1738	7225393.	-41787.	-0.00352	0.00	4.27E+12
-1364.	16014.	0.00				
8.6700	0.1666	7137497.	-44588.	-0.00351	0.00	4.27E+12
-1381.	16910.	0.00				
8.8400	0.1595	7043852.	-47421.	-0.00351	0.00	4.27E+12
-1396.	17861.	0.00				
9.0100	0.1523	6944395.	-50283.	-0.00351	0.00	4.27E+12
-1409.	18872.	0.00				
9.1800	0.1452	6839074.	-53168.	-0.00350	0.00	4.28E+12
-1420.	19951.	0.00				
9.3500	0.1380	6727843.	-56074.	-0.00350	0.00	4.28E+12
-1428.	21106.	0.00				
9.5200	0.1309	6610669.	-58993.	-0.00350	0.00	4.28E+12
-1434.	22348.	0.00				
9.6900	0.1238	6487527.	-61922.	-0.00349	0.00	4.28E+12
-1437.	23689.	0.00				
9.8600	0.1167	6358402.	-64855.	-0.00349	0.00	4.28E+12
-1438.	25144.	0.00				
10.0300	0.1095	6223294.	-67786.	-0.00349	0.00	4.28E+12
-1435.	26733.	0.00				
10.2000	0.1024	6082212.	-70708.	-0.00348	0.00	4.28E+12
-1430.	28478.	0.00				
10.3700	0.09533	5935178.	-73619.	-0.00348	0.00	4.28E+12
-1423.	30460.	0.00				
10.5400	0.08823	5782221.	-76513.	-0.00348	0.00	4.28E+12
-1414.	32700.	0.00				
10.7100	0.08114	5623378.	-79385.	-0.00348	0.00	4.28E+12
-1401.	35230.	0.00				
10.8800	0.07405	5458703.	-82226.	-0.00347	0.00	4.28E+12
-1384.	38123.	0.00				
11.0500	0.06697	5288269.	-85026.	-0.00347	0.00	4.28E+12
-1362.	41476.	0.00				
11.2200	0.05990	5112168.	-87776.	-0.00347	0.00	4.28E+12
-1334.	45432.	0.00				
11.3900	0.05283	4930516.	-90462.	-0.00346	0.00	4.29E+12

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-1300.     50197.       0.00
   11.5600   0.04576   4743454.    -92993.   -0.00346       0.00   4.29E+12
-1181.     52656.       0.00
   11.7300   0.03870   4551476.    -95235.   -0.00346       0.00   4.29E+12
-1017.     53593.       0.00
   11.9000   0.03164   4355267.    -97135.   -0.00346       0.00   4.29E+12
-845.789     54529.       0.00
   12.0700   0.02459   4155538.    -98679.   -0.00346       0.00   4.29E+12
-668.552     55466.       0.00
   12.2400   0.01754   3953027.    -99856.   -0.00345       0.00   4.29E+12
-484.952     56402.       0.00
   12.4100   0.01050   3748498.   -100651.   -0.00345       0.00   4.29E+12
-294.989     57338.       0.00
   12.5800   0.00345   3542741.   -101053.   -0.00345       0.00   4.29E+12
-98.663     58275.       0.00
   12.7500  -0.00358   3336573.   -101047.   -0.00345       0.00   4.29E+12
104.0274     59211.       0.00
   12.9200  -0.01062   3130838.   -100622.   -0.00345       0.00   4.29E+12
313.0834     60147.       0.00
   13.0900  -0.01765   2926406.    -99763.   -0.00345       0.00   4.30E+12
528.5065     61084.       0.00
   13.2600  -0.02468   2724173.    -98459.   -0.00344       0.00   4.30E+12
750.2984     62020.       0.00
   13.4300  -0.03171   2525062.    -96696.   -0.00344       0.00   4.30E+12
978.4613     62956.       0.00
   13.6000  -0.03873   2330024.    -94460.   -0.00344       0.00   4.30E+12
1213.     63893.       0.00
   13.7700  -0.04575   2140033.    -91740.   -0.00344       0.00   4.30E+12
1454.     64829.       0.00
   13.9400  -0.05277   1956093.    -88522.   -0.00344       0.00   4.30E+12
1701.     65766.       0.00
   14.1100  -0.05979   1779233.    -85679.   -0.00344       0.00   4.30E+12
1086.     37057.       0.00
   14.2800  -0.06680   1606892.    -83316.   -0.00344       0.00   4.30E+12
1231.     37577.       0.00
   14.4500  -0.07382   1439672.    -80655.   -0.00344       0.00   4.30E+12
1379.     38097.       0.00
   14.6200  -0.08083   1278189.    -77688.   -0.00344       0.00   4.30E+12
1530.     38617.       0.00
   14.7900  -0.08784   1123074.    -74408.   -0.00344       0.00   4.30E+12
1685.     39137.       0.00
   14.9600  -0.09485    974972.    -70809.   -0.00344       0.00   4.30E+12
1844.     39658.       0.00
   15.1300    -0.102    834544.    -66881.   -0.00344       0.00   4.30E+12
2006.     40178.       0.00
   15.3000    -0.109    702465.    -62620.   -0.00344       0.00   4.30E+12
2172.     40698.       0.00
   15.4700    -0.116    579424.    -58016.   -0.00344       0.00   4.30E+12
2341.     41218.       0.00
   15.6400    -0.123    466127.    -53063.   -0.00343       0.00   4.30E+12
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2514.     41738.       0.00
   15.8100     -0.130    363294.    -47754.   -0.00343       0.00   4.30E+12
2691.     42259.       0.00
   15.9800     -0.137    271658.    -42082.   -0.00343       0.00   4.30E+12
2871.     42779.       0.00
   16.1500     -0.144    191970.    -36038.   -0.00343       0.00   4.30E+12
3054.     43299.       0.00
   16.3200     -0.151    124993.    -29616.   -0.00343       0.00   4.30E+12
3242.     43819.       0.00
   16.4900     -0.158     71506.    -22808.   -0.00343       0.00   4.30E+12
3432.     44339.       0.00
   16.6600     -0.165     32303.    -15608.   -0.00343       0.00   4.30E+12
3627.     44860.       0.00
   16.8300     -0.172      8193.     -8008.   -0.00343       0.00   4.30E+12
3825.     45380.       0.00
   17.0000     -0.179       0.00       0.00   -0.00343       0.00   4.30E+12
4026.     22950.       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. 2:

```
Pile-head deflection              =     0.54176654 inches
Computed slope at pile head       =     -0.0036976 radians
Maximum bending moment            =       7936195. inch-lbs
Maximum shear force               =       -101053. lbs
Depth of maximum bending moment   =     5.44000000 feet below pile head
Depth of maximum shear force      =    12.58000000 feet below pile head
Number of iterations              =             21
Number of zero deflection points  =              1
Pile deflection at ground         =     0.45351036 inches
```

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 1	Pile-head Load 1	Load Type 2	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	16600.	M, in-lb	7080000.	12100.	0.5406	-0.00369	-100922.	7932962.
2	V, lb	16600.	M, in-lb	7080000.	26300.	0.5418	-0.00370	-101053.	7936195.

Maximum pile-head deflection = 0.5417665423 inches
Maximum pile-head rotation = -0.0036976208 radians = -0.211858 deg.

The analysis ended normally.

SETTLEMENT ANALYSIS

Summary:

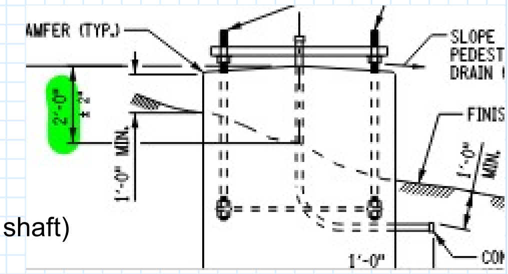
Evaluate the Settlement of Drilled shafts of OHSS at Location - 1 in accordance with the provisions of Chapters 3, 10, and 11 of the AASHTO LRFD Bridge Design Specifications.

References:

1. AASHTO LRFD Bridge Design Specification, 9th Edition, 2020
2. NYSDOT LRFD Bridge Design Specification - 2021
3. NYSDOT Geotechnical Design Manual

General Inputs:

Shaft geometry



$D_{shaft} := 5.50\ ft$ (Shaft Diameter)

$L_{shaft} := 17\ ft$ (Shaft Length)

$d_{embed} := L_{shaft} - 2\ ft = 15\ ft$ (Effective embedment depth of shaft)

$P := 0\ ft$ (Single post for cantilever structure)

Loading

$Q_{structure} := 26.3 \cdot kip$ (Axial Load per shaft from structure)

$W_{shaft} := 150\ pcf \left(\frac{\pi \cdot D_{shaft}^{\ 2}}{4}\right) \cdot L_{shaft} = 60.6\ kip$ (Self weight of drilled shaft)

$Q := Q_{structure} + W_{shaft} = 86.88\ kip$

Short Term Settlement of Drilled Shafts:

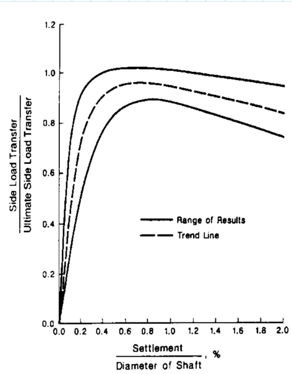


Figure 10.8.2.2.2-1 Normalized Load Transfer in Side Resistance versus Settlement in Cohesive Soils (from O'Neill and Reese, 1999)

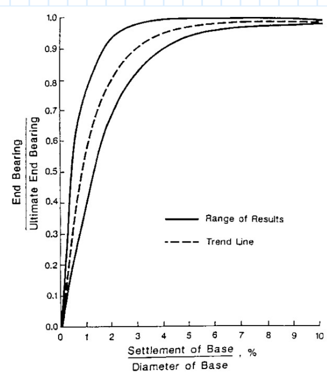


Figure 10.8.2.2.2-2—Normalized Load Transfer in End Bearing versus Settlement in Cohesive Soils (from O'Neill and Reese, 1999)

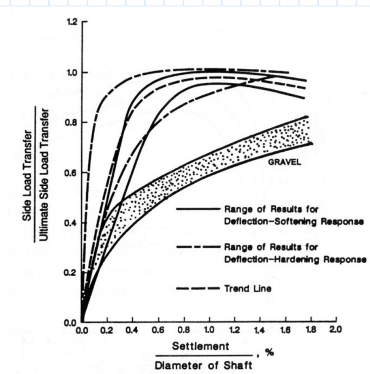


Figure 10.8.2.2.2-3—Normalized Load Transfer in Side Resistance versus Settlement in Cohesionless Soils (from O'Neill and Reese, 1999)

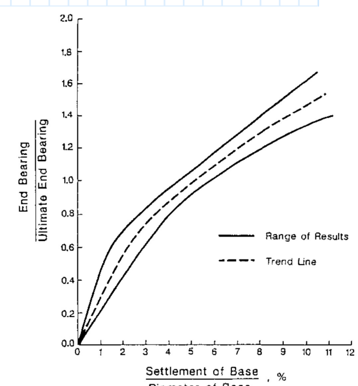


Figure 10.8.2.2.2-4—Normalized Load Transfer in End Bearing versus Settlement in Cohesionless Soils (from O'Neill and Reese, 1999)

Side and end bearing capacities of drilled shaft:

$R_{side} := 355\ kip$

$R_{end} := 1425\ kip$

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Checked by:	KR
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$Ratio_{side} := \frac{0.5 \cdot Q}{R_{side}} = 0.12$

$Ratio_{end} := \frac{0.5 \cdot Q}{R_{end}} = 0.03$

(Assuming half of total load is resisted by side friction and half by tip resistance only, and adding those)

$Ratio_{Settlement\_Side} := 0.02\%$

$Ratio_{Settlement\_End} := 0.1\%$

Short term settlement of drilled shafts:

$\delta_{short\_side} := Ratio_{Settlement\_Side} \cdot D_{shaft} = 0.01\ in$ $\delta_{short\_end} := Ratio_{Settlement\_End} \cdot D_{shaft} = 0.07\ in$

$\delta_{Short\_Term} := \delta_{short\_side} + \delta_{short\_end} = 0.08\ in$

Long Term Settlement of Drilled Shafts:

To calculate the location of equivalent footing, select from the following (AASHTO LRFD Figure 10.7.2.3.1-1):

Case a: Tip bearing in hard clay or in sand underlain by soft clay
Case b: supported by side resistance in clay
Case c: supported by side resistance in sand underlain by clay
Case d: supported by side and tip resistance in layered soil profile.

$Case := \text{“d”}$

Depth of equivalent footing:

$$d_{eq} := \begin{cases} d_{embed} & \text{if } Case = \text{“a”} \\ \frac{2}{3} \cdot d_{embed} & \text{else if } Case = \text{“b”} \\ \frac{8}{9} \cdot d_{embed} & \text{else if } Case = \text{“c”} \\ \frac{2}{3} \cdot d_{embed} & \text{else} \end{cases} = 10\ ft$$

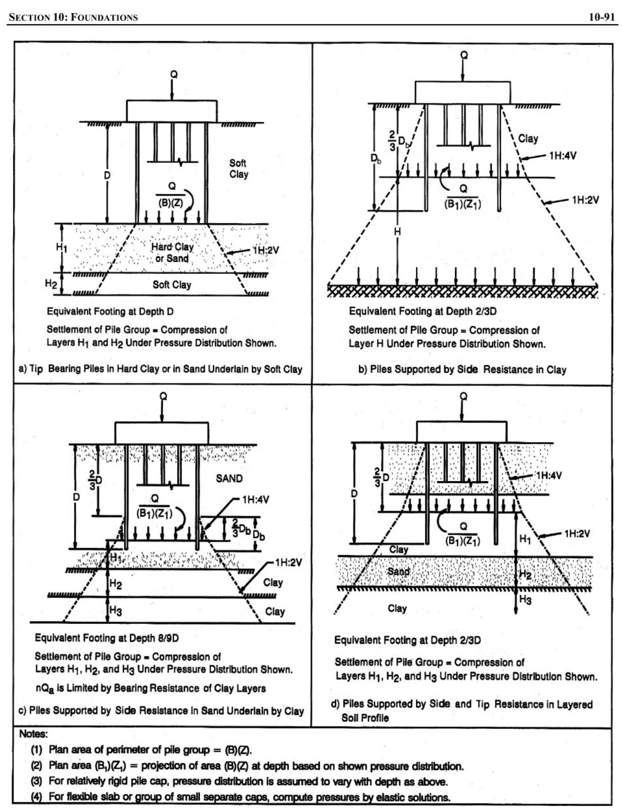

Figure 10.7.2.3.1-1—Stress Distribution below Equivalent Footing for Pile Group after Hannigan et al. (2006)

Area at equivalent footing depth:

$B := D_{shaft} = 5.5\ ft$

$Z := D_{shaft} = 5.5\ ft$

$A_{eq} := B \cdot Z = 30.25\ ft^2$

Applied Vertical Stress:

$q_o := \frac{Q}{A_{eq}} = 2872.2\ psf$

Soil layer thicknesses:

$d'_1 := 12\ ft$ (Layer 1)

$d'_2 := 15\ ft$ (Layer 2)

$d'_3 := 0\ ft$ (Layer 3) (NOT USED)

$d'_4 := 0\ ft$ (Layer 4) (NOT USED)

$d'_5 := 0\ ft$ (Layer 5) (NOT USED)

$d'_6 := 0\ ft$ (Layer 6) (NOT USED)

$d'_7 := 0\ ft$ (Layer 7) (NOT USED)

(Depth of Layer 1 below equivalent footing)

$d''_1 := d'_1 - d_{eq} = 2\ ft$

Effective vertical stress at the equivalent footing depth: (Groundwater is at 12ft)

$\sigma_{eq} := 130\ pcf \cdot \left(d_{eq}\right) = 1300\ psf$

Engineering and Land Surveying, P.C.

Subject: Settlement Analysis
Cantilever Sign Structure (Location 1 - S610.90)

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Checked by: KR
Date: 02/25/2025

Settlement Calculation of Soil Layer 1:

(Layer 1 below equivalent footing)

$Soil_{Layer1} := \text{“Cohesionless”}$

$d_1 := d''_1 = 2\ ft$

$\gamma'_1 := 130 \cdot pcf$

$c'_1 := 0\ psf$

Depth from bottom of foundation to mid-point of soil layer:

$$d'_{1m} := \frac{d_1}{2} = 1\ ft$$

Effective soil stress at midpoint of soil layer:

$$\sigma'_{o1} := \sigma_{eq} + \gamma'_1 \cdot \frac{d_1}{2} = 1430\ psf$$

Stress Influence Factor (AASHTO Fig. 10.6.2.4.1-1):

$$\frac{d'_{1m}}{B} = 0.18 \qquad I_1 := 1$$

Effective vertical stress increase on soil layer:

$$\Delta\sigma'_{v1} := I_1 \cdot q_o = 2872.19\ psf$$

Final Stress at midpoint of soil layer:

$$\sigma'_{f1} := \sigma'_{o1} + \Delta\sigma'_{v1} = 4302.19\ psf$$

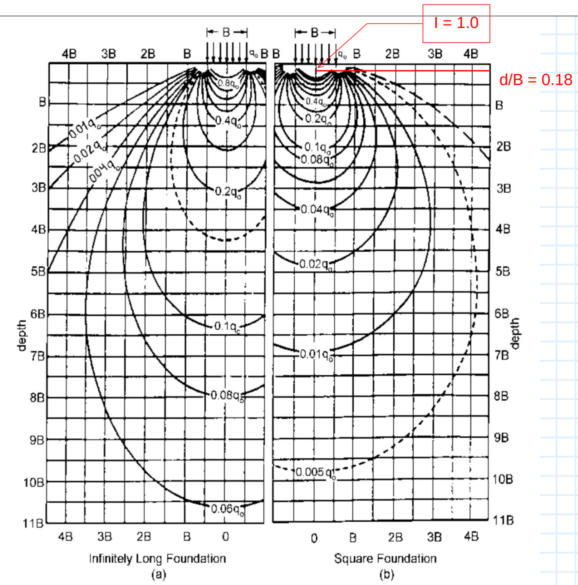


Figure 10.6.2.4.1-1—Boussinesq Vertical Stress Contours for Continuous and Square Footings Modified after Sowers (1979)

Settlement of Cohesionless soil:

$N_{60\_1} := 21$ (SPT corrected for energy)

$Soil := \text{“Sandy GRAVEL, Silty”}$

Bearing Capacity Index from Figure 10.6.2.4.2b-1.

$C'_1 := 80$

Settlement of soil layer:

$$\delta_{e1} := \frac{d_1}{C'_1} \cdot \log\left(\frac{\sigma'_{f1}}{\sigma'_{o1}}\right) = 0.14\ in$$

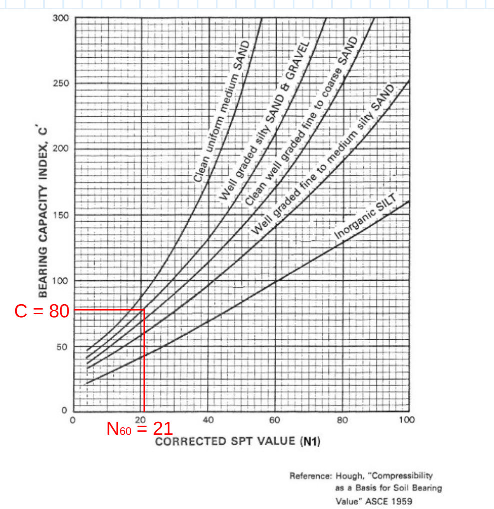


Figure 10.6.2.4.2b-1—Bearing Capacity Index versus Corrected *SPT* (Hough, 1959, as modified in Samtani and Nowatzki, 2006)

Settlement Calculation of Soil Layer 2:

(Layer 2 from soil profile)

$Soil_{Layer2} :=$ "Cohesionless"

$d_2 := d'_2 = 15\ ft$

$\gamma'_2 := 135 \cdot pcf - 62.4\ pcf = 72.6\ pcf$ $\quad c'_2 := 0\ psf$

Depth from bottom of foundation to mid-point of soil layer:

$$d'_{2m} := d'_{1m} + \frac{d_1}{2} + \frac{d_2}{2} = 9.5\ ft$$

Effective soil stress at midpoint of soil layer:

$$\sigma'_{o2} := \sigma'_{o1} + \gamma'_1 \cdot \frac{d_1}{2} + \gamma'_2 \cdot \frac{d_2}{2} = 2104.5\ psf$$

Stress Influence Factor (AASHTO Fig. 10.6.2.4.1-1):

$$\frac{d'_{2m}}{B} = 1.73 \qquad I_2 := 0.16$$

Effective vertical stress increase on soil layer:

$$\Delta\sigma'_{v2} := I_2 \cdot q_o = 459.55\ psf$$

Final Stress at midpoint of soil layer:

$$\sigma'_{f2} := \sigma'_{o2} + \Delta\sigma'_{v2} = 2564.05\ psf$$

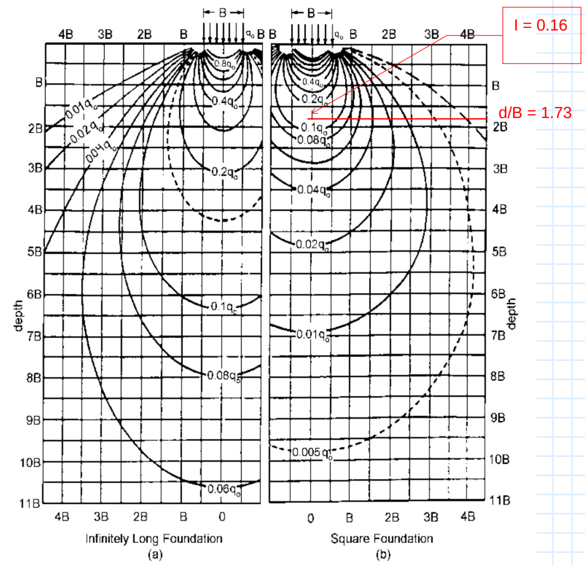


Figure 10.6.2.4.1-1—Boussinesq Vertical Stress Contours for Continuous and Square Footings Modified after Sowers (1979)

Settlement of Cohesionless soil:

$N_{60\_2} := 60$ (SPT corrected for energy)

$Soil :=$ "Silty SAND, Gravelly"

Bearing Capacity Index from Figure 10.6.2.4.2b-1.

$C'_2 := 143$

Settlement of soil layer:

$$\delta_{e2} := \frac{d_2}{C'_2} \cdot \log\left(\frac{\sigma'_{f2}}{\sigma'_{o2}}\right) = 0.11\ in$$

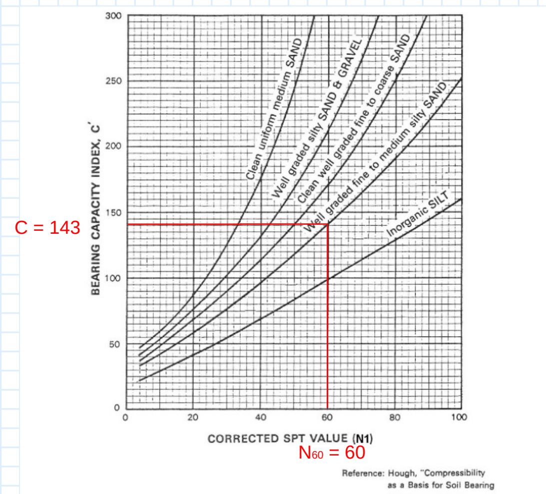


Figure 10.6.2.4.2b-1—Bearing Capacity Index versus Corrected *SPT* (Hough, 1959, as modified in Samtani and Nowatzki, 2006)

Total Elastic Settlement:

$\delta_e := \delta_{e1} + \delta_{e2} = 0.25\ in$

Total Consolidation Settlement:

$\delta_c := 0\ in$

Total Settlement:

$\delta := \delta_{Short\_Term} + \delta_e + \delta_c = 0.33\ in$

Summary:

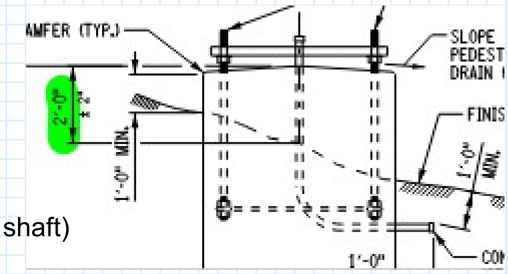
Evaluate the Settlement of Drilled shafts of OHSS at Location - 1 in accordance with the provisions of Chapters 3, 10, and 11 of the AASHTO LRFD Bridge Design Specifications.

References:

1. AASHTO LRFD Bridge Design Specification, 9th Edition, 2020
2. NYSDOT LRFD Bridge Design Specification - 2021
3. NYSDOT Geotechnical Design Manual

General Inputs:

Shaft geometry



$D_{shaft} := 5.50\ ft$ (Shaft Diameter)

$L_{shaft} := 17\ ft$ (Shaft Length)

$d_{embed} := L_{shaft} - 2\ ft = 15\ ft$ (Effective embedment depth of shaft)

$P := 0\ ft$ (Single post for cantilever structure)

Loading

$Q_{structure} := 26.3 \cdot kip$ (Axial Load per shaft from structure)

$W_{shaft} := 150\ pcf \left(\frac{\pi \cdot D_{shaft}^2}{4}\right) \cdot L_{shaft} = 60.6\ kip$ (Self weight of drilled shaft)

$Q := Q_{structure} + W_{shaft} = 86.88\ kip$

Short Term Settlement of Drilled Shafts:

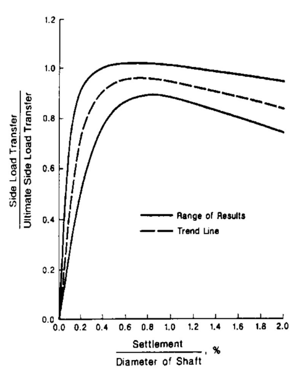


Figure 10.8.2.2.2-1 Normalized Load Transfer in Side Resistance versus Settlement in Cohesive Soils (from O'Neill and Reese, 1999)

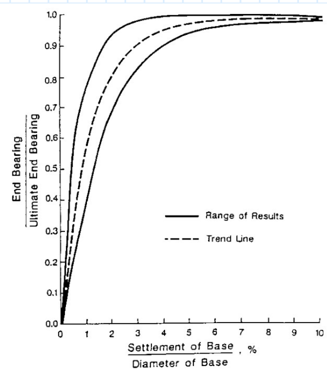


Figure 10.8.2.2.2-2—Normalized Load Transfer in End Bearing versus Settlement in Cohesive Soils (from O'Neill and Reese, 1999)

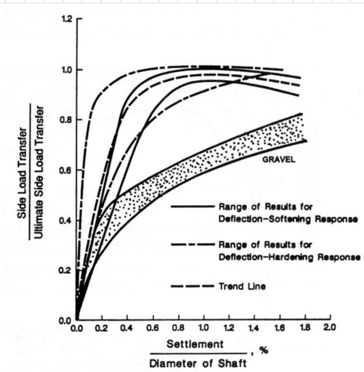


Figure 10.8.2.2.2-3—Normalized Load Transfer in Side Resistance versus Settlement in Cohesionless Soils (from O'Neill and Reese, 1999)

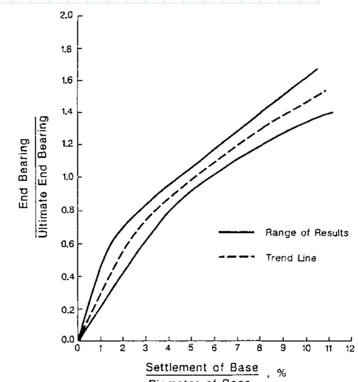


Figure 10.8.2.2.2-4—Normalized Load Transfer in End Bearing versus Settlement in Cohesionless Soils (from O'Neill and Reese, 1999)

Side and end bearing capacities of drilled shaft:

$R_{side} := 363\ kip$

$R_{end} := 1425\ kip$

$Ratio_{side} := \frac{0.5 \cdot Q}{R_{side}} = 0.12$

(Assuming half of total load is resisted by side friction and half by tip resistance only, and adding those)

$Ratio_{end} := \frac{0.5 \cdot Q}{R_{end}} = 0.03$

$Ratio_{Settlement\_Side} := 0.02\%$

$Ratio_{Settlement\_End} := 0.1\%$

Short term settlement of drilled shafts:

$\delta_{short\_side} := Ratio_{Settlement\_Side} \cdot D_{shaft} = 0.01\ in$ $\delta_{short\_end} := Ratio_{Settlement\_End} \cdot D_{shaft} = 0.07\ in$

$\delta_{Short\_Term} := \delta_{short\_side} + \delta_{short\_end} = 0.08\ in$

Long Term Settlement of Drilled Shafts:

To calculate the location of equivalent footing, select from the following (AASHTO LRFD Figure 10.7.2.3.1-1):

Case a: Tip bearing in hard clay or in sand underlain by soft clay
Case b: supported by side resistance in clay
Case c: supported by side resistance in sand underlain by clay
Case d: supported by side and tip resistance in layered soil profile.

$Case := \text{“d”}$

Depth of equivalent footing:

$$d_{eq} := \begin{cases} d_{embed} & \text{if } Case = \text{“a”} \\ \frac{2}{3} \cdot d_{embed} & \text{else if } Case = \text{“b”} \\ \frac{8}{9} \cdot d_{embed} & \text{else if } Case = \text{“c”} \\ \frac{2}{3} \cdot d_{embed} & \text{else} \end{cases} = 10\ ft$$

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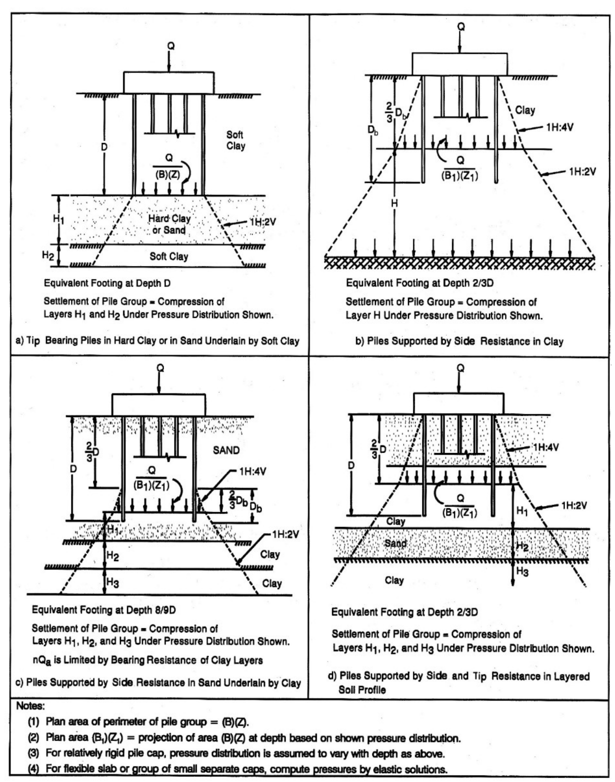

Figure 10.7.2.3.1-1—Stress Distribution below Equivalent Footing for Pile Group after Hannigan et al. (2006)

Area at equivalent footing depth:

$B := D_{shaft} = 5.5\ ft$

$Z := D_{shaft} = 5.5\ ft$

$A_{eq} := B \cdot Z = 30.25\ ft^2$

Applied Vertical Stress:

$q_o := \frac{Q}{A_{eq}} = 2872.2\ psf$

Soil layer thicknesses:

$d'_1 := 12\ ft$ (Layer 1)

$d'_2 := 2\ ft$ (Layer 2)

$d'_3 := 6\ ft$ (Layer 3)

$d'_4 := 7\ ft$ (Layer 4)

$d'_5 := 0\ ft$ (Layer 5) (NOT USED)

$d'_6 := 0\ ft$ (Layer 6) (NOT USED)

$d'_7 := 0\ ft$ (Layer 7) (NOT USED)

(Depth of Layer 1 below equivalent footing)

$d''_1 := d'_1 - d_{eq} = 2\ ft$

Effective vertical stress at the equivalent footing depth: (Groundwater is at 12ft)

$\sigma_{eq} := 135\ pcf \cdot (d_{eq}) = 1350\ psf$

Settlement Calculation of Soil Layer 1:

(Layer 1 below equivalent footing)

$Soil_{Layer1} :=$ "Cohesionless"

$d_1 := d''_1 = 2\ ft$

$\gamma'_1 := 135 \cdot pcf$ $\quad c'_1 := 0\ psf$

Depth from bottom of foundation to mid-point of soil layer:

$$d'_{1m} := \frac{d_1}{2} = 1\ ft$$

Effective soil stress at midpoint of soil layer:

$$\sigma'_{o1} := \sigma_{eq} + \gamma'_1 \cdot \frac{d_1}{2} = 1485\ psf$$

Stress Influence Factor (AASHTO Fig. 10.6.2.4.1-1):

$$\frac{d'_{1m}}{B} = 0.18 \qquad I_1 := 1$$

Effective vertical stress increase on soil layer:

$$\Delta\sigma'_{v1} := I_1 \cdot q_o = 2872.19\ psf$$

Final Stress at midpoint of soil layer:

$$\sigma'_{f1} := \sigma'_{o1} + \Delta\sigma'_{v1} = 4357.19\ psf$$

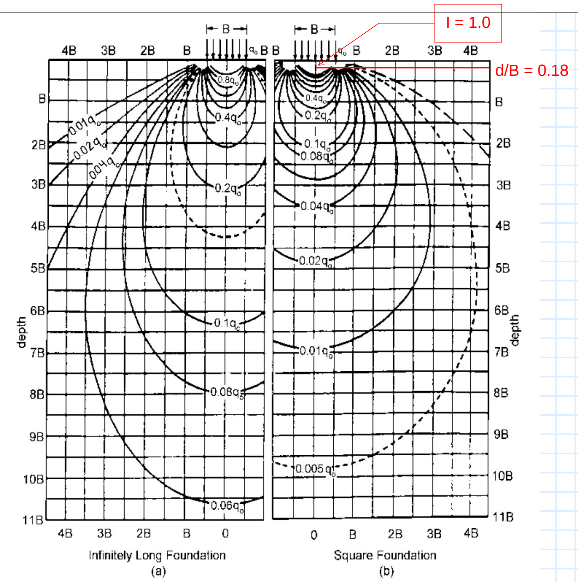

Figure 10.6.2.4.1-1—Boussinesq Vertical Stress Contours for Continuous and Square Footings Modified after Sowers (1979)

Settlement of Cohesionless soil:

$N_{60\_1} := 35$ (SPT corrected for energy)

$Soil :=$ "Silty SAND, Gravelly"

Bearing Capacity Index from Figure 10.6.2.4.2b-1.

$C'_1 := 85$

Settlement of soil layer:

$$\delta_{e1} := \frac{d_1}{C'_1} \cdot \log\left(\frac{\sigma'_{f1}}{\sigma'_{o1}}\right) = 0.13\ in$$

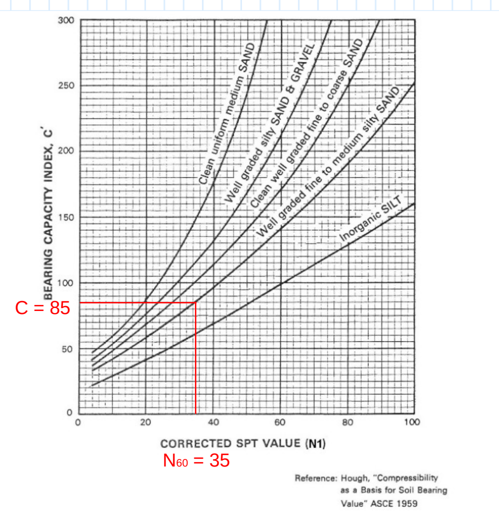

Figure 10.6.2.4.2b-1—Bearing Capacity Index versus Corrected *SPT* (Hough, 1959, as modified in Samtani and Nowatzki, 2006)

Settlement Calculation of Soil Layer 2:

(Layer 2 from soil profile)

$Soil_{Layer2} :=$ "Cohesionless"

$d_2 := d'_2 = 2\ ft$

$\gamma'_2 := 130 \cdot pcf - 62.4\ pcf = 67.6\ pcf$ $\quad c'_2 := 0\ psf$

Depth from bottom of foundation to mid-point of soil layer:

$$d'_{2m} := d'_{1m} + \frac{d_1}{2} + \frac{d_2}{2} = 3\ ft$$

Effective soil stress at midpoint of soil layer:

$$\sigma'_{o2} := \sigma'_{o1} + \gamma'_1 \cdot \frac{d_1}{2} + \gamma'_2 \cdot \frac{d_2}{2} = 1687.6\ psf$$

Stress Influence Factor (AASHTO Fig. 10.6.2.4.1-1):

$$\frac{d'_{2m}}{B} = 0.55 \qquad I_2 := 0.65$$

Effective vertical stress increase on soil layer:

$$\Delta\sigma'_{v2} := I_2 \cdot q_o = 1866.92\ psf$$

Final Stress at midpoint of soil layer:

$$\sigma'_{f2} := \sigma'_{o2} + \Delta\sigma'_{v2} = 3554.52\ psf$$

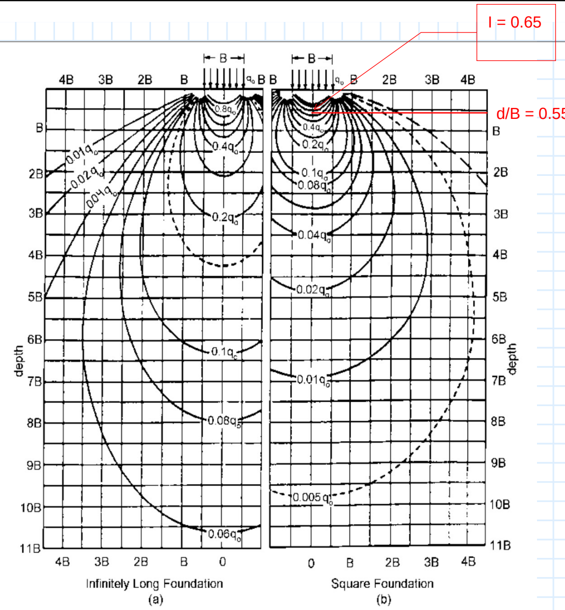

Figure 10.6.2.4.1-1—Boussinesq Vertical Stress Contours for Continuous and Square Footings Modified after Sowers (1979)

Settlement of Cohesionless soil:

$N_{60\_2} := 23$ (SPT corrected for energy)

$Soil :=$ "Silty GRAVEL, Sandy"

Bearing Capacity Index from Figure 10.6.2.4.2b-1.

$C'_2 := 84$

Settlement of soil layer:

$$\delta_{e2} := \frac{d_2}{C'_2} \cdot \log\left(\frac{\sigma'_{f2}}{\sigma'_{o2}}\right) = 0.09\ in$$

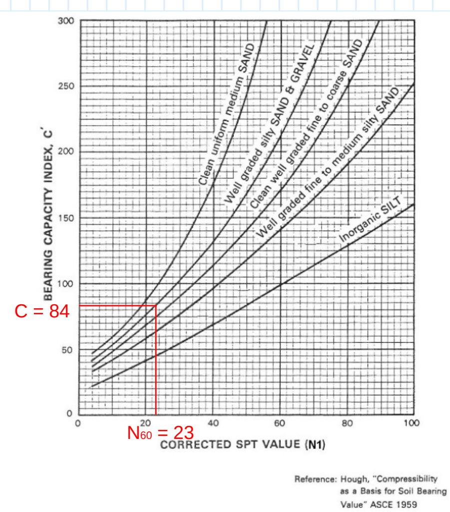

Figure 10.6.2.4.2b-1—Bearing Capacity Index versus Corrected *SPT* (Hough, 1959, as modified in Samtani and Nowatzki, 2006)

Settlement Calculation of Soil Layer 3:

(Layer 3 from soil profile)

$Soil_{Layer3} :=$ "Cohesionless"

$d_3 := d'_3 = 6\ ft$

$\gamma'_3 := 135 \cdot pcf - 62.4\ pcf = 72.6\ pcf$ $\quad c'_3 := 0\ psf$

Depth from bottom of foundation to mid-point of soil layer:

$$d'_{3m} := d'_{2m} + \frac{d_2}{2} + \frac{d_3}{2} = 7\ ft$$

Effective soil stress at midpoint of soil layer:

$$\sigma'_{o3} := \sigma'_{o2} + \gamma'_2 \cdot \frac{d_2}{2} + \gamma'_3 \cdot \frac{d_3}{2} = 1973\ psf$$

Stress Influence Factor (AASHTO Fig. 10.6.2.4.1-1):

$$\frac{d'_{3m}}{B} = 1.27 \qquad I_3 := 0.27$$

Effective vertical stress increase on soil layer:

$$\Delta\sigma'_{v3} := I_3 \cdot q_o = 775.49\ psf$$

Final Stress at midpoint of soil layer:

$$\sigma'_{f3} := \sigma'_{o3} + \Delta\sigma'_{v3} = 2748.49\ psf$$

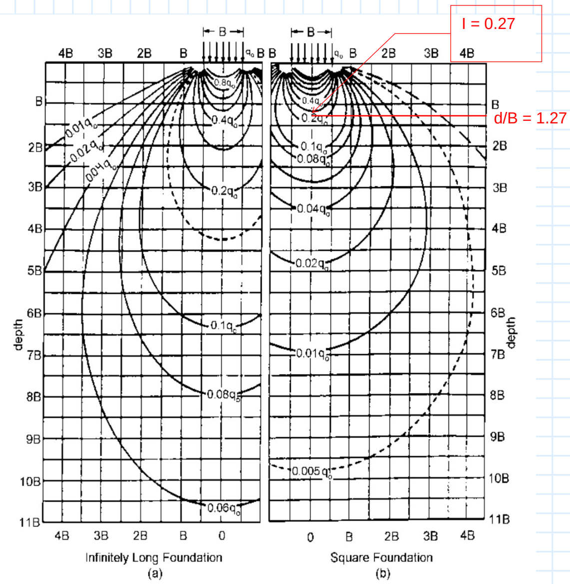

Figure 10.6.2.4.1-1—Boussinesq Vertical Stress Contours for Continuous and Square Footings Modified after Sowers (1979)

Settlement of Cohesionless soil:

$N_{60\_3} := 61$ (SPT corrected for energy)

$Soil :=$ "Sandy GRAVEL, Silty"

Bearing Capacity Index from Figure 10.6.2.4.2b-1.

$C'_3 := 215$

Settlement of soil layer:

$$\delta_{e3} := \frac{d_3}{C'_3} \cdot \log\left(\frac{\sigma'_{f3}}{\sigma'_{o3}}\right) = 0.05\ in$$

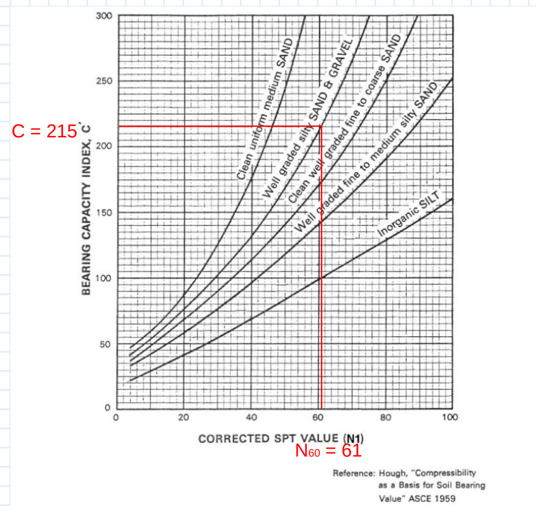

Figure 10.6.2.4.2b-1—Bearing Capacity Index versus Corrected *SPT* (Hough, 1959, as modified in Samtani and Nowatzki, 2006)

Settlement Calculation of Soil Layer 4:

(Layer 4 from soil profile)

$Soil_{Layer4} := \text{"Cohesionless"}$

$d_4 := d'_4 = 7\ ft$

$\gamma'_4 := 130 \cdot pcf - 62.4\ pcf = 67.6\ pcf$ $c'_4 := 0\ psf$

Depth from bottom of foundation to mid-point of soil layer:

$$d'_{4m} := d'_{2m} + \frac{d_2}{2} + \frac{d_3}{2} = 7\ ft$$

Effective soil stress at midpoint of soil layer:

$$\sigma'_{o4} := \sigma'_{o2} + \gamma'_2 \cdot \frac{d_2}{2} + \gamma'_3 \cdot \frac{d_3}{2} = 1973\ psf$$

Stress Influence Factor (AASHTO Fig. 10.6.2.4.1-1):

$$\frac{d'_{3m}}{B} = 1.27 \qquad I_4 := 0.27$$

Effective vertical stress increase on soil layer:

$$\Delta\sigma'_{v4} := I_3 \cdot q_o = 775.49\ psf$$

Final Stress at midpoint of soil layer:

$$\sigma'_{f4} := \sigma'_{o3} + \Delta\sigma'_{v3} = 2748.49\ psf$$

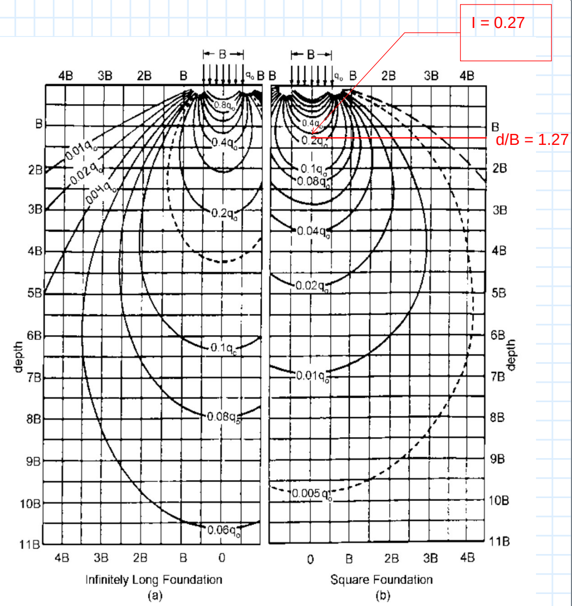

Figure 10.6.2.4.1-1—Boussinesq Vertical Stress Contours for Continuous and Square Footings Modified after Sowers (1979)

Settlement of Cohesionless soil:

$N_{60\_4} := 31$ (SPT corrected for energy)

$Soil := \text{"Silty SAND, Gravelly"}$

Bearing Capacity Index from Figure 10.6.2.4.2b-1.

$C'_4 := 78$

Settlement of soil layer:

$$\delta_{e4} := \frac{d_4}{C'_4} \cdot \log\left(\frac{\sigma'_{f4}}{\sigma'_{o4}}\right) = 0.16\ in$$

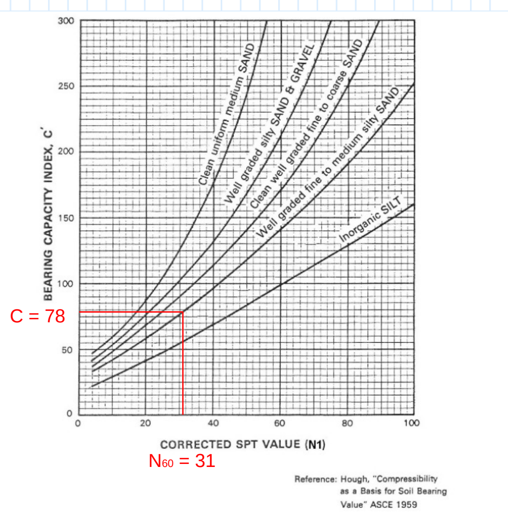

Figure 10.6.2.4.2b-1—Bearing Capacity Index versus Corrected *SPT* (Hough, 1959, as modified in Samtani and Nowatzki, 2006)

Total Elastic Settlement:

$\delta_e := \delta_{e1} + \delta_{e2} + \delta_{e3} + \delta_{e4} = 0.43\ in$

Total Consolidation Settlement:

$\delta_c := 0\ in$

Total Settlement:

$\delta := \delta_{Short\_Term} + \delta_e + \delta_c = 0.51\ in$

STRUCTURAL DESIGN

Project:	**120186 NYSTA I-95 OHSS**		
Contract No.		P.I.N.	
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Calculated By:	RG	Date:	05/23/25
Checked By:	RK	Date:	05/23/25

Subject: Cantilever Sign Structure
Drilled Shaft Structural Design Loc. 1

(All references are to *AASHTO Standard Specifications for Highway Bridges, 17th ed - 2002, Division I - Design* unless otherwise noted.)

Per Section 13.6.2 of AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals Sixth Edition (2013) with 2015 Interims, the structural design of drilled shafts is in accordance with the provisions for the design of reinforced concrete given in the Standard Specifications for Highway Bridges (2002).

Material Properties

f_c' = 4.00 ksi (28 days min. compressive strength of concrete)

$E_c = 57{,}000\sqrt{f_c'}$ (Modulus of elasticity of concrete, Section 8.7.1)

E_c = 3605.00 ksi

f_y = 60.00 ksi (Yield strength of the reinforcing steel)

E_s = 29000 ksi (Modulus of elasticity of reinforcing steel, Section 8.7.2)

Foundation Loads

The maximum moment and shear demand was determined by analysis with LPile 2019. The design loads are summarized below.

N =	26.3	kips	(Max. Axial Loading, see Foundation loads) (Updated to include the shaft weight)
M =	7896.84	kip-in	(Max. Moment per LPile output)
V =	93.76	kips	(Max. Shear force per LPile output)
T =	0.00	kips	(Max. uplift load)

D =	66.00	in	(Outer diameter of shaft foundation)
Cover =	3.00	in	(Clear cover to reinforcement, (NYSDOT BD-OS10) & Section 8.22.1)
Exposed H =	24.00	in	(Approximate exposed height above grade)
A_g =	3421.19	in^2	

Lateral Ties

Bar Size =	4		
Bar Dia. =	0.50	in	
Bar Spacing =	6.00	in	
A_b =	0.31	in^2	(Area of one bar)

Longitudinal Bars

Bar Size =	8		(Assumed)
Bar Dia. =	1.00	in	
Bar Quantity =	44		(Assumed)
A_b =	0.44	in^2	(Area of one bar)
A_{st} =	19.36	in^2	(Total area of steel, based on assumed reinforcement)

Allowable Stresses in Compression Members

Per section 8.15.4, combined flexural and load capacity is calculated as 35% of the capacity calculated in the Load Factor Design method in section 8.16.4. Slenderness requirements per section 8.16.5 shall also be met. Load factor ϕ is taken as 1.0.

(All references are to *AASHTO Standard Specifications for Highway Bridges, 17th ed - 2002, Division I - Design* unless otherwise noted.)

Max. Axial Load

Per section 8.16.4.1.2, members subjected to combined loading cannot have an axial load exceeding $P_{n(max)}$

$$\varphi P_{n(max)} = \varphi * 0.80[0.85 f'_c(A_g - A_{st}) + f_y A_{st}]$$ For members with tie reinforcement, Section 8.16.4.1

$$N \leq 0.35 P_{n(max)}$$

ϕ = 1.0 (Section 8.15.4)

$\phi P_{n(max)}$ = 10182.27 kips

$0.35*\phi P_{n(max)}$ = 3563.79 kips (Axial capacity is taken as 35% of capacity per section 8.15.4)

N = 26.3 kips (Axial load)

N < 0.35ϕPn(max), therefore axial capacity is OK

To determine the minimum gross area required to meet the axial capacity:

$$\varphi P_{n(max)} = \varphi * 0.80[0.85 f'_c(A_g - A_{st}) + f_y A_{st}]$$

$$N \leq 0.35 P_{n(max)}$$

assume $A_{st} = 0.01 A_g$

therefore, solving the above equation for A_g:

$$A_g \geq \frac{3.57N}{0.8415 f'_c + 0.01 f_y}$$

Recall N = 26.3 kips (Axial load)

$A_{g,min}$ = 23.67 in^2 (Minimum gross area)

Minimum Reinforcing Steel

Per section 8.18.1.2, the minimum area of longitudinal reinforcement shall not be less than 0.01 times the gross area, Ag, of the section. When the cross section is larger than that required by consideration of loading, a reduced effective area may be used. The reduced effective area shall not be less than that which would require 1% of longitudinal reinforcement to carry the loading.

$A_{st(min)}$ = 34.21 in^2

Ast < Ast(min), therefore use reduced effective area

A_g = 1936.00 in^2 (Reduced effective gross area, taken as $A_{st}/0.01$)

Slenderness Effects

The foundation will be considered to be braced against lateral deflection at a depth of 5 ft below grade. Therefore the unsupported length will be the exposed height + 5'-0". No estimate of this is given in *AASHTO Standard Specifications*, so the estimate is based on *AASHTO LRFD Bridge Specifications, 7th ed* Section C10.8.3.9.3.

It is assumed that the surrounding soil supports the shaft against sidesway.

ℓ_u = 84.00 in (Unsupported length)

k = 1.0 (Section 8.16.5.2.3 for member supported against sidesway)

r = 16.50 in (Section 8.16.5.2.2, 0.25*D)

$k\ell_u/r$ = 5.09

From Section 8.16.5.2.4, for compression members braced against sidesway, slenderness effects can be neglected if:

(All references are to *AASHTO Standard Specifications for Highway Bridges, 17th ed - 2002, Division I - Design* unless otherwise noted.)

$$\frac{kl_u}{r} < 34 - (12\frac{M_{1b}}{M_{2b}})$$

Since the soil exerts no moment on the foundation, the smaller end moment M_{1b} = 0, therefore:
kl/r<34, neglect slenderness effects

Combined Flexure and Axial Load - Load-Moment Interaction

Determine the required reinforcement ratio ρ_g using interaction diagram analysis

h =	66.00	in	(Diameter of shaft)
γh =	58.00	in	(Diameter of circle of reinforcement)
γ =	0.88		
γ_{low} =	0.80		(Lower Bound Table)
γ_{high} =	0.90		(Upper Bound Table)

Refer to ACI SP-17(14) for interaction diagrams C3-60.8 and C3-60.9 (for γ = 0.8 and γ = 0.9 respectively). See the interaction diagrams attached at the end of this section for reference.

Determine the values of K_n and R_n to enter into the interaction diagram:

N =	26.3	kips	(Axial load)
M =	7896.84	kip-in	(Bending moment)

A_{st}/A_g = 0.57%

Use Reduced Effective Area, Ae, for calculation

P_n = 26.30 kips (Assume P_n = N)

$$K_n = \frac{P_n}{f'_c A_g}$$

K_n = 0.003

ρ = 1.00% (Design reinforcement ratio, A_{st}/A_g)

$R_{n,\gamma=0.8}$ = 0.075 (Conservative R_n from Diagram C3-60.8)

$$R_n = \frac{M_n}{f'_c A_g h}$$

M_n =	38332.80	kip-in
0.35 *M_n =	13416.48	kip-in

0.35Mn ≥ M, reinforcement is adequate, OK

Section Properties

D =	66.00	in	(Outer diameter of drilled shaft foundation)
Cover =	3.00	in	(Clear cover to reinforcement, Section 8.22.1)

Lateral Ties

Bar Size = 4 (#4 ties used for shear reinforcement)

(All references are to *AASHTO Standard Specifications for Highway Bridges, 17th ed - 2002, Division I - Design* unless otherwise noted.)

Bar Spacing = 6.00 in

Longitudinal Bars

Bar Size = 8
Bar Quantity = 44

Longitudinal Bar Spacing (Section 4.6.6.2.1)

Min. Spacing =	3.00	in	(3 * bar diameter)
d_{reinf} =	58.00	in	(Diameter of reinforcement circle)
Spacing =	4.14	in	(Circumference of reinforcement circle/bar quantity)

Min. spacing requirement is OK

Allowable Stresses

Stress on Extreme Compression Fiber

N =	26.3	kip	(Axial load)
A_g =	3421.19	in^2	(Area of concrete section)
M =	7896.84	kip-in	(Bending moment)
S =	28224.85	in^3	(Section Modulus of concrete section)
F_c =	0.29	ksi	(Compression on extreme fiber, N/A + M/S)
f_c =	1.60	ksi	(Allowable compression stress on extreme fiber, 0.4*f'_c, Section 8.15.2.1.1)

Fc < fc, therefore compression capacity of concrete is OK

Tension Capacity

f_s =	24.00	ksi	(Allowable stress in reinforcement, Section 8.15.2.2)
A_{st} =	19.36	in^2	(Total area of steel)
F_t =	464.64	kip	f_s*A_{st})
T =	0.00	Kip	(Okay)

Shear in Compression Members

V =	93.76	kips	(Shear Force)
b_w =	66.00	in	(Diameter of shaft)
d =	51.46	in	(Distance from extreme compression fiber to centroid of tension reinforcement = $b_w/2+2(d_{reinf}/2)/\pi$)

$$v=\frac{V}{b_w d}$$ (Section 8.15.5.1.1)

v = 0.03 ksi (Design shear stress)

$$v_c=0.95\sqrt{f'_c}$$ (Section 8.15.5.2.2)

v_c = 0.06 ksi (Allowable shear stress carried by concrete)

v < vc, therefore shear capacity of concrete is sufficient, OK

Per 8.19.1.1(b), since v/vc < 0.5, check for quantity of shear reinforcement is not required

Engineering and Land Surveying, P.C.

Project: **120186 NYSTA I-95 OHSS**

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Sheet No.		of	
Calculated By:	RG	Date:	05/23/25
Checked By:	RK	Date:	05/23/25

Subject: Cantilever Sign Structure
Drilled Shaft Structural Design Loc. 1

(All references are to *AASHTO Standard Specifications for Highway Bridges, 17th ed - 2002, Division I - Design* unless otherwise noted.)

Shear Friction

Check the shear capacity at the interface between the steel anchor bolts and the concrete shaft, assuming cracking along the plane of the connection.

V =	93.76	kips	(Shear Force)
f_s =	24.00	ksi	(Allowable stress in reinforcement, Section 8.15.2.2)
μ =	0.7		(Coefficient of friction for normal weight concrete anchored to studs or reinforcing bars, section 8.15.5.4.3)

$$A_{vf} = \frac{V}{f_s \mu}$$ (Section 8.15.5.4.3)

A_{vf} =	5.58	in^2	(Required area of shear reinforcement)
Recall A_{st} =	19.36	in^2	(Area of longitudinal steel reinforcement)

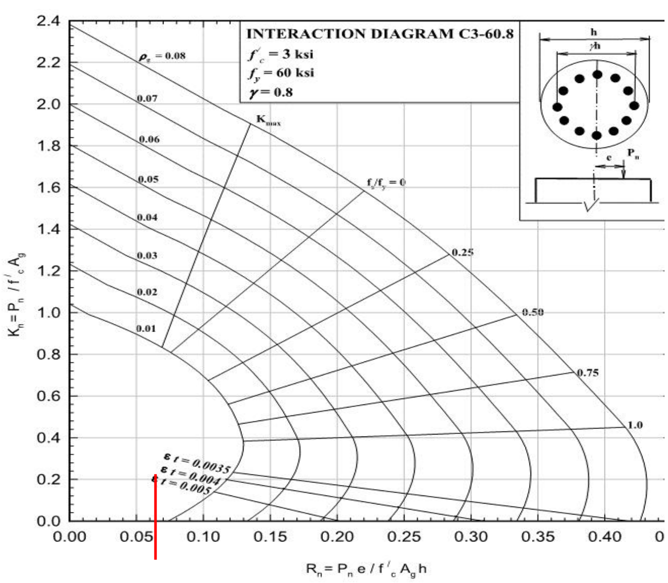
Avf < Ast, therefore shear capacity of reinforcement is OK

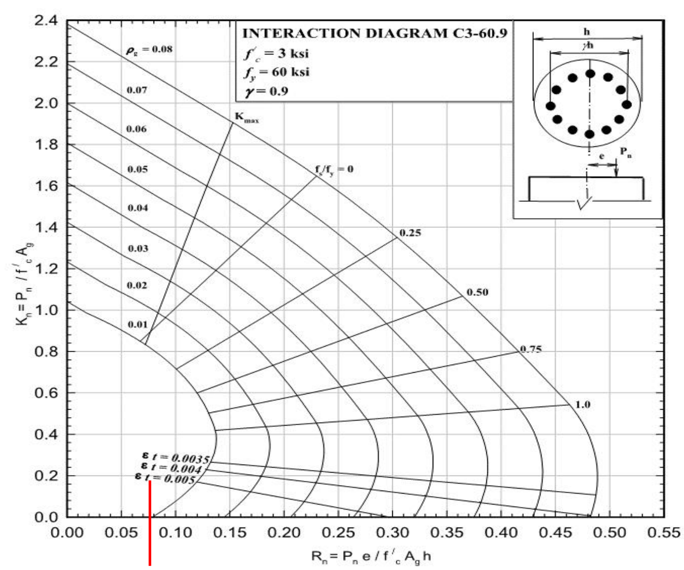
Temperature Reinforcement

C =	17.28	ft	(Shaft Circumference)
A_{st} =	19.36	in^2	(Longitudinal Steel Area)
A_{st} /C =	1.12	in^2 /ft	(Temperature reinforcement provided)
Min. =	0.125	in^2 /ft	(Minimum temperature reinforcement, Section 8.20.1)

Ast > Min., therefore temperature reinforcement is OK

Interaction Diagrams from ACI SP-17(14)





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Subject: Cantilever Sign Structure
Drilled Shaft Structural Design Loc. 2

(All references are to *AASHTO Standard Specifications for Highway Bridges, 17th ed - 2002, Division I - Design* unless otherwise noted.)

Per Section 13.6.2 of AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals Sixth Edition (2013) with 2015 Interims, the structural design of drilled shafts is in accordance with the provisions for the design of reinforced concrete given in the Standard Specifications for Highway Bridges (2002).

Material Properties

f_c' = 4.00 ksi (28 days min. compressive strength of concrete)

$E_c = 57{,}000\sqrt{f_c'}$ (Modulus of elasticity of concrete, Section 8.7.1)

E_c = 3605.00 ksi

f_y = 60.00 ksi (Yield strength of the reinforcing steel)

E_s = 29000 ksi (Modulus of elasticity of reinforcing steel, Section 8.7.2)

Foundation Loads

The maximum moment and shear demand was determined by analysis with LPile 2019. The design loads are summarized below.

N =	26.3	kips	(Max. Axial Loading, see Foundation loads) (Updated to include the shaft weight)
M =	7936.20	kip-in	(Max. Moment per LPile output)
V =	101.05	kips	(Max. Shear force per LPile output)
T =	0.00	kips	(Max. uplift load)

D =	66.00	in	(Outer diameter of shaft foundation)
Cover =	3.00	in	(Clear cover to reinforcement, (NYSDOT BD-OS10) & Section 8.22.1)
Exposed H =	24.00	in	(Approximate exposed height above grade)
A_g =	3421.19	in^2	

Lateral Ties

Bar Size =	4		
Bar Dia. =	0.50	in	
Bar Spacing =	6.00	in	
A_b =	0.31	in^2	(Area of one bar)

Longitudinal Bars

Bar Size =	8		(Assumed)
Bar Dia. =	1.00	in	
Bar Quantity =	44		(Assumed)
A_b =	0.44	in^2	(Area of one bar)
A_{st} =	19.36	in^2	(Total area of steel, based on assumed reinforcement)

Allowable Stresses in Compression Members

Per section 8.15.4, combined flexural and load capacity is calculated as 35% of the capacity calculated in the Load Factor Design method in section 8.16.4. Slenderness requirements per section 8.16.5 shall also be met. Load factor ϕ is taken as 1.0.

(All references are to *AASHTO Standard Specifications for Highway Bridges, 17th ed - 2002, Division I - Design* unless otherwise noted.)

Max. Axial Load

Per section 8.16.4.1.2, members subjected to combined loading cannot have an axial load exceeding $P_{n(max)}$

$$\varphi P_{n(max)} = \varphi * 0.80[0.85 f'_c (A_g - A_{st}) + f_y A_{st}]$$

For members with tie reinforcement, Section 8.16.4.1

$$N \leq 0.35 P_{n(max)}$$

ϕ =	1.0		(Section 8.15.4)
$\phi P_{n(max)}$ =	10182.27	kips	
0.35*$\phi P_{n(max)}$ =	3563.79	kips	(Axial capacity is taken as 35% of capacity per section 8.15.4)
N =	26.3	kips	(Axial load)

N < 0.35ϕPn(max), therefore axial capacity is OK

To determine the minimum gross area required to meet the axial capacity:

$$\varphi P_{n(max)} = \varphi * 0.80[0.85 f'_c (A_g - A_{st}) + f_y A_{st}]$$

$$N \leq 0.35 P_{n(max)}$$

assume $A_{st} = 0.01 A_g$

therefore, solving the above equation for A_g:

$$A_g \geq \frac{3.57N}{0.8415 f'_c + 0.01 f_y}$$

Recall N =	26.3	kips	(Axial load)
$A_{g,min}$ =	23.67	in^2	(Minimum gross area)

Minimum Reinforcing Steel

Per section 8.18.1.2, the minimum area of longitudinal reinforcement shall not be less than 0.01 times the gross area, Ag, of the section. When the cross section is larger than that required by consideration of loading, a reduced effective area may be used. The reduced effective area shall not be less than that which would require 1% of longitudinal reinforcement to carry the loading.

$A_{st(min)}$ = 34.21 in^2

Ast < Ast(min), therefore use reduced effective area

A_g = 1936.00 in^2 (Reduced effective gross area, taken as A_{st}/0.01)

Slenderness Effects

The foundation will be considered to be braced against lateral deflection at a depth of 5 ft below grade. Therefore the unsupported length will be the exposed height + 5'-0". No estimate of this is given in *AASHTO Standard Specifications*, so the estimate is based on *AASHTO LRFD Bridge Specifications, 7th ed* Section C10.8.3.9.3.

It is assumed that the surrounding soil supports the shaft against sidesway.

ℓ_u =	84.00	in	(Unsupported length)
k =	1.0		(Section 8.16.5.2.3 for member supported against sidesway)
r =	16.50	in	(Section 8.16.5.2.2, 0.25*D)
$k\ell_u/r$ =	5.09		

From Section 8.16.5.2.4, for compression members braced against sidesway, slenderness effects can be neglected if:

(All references are to *AASHTO Standard Specifications for Highway Bridges, 17th ed - 2002, Division I - Design* unless otherwise noted.)

$$\frac{kl_u}{r} < 34 - (12\frac{M_{1b}}{M_{2b}})$$

Since the soil exerts no moment on the foundation, the smaller end moment M_{1b} = 0, therefore:
kl/r<34, neglect slenderness effects

Combined Flexure and Axial Load - Load-Moment Interaction

Determine the required reinforcement ratio ρ_g using interaction diagram analysis

h =	66.00	in	(Diameter of shaft)
γh =	58.00	in	(Diameter of circle of reinforcement)
γ =	0.88		
γ_{low} =	0.80		(Lower Bound Table)
γ_{high} =	0.90		(Upper Bound Table)

Refer to ACI SP-17(14) for interaction diagrams C3-60.8 and C3-60.9 (for γ = 0.8 and γ = 0.9 respectively). See the interaction diagrams attached at the end of this section for reference.

Determine the values of K_n and R_n to enter into the interaction diagram:

N =	26.3	kips	(Axial load)
M =	7936.2	kip-in	(Bending moment)

A_{st}/A_g = 0.57%

Use Reduced Effective Area, Ae, for calculation

P_n = 26.30 kips (Assume P_n = N)

$$K_n = \frac{P_n}{f'_c A_g}$$

K_n = 0.003

ρ = 1.00% (Design reinforcement ratio, A_{st}/A_g)

$R_{n.\gamma=0.8}$ = 0.075 (Conservative R_n from Diagram C3-60.8)

$$R_n = \frac{M_n}{f'_c A_g h}$$

M_n =	38332.80	kip-in
0.35 *M_n =	13416.48	kip-in

0.35Mn ≥ M, reinforcement is adequate, OK

Section Properties

D =	66.00	in	(Outer diameter of drilled shaft foundation)
Cover =	3.00	in	(Clear cover to reinforcement, Section 8.22.1)

Lateral Ties

Bar Size = 4 (#4 ties used for shear reinforcement)

Engineering and Land Surveying, P.C.

Project:	**120186 NYSTA I-95 OHSS**		
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Checked By:	RK	Date:	05/23/25

Subject: Cantilever Sign Structure
Drilled Shaft Structural Design Loc. 2

(All references are to *AASHTO Standard Specifications for Highway Bridges, 17th ed - 2002, Division I - Design* unless otherwise noted.)

Bar Spacing = 6.00 in

Longitudinal Bars

Bar Size = 8
Bar Quantity = 44

Longitudinal Bar Spacing (Section 4.6.6.2.1)

Min. Spacing =	3.00	in	(3 * bar diameter)
d_{reinf} =	58.00	in	(Diameter of reinforcement circle)
Spacing =	4.14	in	(Circumference of reinforcement circle/bar quantity)

Min. spacing requirement is OK

Allowable Stresses

Stress on Extreme Compression Fiber

N =	26.3	kip	(Axial load)
A_g =	3421.19	in^2	(Area of concrete section)
M =	7936.2	kip-in	(Bending moment)
S =	28224.85	in^3	(Section Modulus of concrete section)
F_c =	0.29	ksi	(Compression on extreme fiber, N/A + M/S)
f_c =	1.60	ksi	(Allowable compression stress on extreme fiber, 0.4*f'_c, Section 8.15.2.1.1)

Fc < fc, therefore compression capacity of concrete is OK

Tension Capacity

f_s =	24.00	ksi	(Allowable stress in reinforcement, Section 8.15.2.2)
A_{st} =	19.36	in^2	(Total area of steel)
F_t =	464.64	kip	f_s*A_{st})
T =	0.00	Kip	(Okay)

Shear in Compression Members

V =	101.05	kips	(Shear Force)
b_w =	66.00	in	(Diameter of shaft)
d =	51.46	in	(Distance from extreme compression fiber to centroid of tension reinforcement = $b_w/2+2(d_{reinf}/2)/\pi$)

$$v=\frac{V}{b_w d}$$ (Section 8.15.5.1.1)

v = 0.03 ksi (Design shear stress)

$$v_c=0.95\sqrt{f'_c}$$ (Section 8.15.5.2.2)

v_c = 0.06 ksi (Allowable shear stress carried by concrete)

v < vc, therefore shear capacity of concrete is sufficient, OK

Per 8.19.1.1(b), since v/vc < 0.5, check for quantity of shear reinforcement is not required

Engineering and Land Surveying, P.C.

Project: 120186 NYSTA I-95 OHSS

Contract No.		P.I.N.	
Sheet No.		of	
Calculated By:	RG	Date:	05/23/25
Checked By:	RK	Date:	05/23/25

Subject: Cantilever Sign Structure
Drilled Shaft Structural Design Loc. 2

(All references are to *AASHTO Standard Specifications for Highway Bridges, 17th ed - 2002, Division I - Design* unless otherwise noted.)

Shear Friction

Check the shear capacity at the interface between the steel anchor bolts and the concrete shaft, assuming cracking along the plane of the connection.

$V =$	101.05	kips	(Shear Force)
$f_s =$	24.00	ksi	(Allowable stress in reinforcement, Section 8.15.2.2)
$\mu =$	0.7		(Coefficient of friction for normal weight concrete anchored to studs or reinforcing bars, section 8.15.5.4.3)

$$A_{vf} = \frac{V}{f_s \mu}$$ (Section 8.15.5.4.3)

$A_{vf} =$	6.01	in^2	(Required area of shear reinforcement)
Recall $A_{st} =$	19.36	in^2	(Area of longitudinal steel reinforcement)

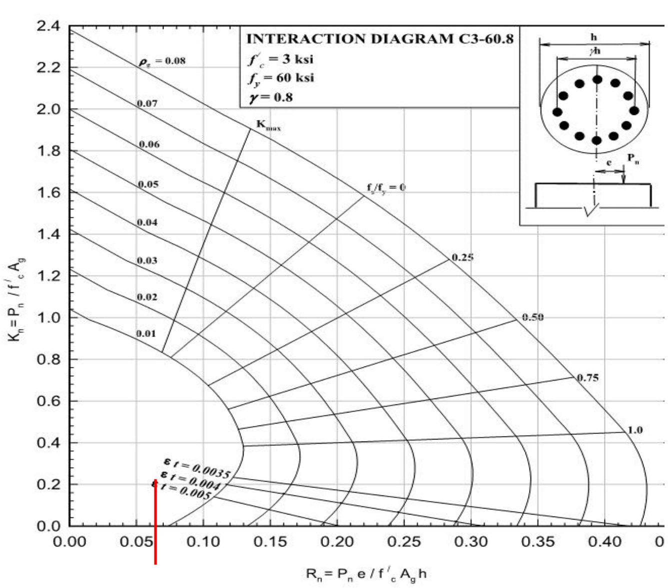
Avf < Ast, therefore shear capacity of reinforcement is OK

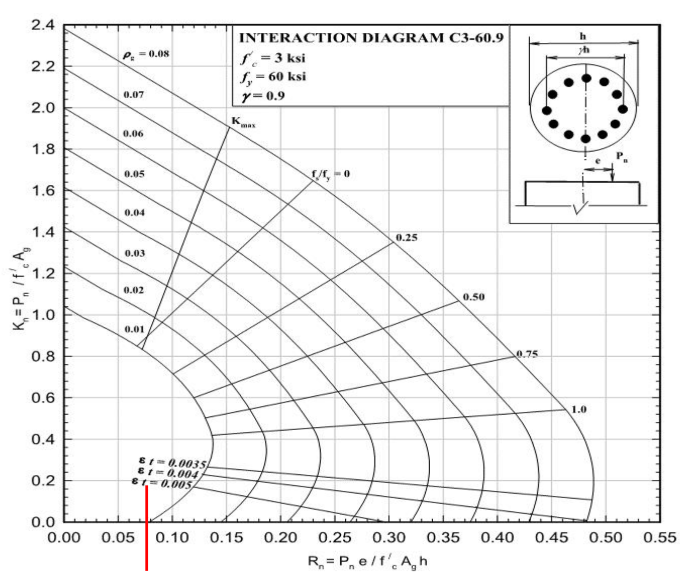
Temperature Reinforcement

$C =$	17.28	ft	(Shaft Circumference)
$A_{st} =$	19.36	in^2	(Longitudinal Steel Area)
$A_{st}/C =$	1.12	in^2 /ft	(Temperature reinforcement provided)
Min. =	0.125	in^2 /ft	(Minimum temperature reinforcement, Section 8.20.1)

Ast > Min., therefore temperature reinforcement is OK

Interaction Diagrams from ACI SP-17(14)





APPENDIX D

SEISMIC DESIGN CRITERIA

All References are to AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition, 2011.

This section determines the seismic design criteria and evaluates the need for liquefaction analysis based on AASHTO Guide Specification for LRFD Seismic Bridge Design, 2nd Edition, 2011.

Seismic Site Class has been determined based on the Average SPT as per Section 3.4.2.1-1. The average SPT of overburden soil for both Borings DM-X-1 and DM-X-2 are equal to 25.30 and 40.58. As per Section 3.4.2.1-1, the site class at both sign structure locations is 'D'.

Figure 3.4.1-4b was used to determine 1-sec period sectral acceleration coeficient (S1). The seismic Design Category as per Table 3.5-1 is 'A'.

As per Section 3.5, liquefaction assesment is not required for structures with SDC 'A'.

SDC A

- No displacement capacity check needed
- No capacity design required
- SDC A minimum requirements
- No liquefaction assessment required

Engineering and Land Surveying, P.C.

Project:	H371.1 Sign Structures		
Contract No.	120186	P.I.N.	
Calculated By:	RG	Date:	2/21/2025
Checked By:	KR	Date:	2/21/2025

Subject: Seismic Design Criteria
H371.1 OHSS - Location 1

All References are to AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition, 2011.

Seismic Site Classification (Section 3.4.2.1-1)

Enter SPT Value of Upper 100ft from the boring:

Boring DM-X-2			
Sample	SPT N (bpf)	Soil layer thickness d (ft)	d/N
1	14	2	0.143
2	15	2	0.133
3	21	2	0.095
4	76	3	0.039
5	15	2	0.133
6	13	2	0.154
7	49	2	0.041
8	31	5	0.161
9	78	5	0.064
10	50	75	1.500
	Sum:	100	2.464

SPT_{avg} =	40.58

Site Class:	D

Seismic Ground Motion

S_1 =	0.040	(Mapped 1-sec period sectral acceleration coeficient, Figure 3.4.1-4b)
F_v =	2.4	(Table 3.4.2.3-2)
S_{D1} =	0.10	(1-sec period design spectral acceleration, $S_{D1} = F_v * S_1$)

SDC:	A	(Seismic Design Category, Table 3.5-1)

Engineering and Land Surveying, P.C.

Project: H371.1 Sign Structures
Contract No. 120186 P.I.N.
Calculated By: RG Date: 2/21/2025
Checked By: KR Date: 2/21/2025

Subject: Seismic Design Criteria
H371.1 OHSS - Location 2

All References are to AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2nd Edition, 2011.

Seismic Site Classification (Section 3.4.2.1-1)

Enter SPT Value of Upper 100ft from the boring:

Boring DM-X-1			
Sample	SPT N (bpf)	Soil layer thickness d (ft)	d/N
1	20	2	0.100
2	23	2	0.087
3	29	2	0.069
4	33	2	0.061
5	26	2	0.077
6	24	2	0.083
7	17	2	0.118
8	46	6	0.130
9	22	5	0.227
10	25	75	3.000
	Sum:	100	3.952

SPT_{avg} =	25.30

Site Class:	D

Seismic Ground Motion

S_1 =	0.040	(Mapped 1-sec period sectral acceleration coeficient, Figure 3.4.1-4b)
F_v =	2.4	(Table 3.4.2.3-2)
S_{D1} =	0.10	(1-sec period design spectral acceleration, $S_{D1} = F_v*S_1$)

SDC:	A	(Seismic Design Category, Table 3.5-1)

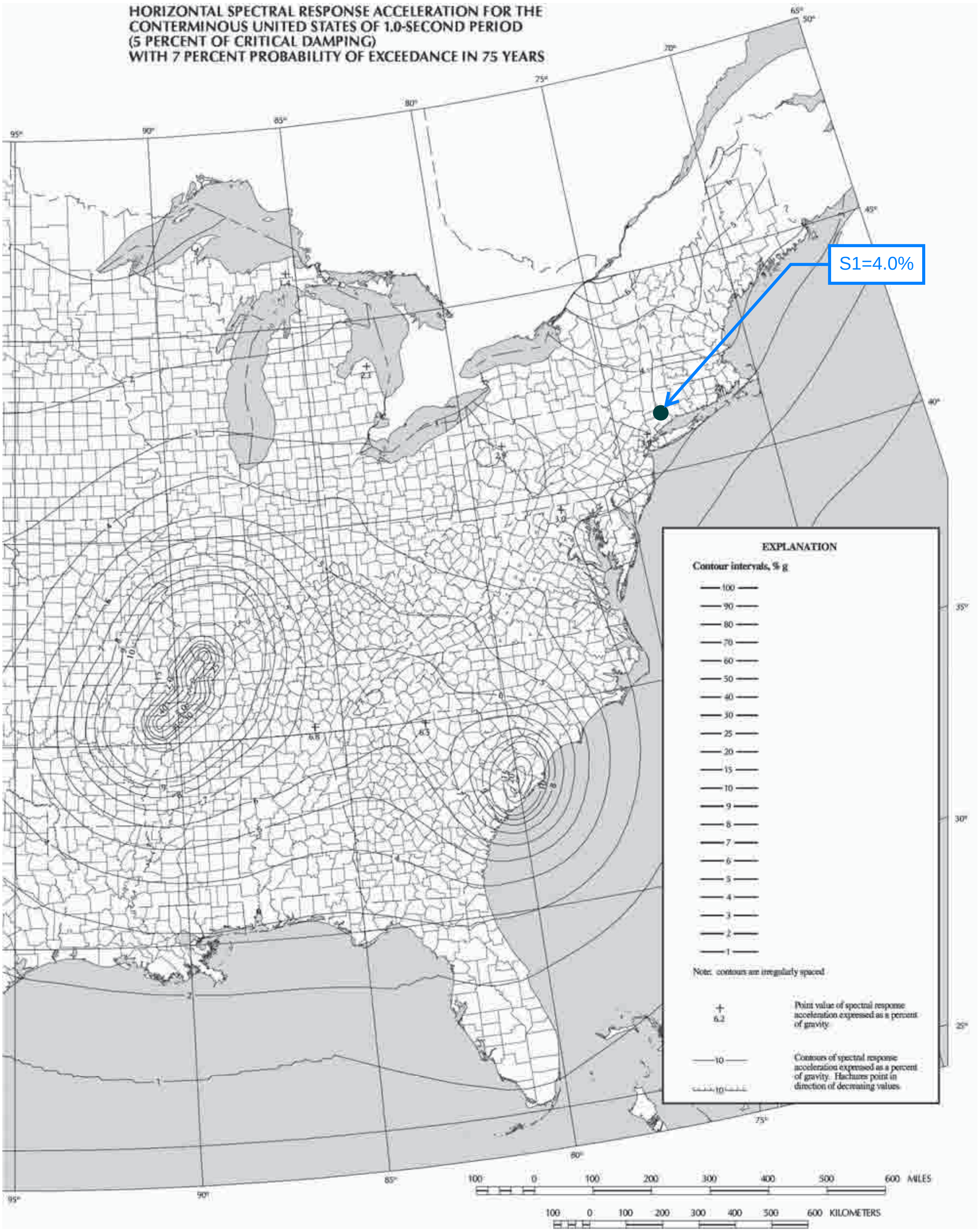


Figure 3.4.1-4b—Horizontal Response Spectral Acceleration Coefficient for the Conterminous United States at Period of 1.0-sec (S_1) with Seven Percent Probability of Exceedance in 75 yr (Approx. 1000-yr Return Period) and Five Percent Critical Damping