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GEOTECHNICAL REPORT

SOUTH BATTERY PARK CITY RESILIENCY
MANHATTAN, NEW YORK

Prepared for:
AECOM
125 Broad St., 15th Floor
New York, NY 10004

Prepared by:
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August 10, 2021

AECOM
125 Broad St., 15th Floor
New York, NY 10004

Attention: Ms. Rachel Dencker

REPORT: Geotechnical Report
South Battery Park City Resiliency
Manhattan, New York
(17-NY165-01)

Ms. Rachel Dencker,

This Report covers the geotechnical investigation and analyses completed for the South Battery Park City Resiliency Project in the Borough of Manhattan, New York.

Thank you for the opportunity of assisting you on this project. If you have any questions concerning the information or recommendations presented in this report, or if we can be of further assistance, please call.

Sincerely,

OWEIS ENGINEERING INC.

James Malak, P.E.
Geotechnical Project Manager

JM/mas

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PROJECT DESCRIPTION

Location and Proposed Construction

The project is located in Lower Manhattan and consists of a new flood barrier system and construction of a new pavilion structure. The proposed flood barrier system includes seepage barriers below the ground surface consisting of either full cut-off or partial cut-off walls and flood gates that are stored in the ground and raised in the event of a storm condition to prevent the flood waters from inundating the area. The proposed flood barrier is approximately 1,500 linear feet and is to be extended from the Museum of Jewish Heritage, through Wagner Park, across the Pier A Plaza and potentially along a line south of Battery Place to State Street (see Figure 1). The new pavilion structure is to be built to the north east of the existing structure, and foundation support is to be evaluated as part of the project.

Figure 1: Site Location Map

PURPOSE AND SCOPE OF SERVICES

The purpose of this investigation is to explore and evaluate physical subsurface conditions based on the soil borings, field permeability tests and laboratory tests and to provide geotechnical recommendations and design criteria related to the proposed construction.

The following services were performed:

1. Developed an investigation program consisting of borings and field permeability tests. OEI coordinated with AECOM in locating the borings and utilized the MTA drawings to check the minimum required clearance between soil borings and the tunnel.
2. Procurement of contractors, and implementation and observation of the field investigation including soil borings, installation of monitor wells and permeability tests.
3. Arranged for performance of soil tests including Grain Size Tests and Atterberg Limits on selected spoon samples of both granular and cohesive material to aid in classification of the materials sampled and to assess their engineering properties.
4. Correlated and evaluated the data gathered, performed engineering analyses and evaluation including liquefaction potential analyses, seepage analyses (using hydrograph of 100-Year Storm Water Level provided by AECOM), stability analyses of the proposed floodwall foundation, bearing capacity check of feasible foundations for the proposed pavilion structures, settlement analyses due to raised grades, evaluation of typical rigid pavement sections, recommended soil parameters for retaining wall design, and construction recommendations.
5. Prepared this report containing our conclusions and recommendations.

SITE HISTORY AND GEOLOGY

The subsurface conditions below Battery Park City are the multiple shoreline expansions into the Hudson River originating back from the late 1700's. Prior to these expansions, the original shore line was to the West of Washington Street, and consisted of rock-filled cribs, timber wharves and other structures that have since been covered up by miscellaneous fill materials. According to

Surficial Geologic Map of New York, the surficial geology of the original site comprises primarily of till of variable texture (e.g., clay, silt-clay, boulder clay). The underlining bedrock formation is Manhattan Schist according to U. S. Geological Survey.

SUBSURFACE INVESTIGATION AND CONDITIONS

General

The subsurface investigation consisted of performing eleven (11) geotechnical borings and ten (10) field permeability tests performed in six (6) selected boreholes at various depths to evaluate the geotechnical properties including hydraulic properties of soil and rock for the proposed pavilion and floodwall structures.

Soil Borings

The soil borings were designated as (B-1 to B-11) with approximate locations shown on Drawing No 1-Boring Location Plan. The borings were drilled by Craig Test Boring Co. between May 7th to May 21th 2019, and resident observation provided by Oweis Engineering Inc. (OEI). The borings were advanced to depths ranging from 32 to 65 feet below the existing ground surface except boring B-10 which was attempted multiple times at various locations and was finally abandoned due to various obstructions within the upper 10 feet below existing grades.

The borings were drilled using CME-75 drilling rig and mud rotary drilling technique. Soil and rock samples were obtained using techniques and equipment in general accordance with the American Society for Testing and Materials (ASTM) Standard Specification D1586-Standard Penetration Test (SPT). When encountered within the limits of the boring, rock coring was performed using a five-foot long NX (2-1/8 in O.D.) core barrel. Ten-foot rock cores were obtained at six (6) of the eleven (11) borings. Rock coring was performed in order to verify the presence of bedrock, and assess its quality as indicated by Core Recovery and Rock Quality Designation (RQD). SPT-N values obtained with an automatic trip hammer were corrected for use in the analyses when appliable to allow for above 60% hammer efficiencies. All samples were identified in the field according to the Burmister Soil Classification Method. Boring logs are included in Appendix A.

Generalized Soil Profile

The subsurface conditions are based on our interpretation of the results of the field investigation. Subsurface conditions can be described by the following soil strata and generalized subsurface profiles along the proposed floodwall alignment and the area for the proposed pavilion are included as Drawings 2 and 3, respectively.

Stratum 1: Fill Materials: Light Brown/Dark Brown Sand - Stratum 1 includes loose to medium dense sand with varying components of silt and gravel. Typically, brick fragments were encountered within the top 2 ~ 5 feet, except at B-7 and B-8 where brick fragments were encountered to depths of 22 feet. This stratum was generally encountered from existing grade to approximately 15 ~ 19 feet below exiting grades except at B-11 where it was encountered at a depth of 28.5ft. The Stratum is generally in a medium dense condition with typical SPT N values ranging from 12 ~ 27 blows per foot (bpf) except at B-7 and B-8, where typical SPT N values range from 4 ~ 10 blows per foot.

Stratum 2: Possible Fill Materials: Gray/Brown/Black Sands **-** This Stratum generally consists of medium to fine sand with a trace of silt and clay. Higher concentrations of organic silt and clay were also encountered at the bottom of this stratum. The thickness of this layer varied from 20 feet to 38 feet. This stratum is generally in loose to medium dense condition with typical SPT N-values ranging from 5 bpf to 14 bpf except at B-7 and B-8 where SPT N-values ranged from 2 bpf to 4 bpf. One (1) boring (B-11) was terminated in this stratum. This stratum is classified as "possible fill due to the presence of wood observed in the stratum and inconsistent SPT N-values.

Stratum 3: Organic Silt and Clay - Stratum 3 generally consists of soft black organic silt or dark gray/black silty clay with components of gravel. Occasionally, decomposed wood and shell fragments are observed in this stratum. This stratum starts from the bottom of Stratum 2 and extends to the top of bedrock with a thickness ranging from approximately 5 feet to 20 feet. Occasionally, high SPT blow counts were recorded in this stratum due to existence of gravel and decomposed wood.

Stratum 4: Manhattan Schist - Bedrock consists of gray hard, slightly weathered, slightly fractured schist. This stratum was encountered at approximately 50 feet to 55 feet below existing grades. The rock cores obtained during the field investigation indicate good to excellent rock quality with core recovery of 78.3% ~ 100% and Rock Quality Designation (RQD) of 78.3% ~ 100% except at B-5 and B-9 with RQD of 16.7% ~ 55% and 52.5% ~ 74.2%, respectively.

Groundwater Conditions

Two (2) temporary groundwater observation wells were installed at B-2 and B-5 at the completion of drilling operations. Depths of water observed in the two temporary wells during the subsurface investigation ranged from 9.6 ft. to 10.7 ft. below the existing ground surface with corresponding elevations estimated from EL -0.4 ~ EL 1.15 (see Appendix B for field water level readings). Groundwater levels can fluctuate with tidal variations in this area.

Geotechnical Laboratory Testing

At the completion of the field investigation, laboratory tests including Grain Size Analysis and Atterberg Limits were performed on thirty-eight (38) spoon samples retrieved from the borings to verify our field classifications. The laboratory testing was performed by TerraSense, LLC located in Totowa, NJ. The results of the geotechnical laboratory testing are included in Appendix C.

Filed Permeability Tests

Field permeability tests were performed at various depths in the selected boreholes. Ten (10) falling head tests were conducted within the saturated zone in five selected boreholes (B-1, B-2, B-4, B-5 and B-8) at depths ranging from 15 ft. to 52 ft. below the existing ground surface and, at 2 ft. intervals in general accordance with ASTM D6391-11. Three (3) falling head tests were also performed within the unsaturated zone in B-11 in accordance with Procedures Governing Limited Geotechnical Investigations for Right of Way, Green Infrastructure Practices, July, 2017. In all tests, an In-Situ Level Troll 700 Data Logger which meets the USGS surface water specification of ±0.01 foot was used to capture a continuous water level, water pressure and temperature. Field measured hydraulic conductivities in B-1, B-2, B-4, B-5 and B-8 were estimated in accordance with the method specified in Table 15 of Geotechnical Design Manual DM7 7.1-105 while the hydraulic conductivities for B-11 were estimated in accordance with the method specified in ASTM D6391-11.

A summary of the estimated field measured permeability's is presented in Table 1. The results at B-2 at depth of 50-52 ft. bgs. were not reported due to the low quality of the field data. The collected field data and estimations of hydraulic conductivities of soil are presented in Appendix D.

Table 1: Field Permeability Test Results

Boring No.	Test Interval (ft) (Depth Below Ground Surface)	Hydraulic Conductivity (ft/day)	Remarks
B-1	15-17	1.2	Fill (brown fine sand, trace silt)
B-2	45-47	1.5	Fill (brown medium-fine sand, trace silt, trace fine gravel)
	50-52	N/A	Poor data quality
B-4	15-17	6.4	Fill (brown fine sand, trace silt)
	30-32	6.9	Fill (gray fine sand, trace silt)
B-5	25-27	1.6	Fill (gray fine sand, trace silt)
B-8	25-27	17.0	Fill (gray coarse to fine sand, some coarse to fine gravel, little silty clay)
B-11	4	2.7	Fill (light brown fine sand, trace silt)
	6	2.9	Fill (light brown fine sand, trace silt, trace gravel)
	10	1.2	Fill (light brown fine sand, trace silt)

<u>**Permeability Derived from Grain Size**</u>

Permeability of granular material was also estimated based on published correlations between permeability and grain sizes of soil. Eight (8) different methods including Hazen, Kozney-Carman, Brayer, Slitcher, Terzaghi, USBR, Alyamani & Sen and Masch & Denny Methods were utilized to predict permeability from the grain size curves of total thirty-five (35) granular soil samples which were collected during the subsurface investigation at various depths and sent to a Lab for grain size analyses. Assumptions and limitations of each method are explained in the literature and not presented here. Table 2 shows the summary. As shown in the Table 2, the average permeability varies between 25.8 ft./day and 85.4 ft./day. Cozney - Carman, Hazen and Brayer Methods estimated higher permeabilities while Slitcher, USBR and Masch and Denny estimated the lower ones. Permeabilities estimated by Terzaghi method stay in the middle.

Table 2: Grain - Size Derived Permeabilities

Boring No.	Depth (ft.)	Permeability (ft./day)							
		Hazen	Kozney-Carman	Brayer	Slitcher	Terzaghi	USBR	Alyamani & Sen	Masch and Denny
B-1	10-12	60.0	73.9	53.3	22.9	40.3	19.7	19.6	27.7
B-1	15-17	64.3	84.8	56.7	25.5	45.0	17.0	22.0	27.7
B-1	20-22	86.5	116.7	76.1	34.8	61.4	22.6	22.2	25.0
B-1	45-47	82.2	67.0	81.9	24.4	42.0	50.0	61.0	25.0
B-2	5-6	80.2	87.4	73.0	28.4	49.9	22.6	23.2	20.0
B-2	25-27	105.3	142.0	92.6	42.3	74.7	25.8	25.0	29.0
B-2	45-47	38.0	30.6	38.1	11.2	19.3	32.9	28.7	24.0
B-2	50-52	124.3	121.5	116.4	41.3	72.0	65.6	106.1	52.0
B-3	1-3	82.9	79.7	78.0	27.2	47.5	41.0	68.3	34.0
B-3	20-22	58.7	79.2	51.6	23.6	41.6	12.2	44.1	31.0
B-3	30-32	108.4	136.5	96.0	41.9	73.8	25.8	75.6	
B-4	10-12	68.2	85.9	60.5	26.4	46.4	17.0	53.7	47.0
B-4	15-17	61.4	79.1	54.3	24.0	42.4	17.0	53.6	28.0
B-4	20-22	68.8	90.7	60.6	27.3	48.1	17.0	53.4	30.0
B-4	30-32	67.7	89.2	59.6	26.8	47.3	17.0	53.5	32.0
B-4	35-37	67.7	89.2	59.6	26.8	47.3	17.0	53.5	33.0
B-5	5-7	38.7	43.0	35.1	13.9	24.4	14.5	29.3	25.0
B-5	20-22	90.2	124.6	79.2	36.7	64.9	19.7	63.0	35.0
B-5	25-27	66.5	87.7	58.6	26.4	46.6	17.0	53.2	31.0
B-5	30-32	59.0	77.8	52.0	23.4	41.3	14.5	44.1	28.0
B-6	20-22	76.7	103.4	67.4	30.8	54.4	19.7	63.0	31.0
B-6	30-32	57.3	73.8	50.6	22.4	39.5	12.2	44.3	26.0
B-7	1-3	-	-	-	3.8	5.5	65.6	34.4	-
B-7	15-17	-	-	-	-	-	2.9	-	-
B-8	20-22	-	-	-	-	-	22.6	-	-
B-8	25-27	-	-	-	-	-	32.9	-	-
B-8	30-32	-	-	-	-	-	65.6	-	-
B-11	0-2	64.7	59.3	61.9	20.6	35.9	41.0	58.1	38.0
B-11	2-4	68.3	60.6	65.9	21.3	37.1	41.0	58.4	32.0
B-11	4-6	47.1	55.6	42.1	17.5	30.8	17.0	34.3	21.0
B-11	6-8	73.6	94.8	65.0	28.8	50.8	19.7	63.5	28.0
B-11	8-10	69.4	87.3	61.4	26.8	47.2	19.7	63.6	26.0
B-11	10-12	57.2	69.0	51.0	21.5	37.9	19.7	49.2	26.0
Average		**71.2**	**85.4**	**64.2**	**25.8**	**45.4**	**26.2**	**49.0**	**30.1**
STD		**19.4**	**25.9**	**17.8**	**8.5**	**15.1**	**16**	**19.3**	**7**

Figure 2 shows the grain -size correlated permeability together with the field permeability tests. Filed measured permeabilities are at the lower bound of the derived ones according to Figure 2. There is also an increase in the permeability between the depth of 20 ft. to 30 ft.

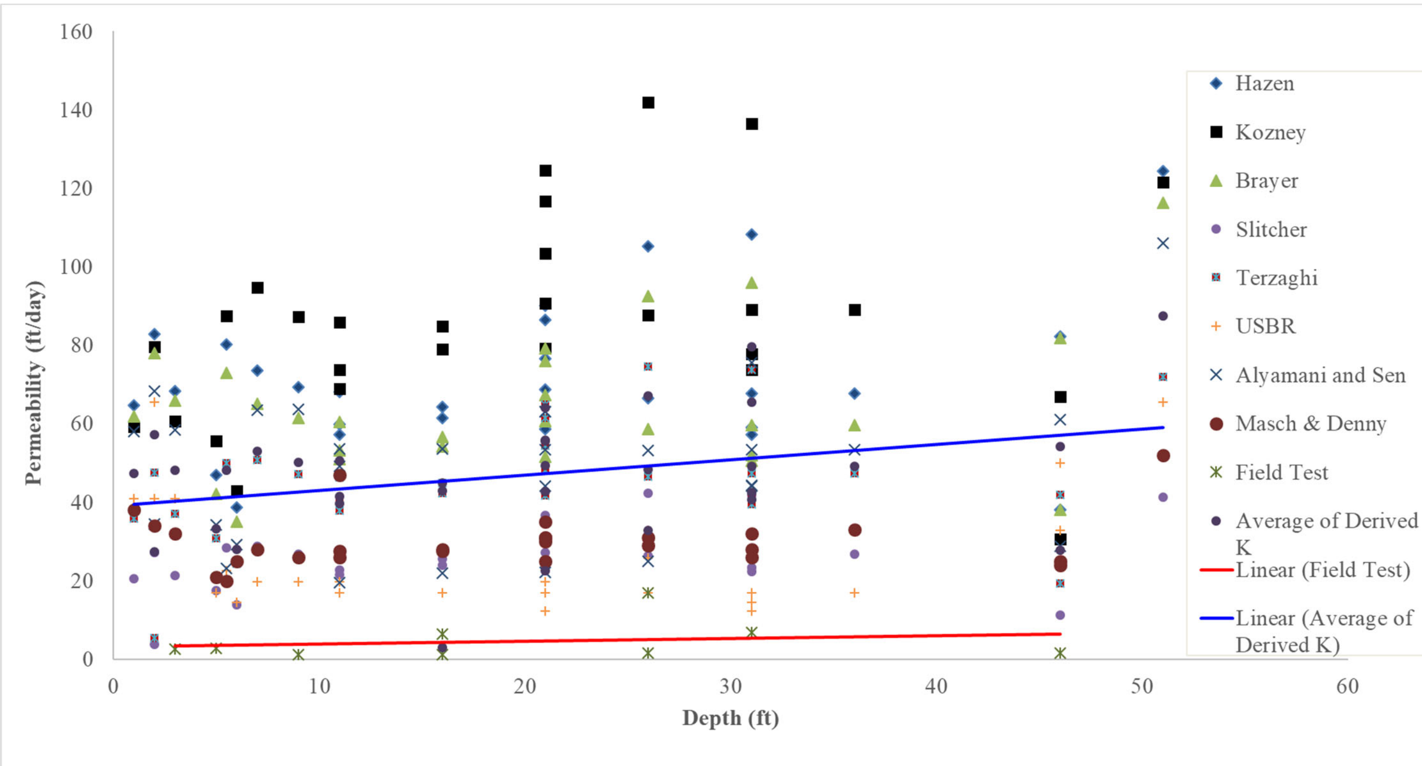


Figure 2: Relationship of Permeability with Depth of Field Measures and Derived Values

ENGINEERING EVALUATIONS

General

This section of the report presents the determination of the seismic site class, the recommendations for the minimum required depth of penetration for the proposed flood barrier, feasible foundation types for the proposed pavilion, soil parameters for design of floodwall foundations and retaining walls and evaluation of the typical sections of rigid pavement based on the provided traffic data. Our evaluation and recommendations are based on the subsurface conditions encountered at the boring locations, our current understanding of the proposed construction, correspondence with you regarding construction feasibility considerations, and our understanding of the subsurface soil and site geologic conditions and requirements of New York City Building Code and ASCE 7-16.

Liquefaction Evaluation

The assessments of liquefaction potential at the referenced site were performed according to the following three references:

- Reference 1: Liquefaction Assessment Diagram in NYC Building Code 1813.1.
- Reference 2: NYC BUILDING CODE, and I.M. Idriss and R.W. Boulanger (2004): *Semi-empirical Procedures for Evaluating Liquefaction Potential During Earthquakes, 11th International Conferences on Soil Dynamics & Earthquake Engineering (ICSDEE)*.
- Reference 3: NYCDOT-SDGBDR *(SEISMIC DESIGN GUIDELINES FOR BRIDGES IN DOWNSTATE REGION)*, and I.M. Idriss and R.W. Boulanger (2004): *Semi-empirical Procedures for Evaluating Liquefaction Potential During Earthquakes, 11th International Conferences on Soil Dynamics & Earthquake Engineering (ICSDEE)*.

In accordance with both the NYC Building Code (Reference 2) and NYCDOT-SDGBDR (Reference 3), an inhouse spreadsheet was developed based on the semi-empirical procedures developed by Idriss and Boulanger (2004) to perform the liquefaction analyses. The factor safety for liquefaction was obtained by comparing the cyclic resistance ratio (CRR) of a defined interval layer (i.e., the cyclic shear stress required to cause liquefaction) to the earthquake induced cyclic shear stress ratio (CSR). The CRR is a function of the soil relative density as represented by an index property measurement (e.g., SPT blow count), the fines content of the soil, the in-situ vertical effective stress, an earthquake magnitude scaling factor, and other factors related to the geologic history of the soil. According to the NYC Building Code, the Risk Categories of the proposed pavilion and the proposed floodwall are II and IV, respectively, and the corresponding required factors of safety are FS=1.0 and FS=1.2 against liquefaction, accordingly. The primary parameters used in the liquefaction evaluation, including design magnitude of earthquake and peak ground acceleration and the analyses results are summarized in Appendix F.

In accordance with Reference 1, at all boring locations there are potentially liquefiable layers indicated by the points on the left side of the lines for Structural Risk/Occupancy Category II/III for the proposed pavilion and Structural Risk/Occupancy Category IV for the proposed floodwall. This result is consistent with the results of evaluations performed in accordance with Reference 2 and Reference 3 that at almost all boring locations except B-11, there are potentially liquefiable layers with the estimated safety factors below the required values.

Due to the potential liquefaction issue at the project site, deep foundations bearing on bedrock should be used to support the proposed structures if settlements due to liquefaction are to be considered, and the allowable for such structural elements are provided in the following sections. However, according to U.S. Army Corps of Engineers EM 1110-2-2502 for Retaining and Flood Walls, the probability (risk) of an earthquake during a flood will be much smaller than the probability during a non-flood period. For certain walls, e.g. buried concrete T-Wall, the probability of liquefaction failure and the related consequences may translate into such a small risk that accepting the risk may be the preferred alternative. In such case, the owner is recommended to accepting the risks and consequences of liquefaction.

Seismic Site Class

The site class is determined based on the properties of soil of the upper 100ft of the site profile which contains both soil and rock. The average standard penetration test blow counts (*N-Method*) for the upper 100ft of the soil/rock profile at all borings are within the range of 15 to 50 bpf (see Appendix E). According to the site classification definition in Table 20.3-1 of ASCE 7-16 (ASCE 7), the *N-Method* gives results compatible to Site class D if the soil is not liquefiable under seismic loading.

According to the results of liquefaction analyses summarized above, the site without any ground improvement is classified as F in accordance with New York City Building Code (2014) and ASCE 7, and site-specific response analysis is required. According to AECOM, the proposed building structures and flood protection structures have fundamental periods of vibration less than 0.5s, as a result, site response analysis to determine spectral acceleration for liquefiable soils is not required according to Section 20.3.1 of ASCE 7 and site class is permitted to be determined in accordance with Table 20.3-1 of ASCE 7 based on field SPT values, which is site class D.

Seismic Design Parameters

Recommended seismic design parameters in accordance with ASCE 7 are summarized in Table 3.

Table 3: Recommended Seismic Design Parameters for Site Class D

RISK CATEGORY [1]	II-BUILDING AND SITE STRUCTURES IV - FLOOD PROTECTION STRUCTURES
SEISMIC IMPORTANCE *FACTOR* [2]	1.0 FOR BUILDING AND SITE STRUCTURES 1.5 FOR FLOOD PROTECTION STRUCTURES
SITE CLASS	D
Ss (FOR 0.2 SECOND PERIOD)	0.278
S_1 (FOR 1.0 SECOND PERIOD)	0.071
S_{DS}	0.292
S_{D1}	0.114

[1]: According to Table 1604.5 of New York City Building Code
[2]: According to Table 1604.5 of New York City Building Code

Pavilion Foundation

The proposed pavilion is a two-story building with a footprint of approximately 6,000SF. According to the three (3) borings (B-3, B-5 and B-6) performed by OEI adjacent to/within the proposed footprint of the pavilion, the subsurface conditions include 15 ft. of fill material overlying 25 ft. of possible fill followed by a thin layer of till (0 ft. ~ 8 ft.) consisting of black organic silty clay with fine gravel, above the bedrock. Based on the observed subsurface conditions for the proposed pavilion, three alternatives are evaluated for supporting the proposed pavilion: 1) *Mat Foundation*; 2) *In situ Ground Improvement + Spread Footing*; and 3) *Deep Foundation - Piles*.

Alternative 1 - Mat Foundation

According to the NYC Building Code 1804.2.3, fills other than controlled fill may be utilized as bearing material but an additional field investigation is required in addition to the typical field exploration of one boring for every 2500 square foot of building footprint area. If a mat foundation is used, one test pit or minimum 3-inch diameter sampler boring shall be provided for every 1,000 square feet of building footprint area. For a total potential area of 6,000 square feet, excluding the service yard, it requires an additional geotechnical investigation of four test pits / 3-inch diameter sampler borings.

The settlement of the mat foundation with a 1.5 ton per square foot allowable bearing pressure can be estimated based on the method proposed by Fraser and Wardle (1976) which considers the ratio of stiffness between the concrete mat and multi-layered soil below the mat, down to the incompressible layer. Considering the footing dimensions of 78 ft.×78 ft.×2.5ft. thick for the proposed area of 6,000 s.f., and the average proposed grade at El. 15.0, the maximum settlement occurring at center of the mat based on the most critical surface condition is estimated at 8.5 inches. The proposed mat foundation would experience a differential settlement of approximately 2 inches to 4 inches at points between the center, edge, and corner of the mat.

The settlements due to partial liquefaction for the proposed pavilion are also estimated at the three locations (B-3, B-5 and B-6) according to the method proposed by Tokimatsu and Seed (1987) *[Evaluation of Settlements in Sands due to Earthquake Shaking, Journal of Geotechnical Engineering, 1987, Vol.113, No. 8.]*. Estimated partial liquefaction induced settlements for the proposed pavilion range from 0.3” to 0.7”. The detailed settlement estimations are presented in Appendix G.

Alternative 2 - In situ Ground Improvement + Spread Footing

One feasible method for in-situ ground improvement is compaction grouting. Compaction grouting is a ground improvement method that consists of injecting low mobility grout (1-2 inches slump) into the ground to displace and compact the surrounding soil without permeating or fracturing the soil. Grout is pumped through steel casings, i.e., “grout pipes” installed to required depths. The grout pipe is typically 3 inch in diameter. As grout pipes are withdrawn in stages, columns of grout “bulbs” are formed below the ground surface. Packers are often used to help the grouting staged process. This option is feasible but the spacing required should be determined by a test section to achieve maximum economy. Eight (8) feet spacing is typical but it could be less. Pre-test borings and post grouting - test borings together with pre and post grouting cross hole shear wave velocity measurements would be needed to verify the procedures. Typically, a minimum SPT value of 15 is required between the grout columns. The technique requires a specialty contractor and is better executed on a design -build basis after the technical issues are reviewed by a competent geotechnical engineer. After ground improvement, 2 tsf allowable bearing pressure can be used in spread footing design assuming the fill can be improved to an SPT value of 15 blows / ft. minimum, and the estimated settlement would be less than 0.75 inch. This estimate can be refined once the structural loads are established.

Alternative 3 - Deep Foundation: Piles

In lieu of the alternatives 1 and 2 of shallow foundations, deep foundations are considered using piles bearing on competent rock. The generalized soil profile at the location of the proposed pavilion based on borings B-3, B-5 and B-6 is presented in Table 4. In order to estimate the downdrag due to the settlement of the liquefiable layer, residual strength was assigned to the liquefiable layer as shown in Table 4 (see footnote 3 in the table).

Table 4: Generalized Soil Profile for Pavilion Foundation Design

Elevation (ft.)	Soil Type	Typical Field SPT-N	Recommended Key Soil/Rock Parameters [1][2]
15 ~ 10	New Fill (to be Placed)	-	$\gamma = 125pcf, \varphi = 34°, C = 0, E = 450ksf$
10 ~ 0	Fill (Medium Dense to Dense)	N=20~25	$\gamma = 125pcf, \varphi = 34°, C = 0, E = 450ksf$
0 ~ -5	Fill (Loose to Medium Dense)	N=10~11	$\gamma' = 55.6pcf, \varphi = 30°, C = 0, E = 180ksf$
-5 ~ -22.5	Fill: Liquefiable Layer	N=5~7	$\gamma' = 52.6pcf,$ $S = 0.08\sigma_v'^{[3]},\ E = 90ksf$
-22.5 ~ -32	Fill (Loose to Medium Dense)	N=10~17	$\gamma' = 55.6pcf, \varphi = 31°, C = 0, E = 220ksf$

Table 4: Generalized Soil Profile for Pavilion Foundation Design Cont'd

Elevation (ft.)	Soil Type	Typical Field SPT-N	Recommended Key Soil/Rock Parameters [1][2]
-32~ -41.5	Clay/Silty Clay	N=1~4	$\gamma' = 42.6pcf, c = 300psf, \varphi = 0°$, $C' = 0, \varphi' = 21°^{[4]}$, $E = 50ksf$
~ -41.5	Bedrock-Schist	-	$\gamma' = 85pcf, \varphi = 24°, C = 8ksf$, $E = 200{,}000ksf$

Notes: [1]: Effective frictional angle of granular soil was estimated based on the correlation of $\emptyset' = 27.1 + 0.3N_{60} - 0.00054N_{60}^2$ according to Peck, Hanson and Thornburn (1974); Cohesive strength of normally consolidated clay was estimated based on correlation of $C_u/P_a = 0.06N_{60}$ according to Terzaghi and Peck (1967). [2]: Young's Modulus was estimated based on the empirical correlation that: $\frac{E}{Pa} = 7N_{60}$ where N_{60} is corrected to an average energy ratio of 60 percent per Manual on Estimating Soil Properties for Foundation Design (EPRI EL-6800,1990). [3]: The residue strength of the liquefiable layer is estimated based on the empirical correlation presented in Figure 3A below, where $(N_1)_{60-cs} = (N_1)_{60} + N_{corr}$ and $N_{corr}$is for correction factor depends on the fines content of the sand (see Figure 3B). [4] Effective frictional angle of normally consolidated clay was estimated based on the empirical correlation between frictional angle and plastic index of $\sin\emptyset' = 0.8 - 0.094lnPI$ according to Mitchell (1976).

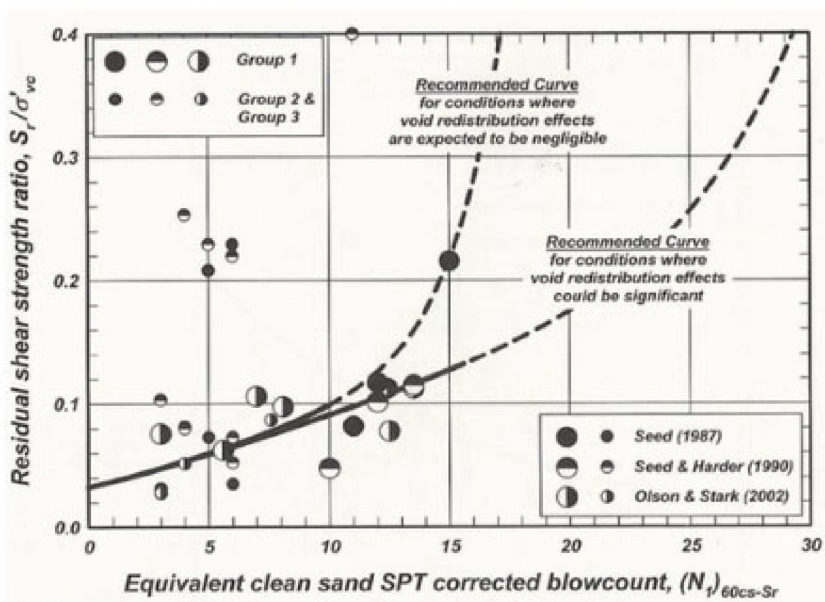


Figure 3A: Relationship between residual strength ratio and equivalent clean-sand normalized SPT blow count by Idriss and Boulanger (2008) for σ'vo (or σ'vc)< 400 kPa. Note the bifurcation of the curve at a blow count of around 10 into curves representing cases where void ratio redistribution is negligible or could be significant. Note also that these investigators apply the same fines correction employed by Seed (1987) and Seed and Harder (1990) to the penetration resistance. SOURCE: Idriss, I.M., and R.W. Boulanger. 2008. *Soil Liquefaction During Earthquakes*. Earthquake Engineering Research Institute MNO 12. Oakland, CA: Earthquake Engineering Research Institute. With permission from the Earthquake Engineering Research Institute.

N_{corr}	0	1	2	4	5
% fines	0	10	25	50	75

Figure 3B: Values of N_{corr} proposed by Seed (1987):

To estimate the liquefaction induced downdrag, the AASHTO LRFD Bridge Design Specifications, Article 3.11.8, recommends the use of the non-liquefied skin friction in the layers above the liquefied zone, and a skin friction value as low as the residual strength within the liquefied soil layers, to calculate downdrag load for the extreme event limit state. The frictional model from NAVFAC DM-7.2 can be used to estimate the downdrag of the pile and is summarized as:

$$DD = \int_0^z A_s \beta \sigma_z' dz \qquad \text{Eq.1}$$

where,

DD = downdrag force,

A_s = shaft skin surface area per unit length,

$\beta = K_h \tan\delta$, K_h = coefficient of earth pressure,

δ = angle of wall friction (sand-steel), σ_z' = effective vertical.

For the downdrag due to the liquefiable layer, the residual strength of soil $S = 0.08\sigma_v'$which is presented in Table 4 can be used in the estimation. $DD = \int_0^z A_s S dz$ where A_s = shaft skin surface area per unit length. The detailed estimations of liquefaction induced downdrag are presented in Appendix H with the results summarized in Table 5. It is noted that driving displacement piles as foundation support may improve the factor of safety against liquefaction and liquefaction would not need to be considered in the design. For such cases, post pile installation borings should be performed to verify that effectiveness of the liquefaction mitigation.

Table 5: Estimated Downdrag Due to Liquefaction for Pavilion Foundation Design

Pile Type	Primary Parameter	Total Downdrag
Micropile	Ave. G.L. at EL.15 $K_h = 0.7$ $\delta = 20°$	28.8D[1] (kips)
Driven H Pile	Ave. G.L.=EL.15 $K_h = 0.8$ $\delta = 20°$	31.5 D_{eq}[2] (kips)
Displacement Pile-Closed End Pipe Pile	Ave. G.L. at EL.15 $K_h = 1.25$ $\delta = 20°$	44.0D[1] (kips)

Table 5: Estimated Downdrag Due to Liquefaction for Pavilion Foundation Design Cont'd

Pile Type	Primary Parameter	Total Downdrag
Displacement Pile- Timber Pile	Ave. G.L.=EL.15 $K_h = 1.75$ $\delta = 25°$	$61.9D_{ave1}$ $+9.5\ D_{ave2}$[3] (kips)

Notes: [1] D is the outer diameter of the steel casing/pile in foot. [2] D_{eq} is the equivalent diameter of H-pile which can be estimated by perimeter of H-pile divided by pi (π). [3] D_{ave1} and D_{ave1} are the average diameter of the timber piles within the non-liquefiable layers above the liquefiable layer and the liquefiable layer, respectively.

Recommended Pile Capacities

Timber pile, closed end pipe piles, H-piles and micropiles were considered as deep foundation alternatives for the proposed pavilion. The calculations of pile capacities in compression and tension and geotechnical lateral capacities are presented in Appendix I1 to I3 (I1-Compressive Capacity; I2-Tensile Capacity; and I3-Geotechnical Lateral Capacity) while the results of each design are summarized as follows:

1. Timber Piles to Bedrock

Structural capacity of a Southern Pine timber pile driven to bedrock with a tip diameter of 8 inches, is about 30 tons with a respective useful design capacity of only about 0 to 8.5kips to allow for downdrag. Therefore, it is not prudent to use timber piles for the proposed pavilion unless the verification borings post pile installation indicates the liquefaction issue is not a concern at the reference site. In that case, the liquefaction induced downdrag is not need to be included in the pile capacity and the useful design capacity is equal to the structural capacity of the timber piles.

2. Pipe Piles, H-Piles and Micropiles

Recommended capacity for the various alternatives are summarized in Tables 6, 7a and 8. Per AECOM's request, the vertical and lateral stiffness of an individual pile of HP 12 × 63 bearing on bedrock with 110 tons allowable compression capacity and 8 tons allowable lateral capacity is also provided in Table 7b. The detailed calculations of the vertical and lateral stiffness are presented in Appendix I4.

2A: Closed End Pipe Piles

Table 6: Capacity of Closed End Pipe Piles (1/2" Plate or Conical Tip)

Pile Diameter (OD) (Inches)	**Wall Thickness (inches)**	**Area (in^2)**	**Steel Grade**	**Pile Capacity in Compression (Not Concrete Filled)**		**Allowable Pile Capacity in Tension (Fill with Concrete)**	**Allowable Pile Capacity in Tension (Not Fill with Concrete)**	**Geotechnical Lateral Capacity [3]**
				Allowable Structural Capacity [1]	Net Allowable Capacity [2]			
9-5/8	0.500	14.334	ASTM A 252- Grade 2	*180kips*	145kips	18.6kips	15.3kips	19.3kips
			ASTM A 252- Grade 3	*232kips*	197kips			
9-5/8	0.545	15.546	ASTM A 252- Grade 2	*195kips*	160kips	18.8kips	15.5kips	19.8kips
			ASTM A 252- Grade 3	*251kips*	216kips			

Notes: [1] Allowable stresses of steel used in the design=$\frac{0.9f_y}{2.5}$, where f_y is the yield strength of steel, 35kis for ASTM A 252- Grade 2 and 45ksi for ASTM A 252- Grade 3. [2] Adjusted for downdrag. If no verification borings to reevaluate the liquefaction potential post the pile installation, the downdrag due to liquefaction should be considered in the design. According to preliminary downdrag estimation, total downdrag for closed end pipe pile is 44D=44*9.625/12=35.3kips. [3] Geotechnical lateral capacity refers to the lateral load applied to top of a single vertical pile which results in one-inch deflection at top of the pile.

2B: H-Piles

Table 7a: Capacity of H-Piles

H-Pile	Area (in^2)	Steel Yield Strength	Pile Capacity in Compression: Allowable Structural Capacity in Compression [1]	Pile Capacity in Compression: Net Allowable Capacity [2]	Allowable Pile Capacity in Tension	Geotechnical Lateral Capacity [3]
HP 12×53	15.5	50ksi	*279kips*	219kips	18.2kips	28.5kips
HP 12×63	18.4	50ksi	*300kips*	240kips	18.9kips	31.0kips
HP 12×74	21.8	50ksi	*300kips*	239kips	19.7kips	33.5kips
HP 12×84	24.6	50ksi	*300kips*	238kips	20.3kips	35.5kips

Notes: [1] Allowable stresses of steel used in the design=$\frac{0.9f_y}{2.5}$, where f_y is the yield strength of steel. 300kips is the maximum allowable pipe capacity for H-piles according to Table 1808.4.1.3 New York City Building Code. [2] Adjusted for downdrag. If no verification borings to reevaluate the liquefaction potential post ground improvement, the downdrag due to liquefaction should be considered in the design. According to preliminary downdrag estimation, total downdrag for H-piles of HP12×53, HP12×63, HP 12×74, and HP 12×84 are 59.8kips, 60.3kips, 61.0kips and 61.7kips, respectively. [3] Geotechnical lateral capacity refers to the lateral load applied to top of a single vertical pile which results in one-inch deflection at top of the pile.

Table 7b: Stiffness of an Individual HP 12×63[1]

H-Pile	Axial Stiffness (kips/ft)	Lateral Stiffness -Strong Axis (kips/ft)	Lateral Stiffness -Weak Axis (kips/ft)
HP 12×63	470	41.1	21.6

Notes: [1] Table 7b is for an individual HP 12×63 only. When applying it to pile group, the impact of adjacent piles should be considered and the calculations presented in Appendix I4 for a single pile should be modified accordingly.

2C: Micropiles

Table 8: Capacity of Micropiles

Micropile O.D.	Casing Thickness	Socket Length in Bedrock	Casing Yield Strength	Pile Capacity in Compression with 5000psi Concrete: Allowable Pile Capacity	Pile Capacity in Compression with 5000psi Concrete: Net Allowable Capacity [1]	Allowable Pile Capacity in Tension [2]	Geotechnical Lateral Capacity [3]
9 5/8	0.50 inches	5.0 ft.	45 ksi	173 kips	150 kips	Grade 75 All-Thread Rebar (ASTM A615): 26 kips for #6 bar; 36 kips for #7 bar; 47 kips for #8 bar; 60 kips for #9 bar; 76 kips for #10 bar.	19.3 kips
		7.5 ft.		235 kips	212 kips		
		10.0 ft.		297 kips	274 kips		
9 5/8	0.545 inches	5.0 ft.		171 kips	148 kips		20.0 kips
		7.5 ft.		232 kips	209 kips		
		10.0 ft.		294 kips	271 kips		
11 7/8	0.582 inches	5.0 ft	80 ksi	229 kips	203 kips		28.0 kips
		7.5 ft.		306 kips	280 kips		

Notes: [1] Adjusted for downdrag. If no verification borings to reevaluate the liquefaction potential post ground improvement, the downdrag due to liquefaction should be considered in the design. According to preliminary downdrag estimation, total downdrag for micropile is 28.8D=28.8*9.625/12=23.1kips for 9.625" O.D. casing and 28.8*11.875=25.2kips for 11.875" O.D. casing. [2] Allowable tensile stress of rebar used in the design=$0.8f_y$, where f_y is the yield strength of rebar. [3] Geotechnical lateral capacity refers to the lateral load applied to top of a single vertical pile with #6 bar at center which results in one-inch deflection at top of the pile.

Floodwall Control of Seepage

According to the 95% design documents, the proposed seepage barrier can be divided into seven parts (sections) beginning from working point WP1 to working point WP55 (Stationing referenced in this section is corresponding to the stationing in the 30% Design documents, beginning of stationing at Sta. 10+00 corresponds to WP6 according to the 95% Design documents):

1. From WP1~WP7 (1st Place)
2. From WP7~WP20 (Sta. 10+45 to Sta. 14+61) (near the Existing Museum of Jewish Heritage)
3. From WP20~WP26 (Sta. 14+61 to 20+50) (near the proposed Pavilion)
4. From WP26~WP29/30 (Sta. 20+50 to 21+50)
5. From WP29/30~WP40 (Sta. 21+50 to 25+00)
6. From WP40~WP46 (Sta. 25+00 to 28+00)
7. From WP46~WP55 (Sta. 28+00 to End (Sta.30+04))

The key design parameters, main assumptions of the analytical profile and proposed wall types that are used in the seepage analyses are summarized as follows:

Part 1: WP1~WP7 (1st Place)

- Ground elevation on the protected side is at EL.10.5 ft.±;
- Bottom of first floor slab of the Museum of Jewish Heritage is at EL. 9.0 ft. ±;
- Bottom of basement slab of the Museum of Jewish Heritage is at EL. -2.64 ft. ±;
- The minimum distance from the flood wall to the first-floor slab of the Museum and to the basement slab are: 51 ft. and 40 ft., respectively according to Drawing SF301 of the 95% Design Documents;
- The basement slab with tie-down is designed for a water elevation near existing grade or even higher according to AECOM;
- Proposed type of seepage barrier: flowable fill.

Part 2: WP7~WP20 (Sta. 10+45 ~ 14+61)

- Ground elevation on the protected side is at EL.11 ft. ±;
- Bottom of basement slab of the Museum of Jewish Heritage is at EL. -2.64 ft. ±;
- Bottom of first floor slab of the Museum of Jewish Heritage is at EL. 4.1 ft. ±;
- The minimum distance from the flood wall to the basement slab and lower portion of first floor slab of the Museum are: 57'10" and 30'8", respectively (see cross-sections 1-1 and 2-2 in Appendix J);
- The basement and first floor slab with tie-down are designed for a water elevation near existing grade or even higher according to AECOM;
- The new fill material to be utilized as part of flood control system which will be placed over the platform is assumed to be scoured away;
- Proposed type of seepage barrier: 2'-0" diameter secant pile with c-c spacing of 21" or Sheet pile wall.

Part 3: WP20~WP26 (Sta. 14+61 ~ 20+50)

- Ground elevation on the protected side is at EL.20 ft. ±;
- Bottom of slab of the proposed Pavilion Building is at EL. 7.5 ft. ±;
- The minimum distance between the flood wall and the proposed Pavilion Building is: 70 ft. ±;
- The new fill material to be utilized as part of flood control system which will be placed over the 70 ft. wide platform is assumed to be scoured away;
- Proposed type of seepage barrier: Sheet pile wall

Part 4: WP26~WP29/30 (Sta. 20+50 ~ 21+50)

- The lowest ground elevation on the protected side is at EL.8.0 ft. ±;
- The minimum distance between the flood wall and the slope on the flood side is: 10 ft. ±;
- Proposed type of seepage barrier: jet grouting

Part 5: WP29/30~WP40 (Sta. 21+50 ~ 25+00)

- The lowest ground elevation on the protected side is at EL.7.0 ft. ±;
- The minimum distance between the flood wall and the bulkhead is: 50 ft. ±;
- Proposed type of seepage barrier: jet grouting.

Part 6: WP40~WP46 (Sta. 25+00 ~ 28+00)

- The lowest ground elevation on the protected side is El.8.00 ±;
- Proposed type of seepage barrier: jet grouting.

Part 7: WP46~WP55 (Sta. 28+00 ~ End (30+04))

- The lowest ground elevation on the protected side is El.10+00 ±;
- Proposed type of seepage barrier: buried concrete T-Wall.

Hydraulic Conductivity of Soil

As indicated by field permeability test results presented in Table 1, the permeability is not uniform with depth and it ranges from 17ft/day in the stratum consisting of silty sand with gravel to 1.2ft/day in the stratum consisting of poorly graded fine sand with silt. In addition, there are soils containing brick pieces, decomposed wood and shells observed in the samples recovered during the soil borings when concentrated may result in higher permeabilities than field-measured values. To take into account uncertainties in permeability due to the heterogeneous nature of the in-situ soils and the potential for voids in the fill materials from the presence of misc. debris, a value of 20 ft./day is used in the seepage analyses. However, permeability of 70 ft./day which is close to the average of derived hydraulic conductivity according to the two widely used empirical correlations of Hazen and Kozney-Carman was also used in the sensitivity analysis for comparison with results using 20ft/day. Hydraulic conductivity of 0.1 ft./day was assigned to the schist bedrock which was observed to be slightly to very slightly fractured and weathered. For the secant pile and sheet pile cut off walls, permeabilities of 8.64E-05 ft./day (with effective thickness of 12 inches) and 4.67E-04 ft./day (with fictious thickness of 6 inches) were assigned to each, respectively. The fill above the water table, approximately at EL.3.0, unsaturated hydraulic properties of the soil were estimated by the software ROSETTA - a program used to translate the basic soil data into hydraulic properties.

Hydrograph

AECOM have provided OEI with hydrographs of the 100-Year Storm Water Level as shown in Figures 4 and 5. Both series have similar maximum flood elevations at El. 13.55 with Figure 4 representing the normal storm peak duration and Figure 5 representing a longer storm peak duration. For seepage analysis, the longer storm peak duration was considered.

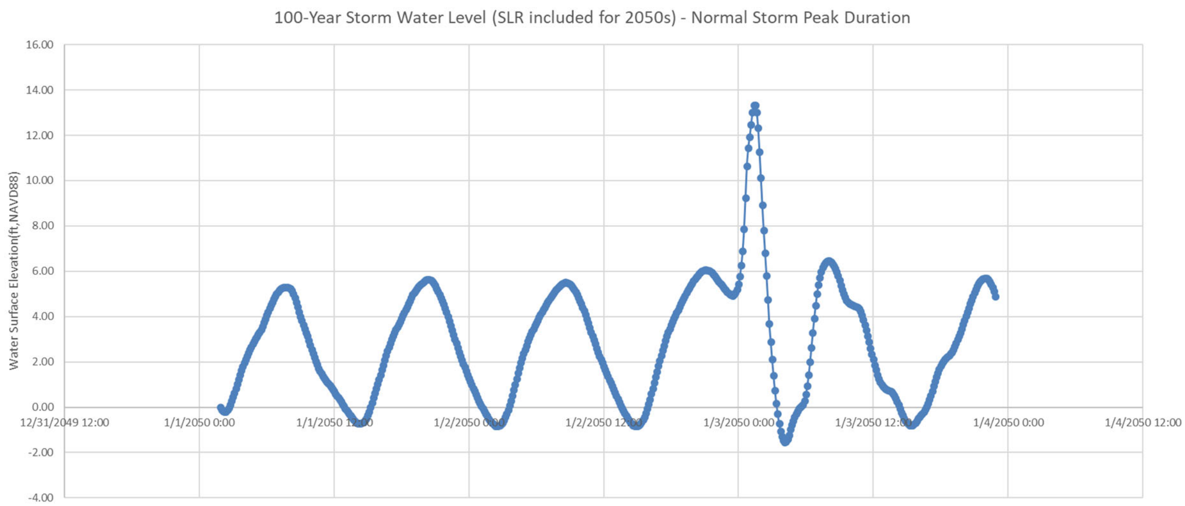


Figure 4: 100-Year Storm Water Level - Normal Storm Peak Duration

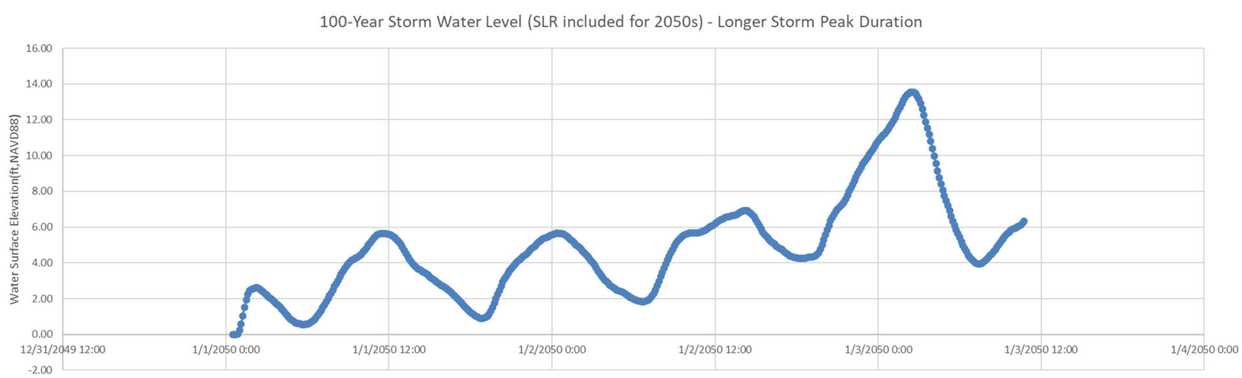


Figure 5: 100-Year Storm Water Level - Longer Storm Peak Duration

Analyses and Results

Seepage analyses to develop recommendations for floodwall cut offs, and asses the factor of safety against piping were done using the commercially available software - SEEP/W for a transient flow condition using the provided hydrographs. Seepage analyses were performed for all of the different sections along the alignment. The results of the analyses are included in Appendix J.

In some areas, sensitivity analyses were warranted, specifically near the Museum of Jewish Heritage where analyses included two (2) permeabilities 20 ft./day and 70 ft./day and three (3) water levels El.1.5, El.2.0 and El. 3.0. The sensitivity analysis results indicate that for all events, the required minimum length of seepage barrier to prevent the slab of JMH at the protected side from being subject to pressure beyond the design capacity of the existing tiedowns is less than the length required for the stability (the stability requirements are presented in the following section). Comparing analyses results using soil permeability of 20 ft./day, the water pressure head generated at bottom of slab is 2.5 ft. ~ 3.0 ft. higher that using derived permeability of 70 ft./day. The results of sensitivity analyses are summarized in Appendix J-2.

Additional sensitivity analyses were also performed using a 100-year Stillwater Elevation + SLR of 13.8. The results of the additional analyses using the slightly higher flood elevation from 13.55 to 13.8 ft. had no impact on the final conclusions or recommendations provided in this report.

Exit Gradients and Piping

Results of seepage analysis indicate water levels will not daylight over the duration of the design flood event. The factor of safety due to piping was calculated based on estimated gradients computed by the software SEEP/W on the protected side, in accordance with procedures in Seepage Analysis and Control for Dams EM 1110-2-1901. The factor of safety against heave was also determined based on the method suggested by Terzaghi (1943) with a single row of sheet piles as shown in Figure 6. According to EM 1110-2-1901, the recommended factor of safety for escape gradient ranges from 1.5 to 15 depending on knowledge of soil and possible seepage conditions, with a generally accepted range of 4~5, proposed by Harr (1962, p. 125).
A summary of the seepage analyses results is presented in Table 9 with detailed calculations of the factor of safety against piping/heave presented in Appendix J-1.

[References: Terzaghi, K.: "Theoretical Soil Mechanics," John Wiley & Sons, Inc., New York, 1943; Harr, M.: "Groundwater and Seepage," McGraw-Hill Book Company, 1962.]

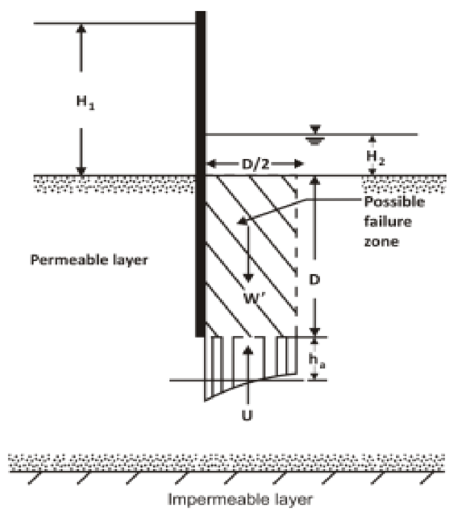


Figure 6: Factor of Safety against Piping by Terzaghi's Method

Table 9: Summary of Seepage Analysis Results

RECOMMENDED LIMITS	TYPE OF SEEPAGE BARRIER	CONTROLING FACTOR IN DESIGN	MINIMUM REQUIRED PENETRATION OF SEEPAGE BARRIER& RESULTS	FACTOR OF SAFETY HEAVE
WP1~WP7 (NA ~ Sta. 10+45) [1]	FLOWABLE FILL	Based on key design parameters including bottom of basement slab and the first-floor slab of the Museum of Jewish Heritage at EL. -2.64 ft. and El. 9.0 ft. respectively, and the corresponding minimum distance from the floodwall of 51 ft. and 40 ft., the required penetration of the sheet pile wall is controlled by **dry condition on protected side.**	• L=5.0 ft. from existing grade at El.11.0 ft with bottom of seepage barrier at **El.6.0**[1].; • Water would rise to El.6.8 which is approximate 2.2 ft. below bottom of first floor slab. The bottom of basement slab would be subject to pressure heads equivalent of about 9.5 ft.	FS=4.4>*[4~5] (Harr, 1962)*
WP7~WP20 (Sta.10+45 ~ Sta.14+61)	SHEET PILE	Based on key design parameters summarized above including bottom slab elevation, distance from the floodwall, capacity of tiedown and etc., the required penetration of the sheet pile wall is controlled by its **stability requirements** [3].	• L=21.5 ft. from one foot below existing grade at El.10.5 ft. with tip of pile at **El.-14.0** [3]; • The bottom of first floor slab and basement slab would be subject to pressure heads equivalent of about 2.4 ft. and 8.0 ft., respectively.	FS=6.1>*[4~5] (Harr, 1962)*
WP20~WP26 (Sta14+61 ~ Sta. 20+50)	SHEETPILE	Based on key design parameters including bottom of slab of the proposed Pavilion at EL. 7.5ft and the minimum distance from the floodwall of 70ft, the required penetration of the sheet pile wall is controlled by its **stability requirements** [3]**.**	• L=25.0 ft. from the existing grade at El.20.0 ft with tip of pile at **El.-5.0**[3] for **WP20~WP21**; • L=35.0 ft. from the existing grade at El.21.0 ft with tip of pile at **El.-14.0**[3] for **WP21~WP26**; • Water would rise to El.4.0 which is approximate 3.5 ft. below bottom of slab.	FS=17.5>*[4~5] (Harr, 1962)*
WP26~WP29/30 (Sta.20+50 ~ Sta.21+50)	JET GROUTING	Based on key design parameters including the lowest ground elevation on protected side at EL. 8.0 ft. and the minimum distance from the floodwall of 10 ft., the required penetration of the sheet pile wall is controlled by **dry condition on protected side**.	• L=11.0 ft. from existing grade at El.8.0 ft. with bottom of seepage barrier at **El.-3.0**; • Water would rise to El.7.0 which is approximate 1.0 ft. below existing grade.	FS=5.1>*[4~5] (Harr, 1962)*

Table 9: Summary of Seepage Analysis Results (*Cont.*)

WP29/30~WP33 (Sta.21+50 ~ Sta.23+00)	JET GROUTING	Based on key design parameters including the lowest ground elevation on protected side at EL. 7.0 ft. and the minimum distance from the floodwall of 50ft, the required penetration of the sheet pile wall is controlled by **dry condition on protected side**.	• L=15 ft. from existing grade at El.7.0 ft with bottom of seepage barrier at **El.-8.0**; • Water would rise to El.6.0 which is approximate 1.0 ft. below existing grade.	FS=6.5>*[4~5] (Harr, 1962)*
WP33~WP40 (Sta.23+00 ~ Sta.25+00[2])	JET GROUTING	Based on key design parameters of the lowest ground elevation on protected side at EL. 7.0 ft., the required penetration of the sheet pile wall is controlled by **dry condition on protected side**.	• L=18.0 ft. from existing grade at El.7.0 ft with bottom of seepage barrier at **El.-11.0**; • Water would rise to El.6.5 which is approximate 6 in. below existing grade.	FS=8.2>*[4~5] (Harr, 1962)*
WP40~WP46 (Sta.25+00 ~ Sta.28+00[2])	JET GROUTING	Based on key design parameters of the lowest ground elevation on protected side at EL. 8.0 ft., the required penetration of the sheet pile wall is controlled by **dry condition on protected side**.	• L=13.0 ft. from existing grade at El.8.0 ft with bottom of seepage barrier at **El.-5.0**; • Water would rise to El.7.0 which is approximate 1.0ft below existing grade.	FS=6.9>*[4~5] (Harr, 1962)*
WP46~WP55 (Sta.28+00 ~ Sta.30+04 (END)[2])	BURIED CONC. T-WALL	Based on key design parameter of the lowest ground elevation on protected side at EL. 10.0 ft., the required bottom of wall footing is controlled by **dry condition on protected side**.	• L=4.0 ft. from existing grade at El. 10.0 ft. with bottom of footing **at El.6.0**; • Water would rise to El. 9.0 which is 1.0 ft. below existing grade.	FS=6.5>*[4~5] (Harr, 1962)*

Notes: [1] The reduced 100-Year Storm with all water elevation reduced by 2.5 feet was used the seepage analyses for WP1~WP7 as per the request by AECOM. [2] Due to the presence of cobbles, boulders, brick fragments and rock fragments observed in the most recent soil boring B-9, the permeability of soil used in the analyses for Sta.23+00~Sta.30+04 was increased by 50% to 30ft/day to count for the uncertainties of the field condition in permeability. [3] the minimum required penetration between Sta. 10+45 and Sta. 20+50 presented here are based on the stability analyses summarized in the following section- ***"Floodwall Foundation"***.

Floodwall Foundations

- *Design Criteria*

The design load estimation and geotechnical analyses of recommended floodwall foundations will be performed by AECOM while OEI is responsible for providing the recommended soil parameters for the relevant geotechnical design. The widely used N_{60} to f’ correlation according to Peck, Hanson and Thornburn (1974) $\emptyset' = 27.1 + 0.3N_{60} - 0.00054N_{60}^2$ was applied in estimating the frictional angle of granular soil. Here, N_{60} is the field SPT N values of blows per foot (bpf) corrected for hammer energy which is obtained by multiplying the field SPT N values (with automatic hammer) by 1.3. The general correlation between unconfined compressive strength of clay and N_{60} published by Terzaghi and Peck (1967) and later modified by Kulhawy and Mayne (1990) of: $C_u/P_a = 0.06N_{60}$ was used to estimate the shear strength of clay. The recommended soil parameters for floodwall foundation design beginning from Sta. 10+00, which is corresponding to the working point WP6 in *Floodwall Plan prepared by AECOM (75% design)*, to Sta. 30+04 are summarized in Tables 10~13. It is noted that in these tables, the soil parameters which were estimated based on the field SPT N-Values are pre-liquefaction strengths. Post liquefaction strength for soils expected to liquefy is typically one tenth of the pre-liquefaction strength.

[*References: [1] Peck, R.B., Hanson, W.E., and Thornburn, T.H. (1974). Foundation engineering, 2nd Ed., Wiley, New York. [2] Terzaghi, K., and Peck, R.B. (1967). Soil mechanics in engineering practice, 2nd Ed., Wiley, New York. [3] Kulhawy, F.H., and Mayne, P.W. (1990). “Manual on estimating soil properties for foundation design.” Electric Power Research Institute, Palo Alto, Calif.*]

Table 10: Generalized Soil Profile for Foundation Design between Sta. 10+00 and Sta.16+00 (WP6~WP21) [1] Based on Borings B-1, B-2 and B-3

Elevation (ft.)	Soil Type	Typical Field SPT Range [2]		Recommended Key Soil / Rock Parameters
		Field N	N_{60}	
10.5 ~ 3	Fill (medium dense sand, little silt)	12~21	15~27	γ=125pcf, φ=31.5~34.8° (Ave=33.2°)
3 ~ -2.5				γ'=62.6pcf, φ=31.5~34.8° (Ave=33.2°)
-2.5 ~ -21.5	Fill (loose to medium dense sand, trace silt)	5~12	6~15	γ'=52.6pcf, φ=28.9~31.5°(Ave=30.0°)
-21.5 ~ -34.5	Fill (loose to medium dense sand, little silty clay, trace gravel)	8~17	10~22	γ'=57.6pcf, φ=30~33.4° Ave=31.8°)
-34.5 ~ -38.5	Soft Clay, with little gravel	4	5	γ'=44.6pcf, C=600psf
-38.5 ~ -43	Sand (medium dense), with little/some silty clay	10	13	γ'=57.6pcf, φ=30.9°
<-43	Bedrock-Schist	-	-	γ'=87.6pcf, Strain Factor=0.0001, q_u=5000psi, E_{ini}=1.5E+6psi, RQD=75%

Notes: [1] This table also applies to WP1~WP6. Stationing of WP1~WP6 was not shown on the 30% Design Document. [2] The typical field SPT range is not the actual range of field SPT values, but it is the typical range based on engineer's judgement.

Table 11: Generalized Soil Profile for Foundation Design between Sta. 16+00 and Sta.19+50 (WP21~WP25) Based on Borings B-4, B-11 and B-5

Elevation (ft.)	Soil Type	Typical Field SPT Range*		Recommended Key Soil/Rock Parameters
		Field N	N_{60}	
10.5 ~ 3.0	Fill (medium dense sand, trace silt)	8~15	10~19	γ=122pcf, φ=30.0~32.6° (Ave=31.2°)
3.0 ~ -7.0	Fill (medium dense sand, trace silt)	12~20	15~26	γ'=62.6pcf, φ=31.5~34.5°(Ave=32.9°)
-7.0 ~ -37.0	Fill (loose to medium dense fine sand, trace silt)	7~11	9~14	γ'=55.6pcf, φ=29.8~31.2° Ave=30.3°)
-37.0 ~ -44.5	Till (gravel)?	15	19	γ'=62.6pcf, φ=32.6°
<-44.5	Bedrock-Schist	-	-	γ'=87.6pcf, Strain Factor=0.0001, q_u=5000psi, E=1.5E+6psi, RQD=55%

*The typical field SPT range is not the actual range of field SPT values, but it is the typical range based on engineer's judgement.

Table 12: Generalized Soil Profile for Foundation Design between Sta. 19+50 and Sta. 23+00 (WP25~WP33) Based on Borings B-7 and B-8

Elevation (ft.)	Soil Type	Typical Field SPT Range*		Recommended Key Soil/Rock Parameters
		Field N	N_{60}	
6 ~ 3	Fill (medium dense sand, little gravel, with brick fragments)	13	17	γ=123pcf, φ=32.0°
3 ~ -28	Fill (loose silty sand, little gravel with brick fragments)	2~4	3~5	γ'=47.6pcf, φ=28.0~28.6°(Ave=28.3°)
-28 ~ -38	Very soft silty clay	2	3	γ'=44.6pcf, C=360psf
-38 ~ -49	Loose silty sand / clayey sand, trace gravel	5~7	6~9	γ'=52.6pcf, φ=28.9~29.8° (Ave=29.2°)
<-49	Bedrock-Schist	-	-	γ'=87.6pcf, Strain Factor=0.0001, q_u=5000psi, E_{ini}=1.5E+6psi, RQD=78%

*The typical field SPT range is not the actual range of field SPT values, but it is the typical range based on engineer's judgement.

Table 13: Generalized Soil Profile for Foundation Design between Sta. 23+00 and Sta. 30+04 (WP33~WP55) Based on Boring B-9

Elevation (ft.)	Soil Type	Typical Field SPT Range [1]		Recommended Key Soil/Rock Parameters
		Field N	N_{60}	
Current Grade [2] ~ 3	Fill (silty sand with gravel and brick fragments)	9	11	γ=122pcf, φ=30.3°
3 ~ -16	Fill (loose to medium dense silty sand, with brick fragments and boulders)	13	16	γ'=60.5pcf, φ=31.5°
-16 ~ -29	Fill (medium dense silty sand/clayey sand with rock fragments and brick fragments)	13	16	γ'=60.5pcf, φ=30.5°
<-29	Bedrock-Schist	-	-	γ'=87.6pcf, Strain Factor=0.0001, q_u=5000psi, E_{ini}=1.5E+6psi, RQD=78%

Notes: [1] Due to the presence of brick, boulders and rock fragments, high SPT obtained during soil boring are not reliable. The typical range presented here references to reasonable SPT values based on engineer's judgement. [2] Currents grades for Sta. 23+00~28+00 and Sta.28+00~30+04 are at El.7.5± and El.11.0 ±, respectively.

Foundation Type - 1 Secant Pile / Sheet Pile Wall (WP11*~WP26)

The sheet-pile analyses were performed on the different proposed sections and soil profiles summarized in Tables 10 through 13 along the alignment using the software CWALSHT (by US Army Corps of Engineers) with the results summarized in tables at the end of each relevant design section. The analyses considered the five load cases (C1 to C5) for coastal flood walls in accordance with Retaining and Flood Walls EM 1110-2-2502. In some instances, certain load cases were omitted from analyses as by simple observation as they would not control the design of the wall.

Detailed outputs are presented in Appendix K, since the software CWALSHT treats both secant pile and sheet pile walls similar, the structural parameters provided are applicable to both types of walls.

➢ ***WP11~WP20 (near MJH)***

The key sheet pile design parameters for the floodwall near MJH including the maximum bending moment, the maximum shear, deflection, and the minimum required penetration depth of the sheet pile were estimated by OEI based on the design loads (called Original Loads) provided by AECOM and which are summarized as follows:

- *Unfactored Moment: 28 kip - ft. / ft.;*
- *Unfactored Shear: 7.4 kip / ft.;*
- *Load Acting at EL.9.5 ft. (NAVD88);*
- *Ground Elevation: 10.5 ft. (NAVD88).*

Analyses were also performed based on the newly provided loads on July 20 2021(called Final Loads) which are summarized as follows:

- *Unfactored Moment: 39.6 kip - ft. / ft.;*
- *Unfactored Vertical: -3.0 kip / ft.;*
- *Unfactored Lateral: -6.2 kip / ft.;*
- *Load Acting at EL.7.0 ft. (BOF EL);*

- *Ground Elevation: 11 ft.*

The results are summarized below while the detailed outputs are presented in Appendix K-1:

SECTION LIMITS	LOAD	MAXIMUM UNFACTORED MOMENT [1]	MAXIMUM UNFACTORED SHEAR [1]	SCALED DEFLECTION AT TOP OF SHEET PILE [2]	REQUIRED PILE TIP ELEVATION [3]
WP7~ WP20	Original Loads	60.2kips-ft. / ft.	9.7kips	6.63×10^9 (lb. - in^3)	-12.0ft
	Final Loads	39.5kips-ft. / ft.	6.6kips	4.0×10^9 (lb. - in^3)	-8.0ft

Notes: [1] These unfactored moment and shear provided here are for structural design and they are calculated using a factor of safety of 1.0 for both active and passive pressures in accordance with Design of Sheet Pile Wall (EM 1110-2-2504) by U.S. Army Corps of Engineers. [2] Top of sheet pile refers to the bottom of footing elevation. Divide scaled deflection by the modulus of elasticity in psi times pile moment of inertia in in^4 to obtain deflection in inches. [3] The required pile tip elevation was determined in accordance with U.S. Army Corps of Engineers ETL 1110-2-575 (Evaluation of I-Walls), and FS=1.5 was applied to the passive pressures for loads most frequently experienced by the system in performing it is primary function throughout its service life according to U.S. Army Corps of Engineers EM 1110-2-2504 (Design of Sheet Pile Walls).

➢ ***WP20 ~ WP21***

The proposed flood wall type for WP20-WP21 is sheet pile with typical section shown in Figure 7. The controlling load cases considered in the wall design for this section are summarized in Figure 8.

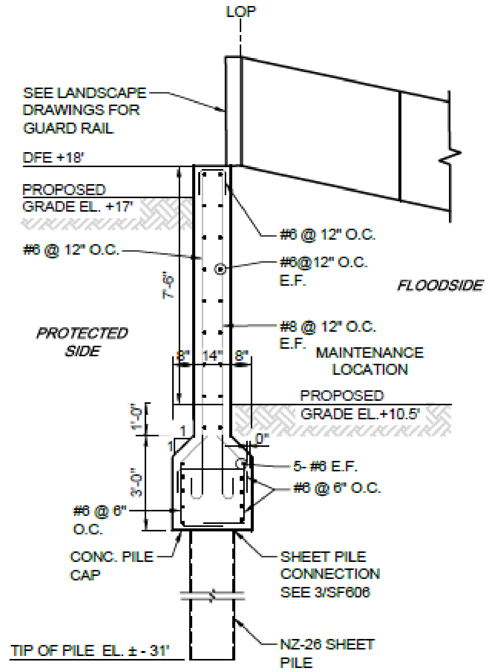
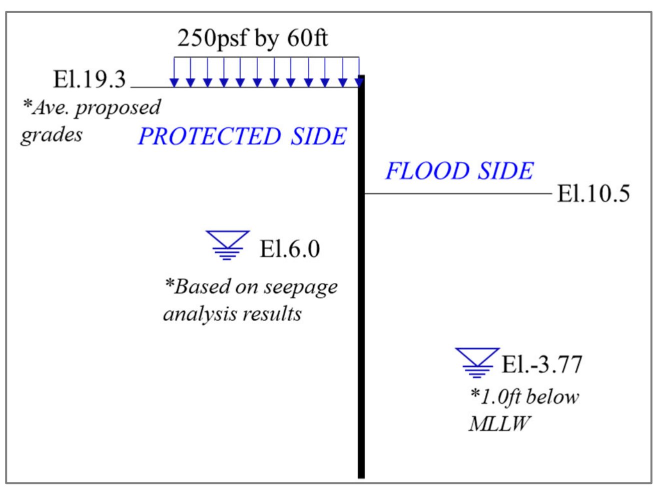
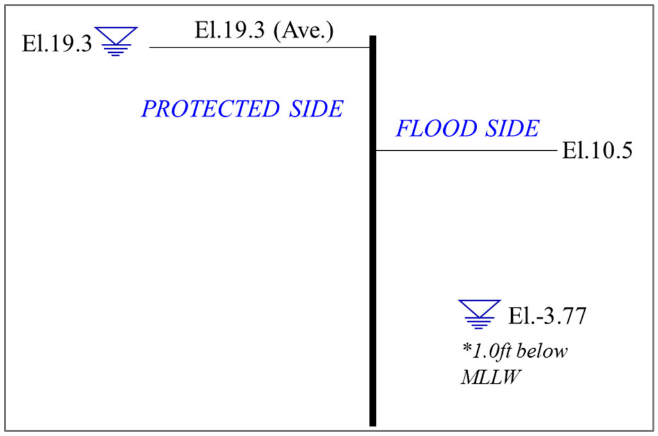


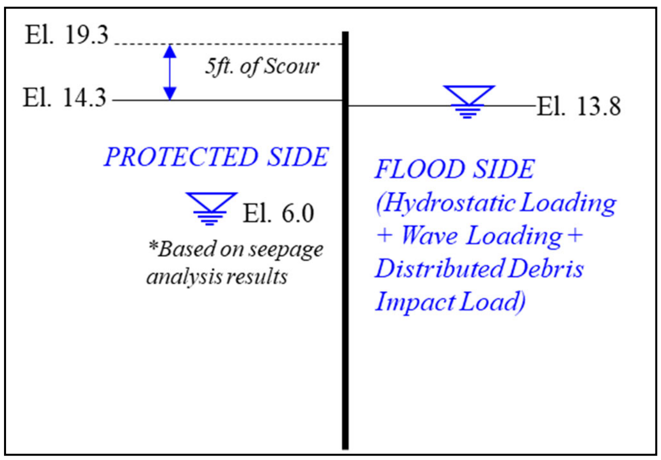
Figure 7: Typical Wall Section for WP20-WP21



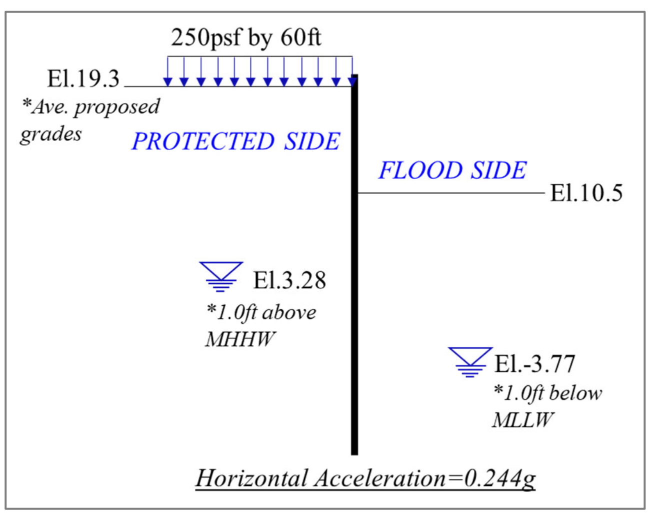
(a) Usual Loading



(b) Unusual Loading-1



(c) Unusual Loading-2



(d) Earthquake Loading

Figure 8: Controlling Load Cases for Floodwall between WP20 and WP21

The results are summarized in the following table while the detailed outputs are presented in Appendix K-2.

LOAD CASE	MAXIMUM UNFACTORED MOMENT [1]	MAXIMUM UNFACTORED SHEAR [1]	SCALED DEFLECTION AT TOP OF SHEET PILE [2]	REQUIRED PILE TIP ELEVATION [3]
a-Usual Loading	14.5kips-ft. / ft.	6.5kips	2.12×10^9 (lb. - in.^{3})	1.0
b-Unusual Loading-1	10.8kips-ft. / ft.	5.1kips	1.28×10^9 (lb.- in.^{3})	0.0
c-Unusual Loading-2	0.3kips-ft./ft.	0.5kips	1.21×10^7 (lb. - in^3)	8.5
d-Earthquake Loading	22.8kips-ft. / ft.	7.1kips	3.9×10^9 (lb. - in.^{3})	-3.5

Notes: [1] These unfactored moment and shear provided here are for structural design and they are calculated using a factor of safety of 1.0 for both active and passive pressures in accordance with Design of Sheet Pile Wall (EM 1110-2-2504) by U.S. Army Corps of Engineers. [2] Divide scaled deflection by the modulus of elasticity in psi times pile moment of inertia in in^4 to obtain deflection in inches. [3] The required pile tip elevation was determined in accordance with U.S, Army Corps of Engineers ETL 1110-2-575 (Evaluation of I-Walls) and FS = 1.5, 1.25 and 1.1 were applied to the passive pressures for usual loading, unusual loading and earthquake loading, respectively according to U.S. Army Corps of Engineers EM 1110-2-2504 (Design of Sheet Pile Walls).

- ***WP21~WP26 (Wagner Park)***

The proposed flood wall between WP21-WP26 in the vicinity of Wagner Park is a tie back sheet pile wall with the proposed tie back at El. 15.5. The typical section of the proposed relieving platform and the flood wall is shown in Figure 9. Geofoam is proposed on the flood side above the relieving platform which is sacrificial, and therefore, and it is assumed there is no resistance on the flood side above the platform in the wall design. The load cases required by EM 1110-2-2502 are summarized in Figure 10.

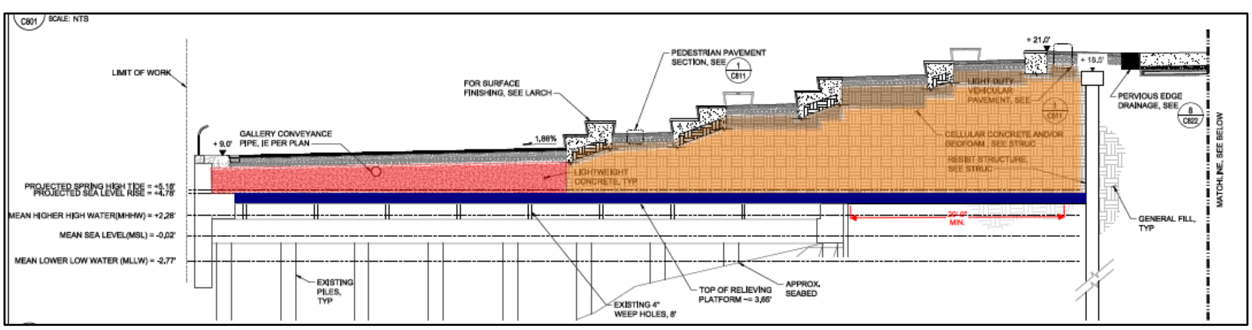
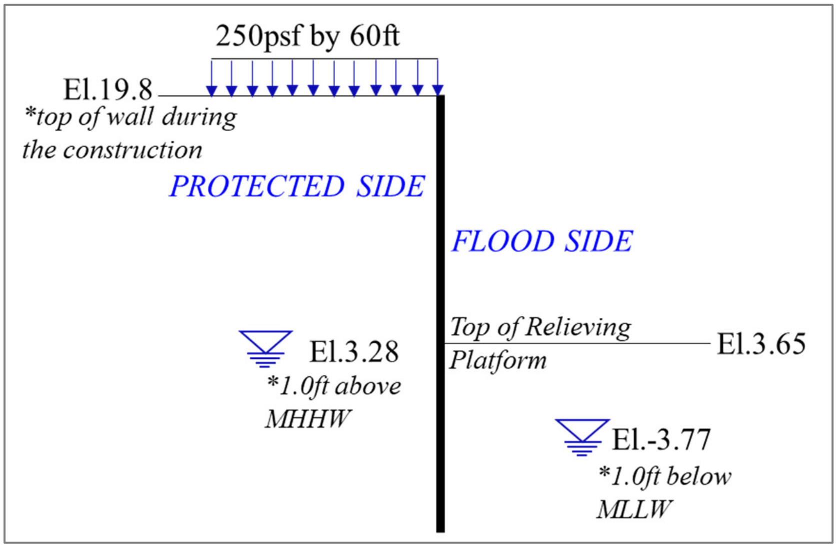
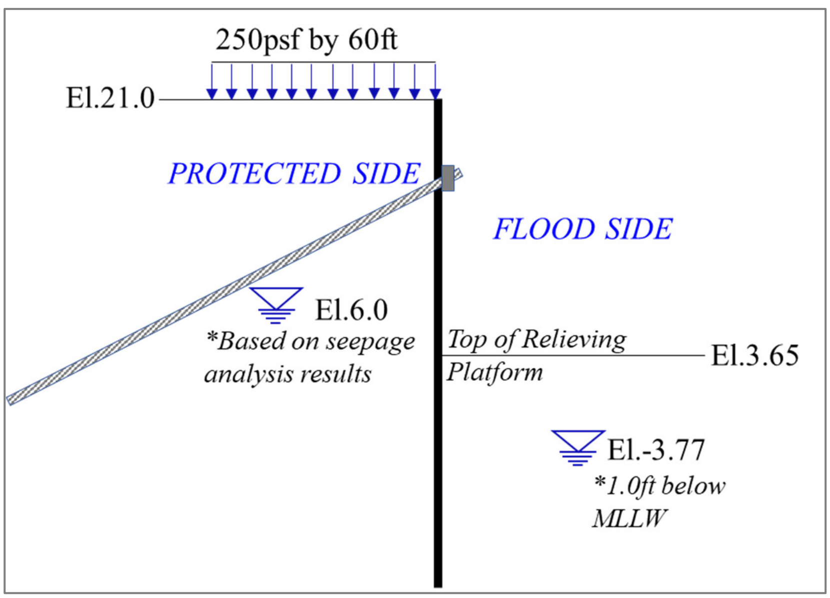


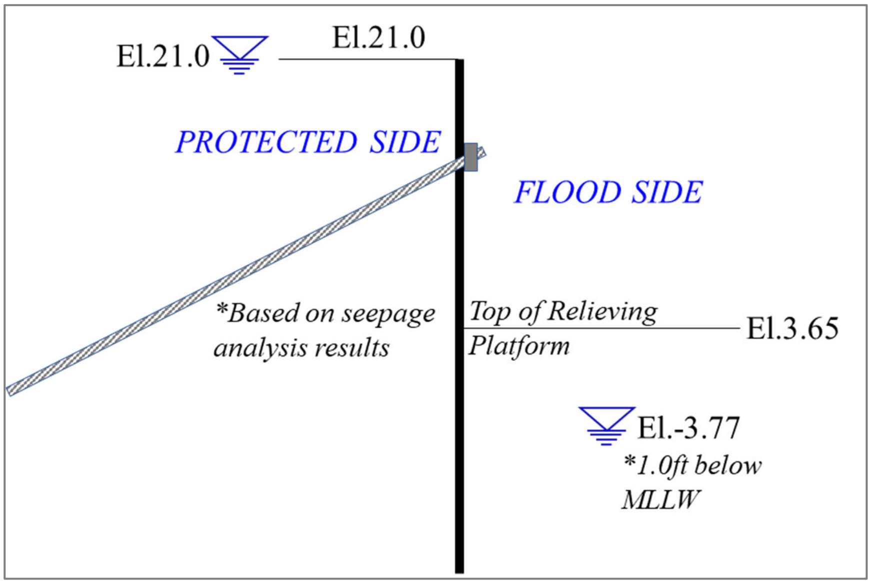
Figure 9: Typical Wall Section for WP21-WP26



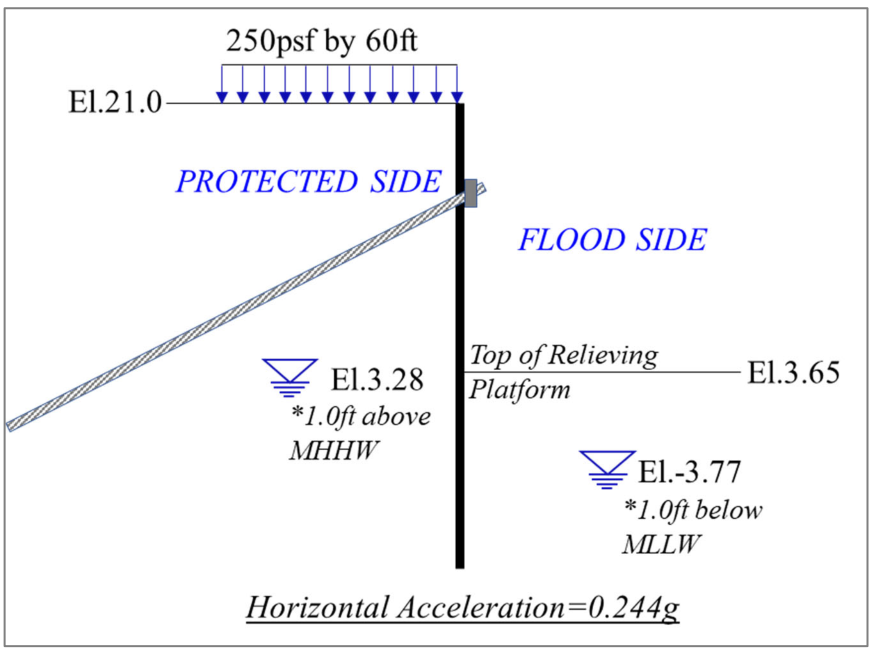
(a) Construction Stage (Cantilever)



(b) Usual Loading (with Tieback at El. 15.5)



(c) Unusual Loading (with Tieback at El. 15.5)



(d) Earthquake Loading (with Tieback at El. 15.5)

Figure 10: Controlling Load Cases for Floodwall between WP21 and WP26

The maximum unfactored moment, maximum unfactored shear and design anchor force presented below are calculated using a factor of safety of 1.0 for both active and passive pressures to avoid compounding factors of safety in sheet piling and waler design as recommended by USACE EM 1110-2-2504 (Chapter 6.1).

For the tieback design, the ultimate bond stress for the ground/grout interface along the anchor bond zone is recommended as 4.6ksf for type B pressure-grouted anchor per Table 6.3 of PTI (1996). A factor of safety of 2 is applied to the ultimate bond stress of the tieback.

The followings are the recommended tieback design for the wall between WP21 and WP26 (Wagner Park):

One level of tiebacks at El.15.5 ft. 4 ft. (below top of sheet pile)
Horizontal Spacing: 8 ft.
Inclination Angle: 25 deg,
Diameter: 6 inches
Design Load = 85 kips
Minimum Required Free Length: 18 ft.
Minimum Required Bond Length*: 25 ft. (Considering ultimate bond stress of 4.6 ksf for type B pressure grout)
Prestressing Steel Bar: Steel Grade 150ksi, Nominal Diameter 1.25” (ASTM A722)
(*it is required to backfill to the top of wall on the protect side prior to the installation of tiebacks in order to have enough confining pressures for the grout*)

The results are summarized in the following table while the detailed outputs are presented in Appendix K-2.

LOAD CASE	MAXIMUM UNFACTORED MOMENT [1]	MAXIMUM UNFACTORED SHEAR [1]	DESIGN ANCHOR FORCE AT EL.15.5	SCALED DEFLECTION AT TOP OF SHEET PILE [2]	REQUIRED PILE TIP ELEVATION [3]
a-Construction Stage	60.6 kips - ft. / ft.	13.4 kips	N/A	2.49×10^{10} (lb. -in.^{3})	-14.0
b-Usual Loading	14.4 kips - ft. / ft.	3.5 kips	4.34 kips / ft.	6.9×10^{8} (lb. - in^{3}.)	-8.5
c-Unusual Loading	45.4 kips-ft. / ft.	7.4 kips	9.7 kips / ft.	2.27×10^{9} (lb. - in^{3}.)	-12.6
d-Earthquake Loading	19.6 kips-ft. / ft.	4.4 kips	5.41 kips/ft	1.10×10^{9} (lb. – in.^{3})	-11.9

Notes: [1] These unfactored moment and shear provided here are for structural design and they are calculated using a factor of safety of 1.0 for both active and passive pressures in accordance with Design of Sheet Pile Wall (EM 1110-2-2504) by U.S. Army Corps of Engineers. [2] Divide scaled deflection by the modulus of elasticity in psi times pile moment of inertia in in^4 to obtain deflection in inches. For example, the deflection at top of the sheet pile during the construction stage with sheet pile NZ26 is: $2.49\times10^{10}/(29\times10^{6}\times419.9)=2.05$ inches. [3] The required pile tip elevation was determined in accordance with U.S, Army Corps of Engineers ETL 1110-2-575 (Evaluation of I-Walls) and FS=1.25, 1.5, 1.25 and 1.1 were applied to the passive pressures for construction stage, usual loading, unusual loading and earthquake loading, respectively according to U.S. Army Corps of Engineers EM 1110-2-2504 (Design of Sheet Pile Walls).

➢ ***<u>Global Stability Analyses</u>***

Global stability analyses were performed for the proposed sheet pile wall (I-Type Wall) near JMH and in Wagner Park for the most critical sections in accordance with EM 1110-2504 and ETL 1110-2-575 Evaluation of I-Walls. Based on the subsurface conditions, GAP analysis is not relevant to the design of the I Type Walls at the referenced site. However, analyses of a deep-seated failure, or a global stability analysis, was performed in accordance with EM 1110-2-575. The soil properties summarized in Table 10 and Table 11 were used in the global stability analyses for sheet piles with the tip elevation at El. -12.0 and El. -14.0, respectively. Based on the global stability analyses, the calculated factor of safety of the global stability for the two cases are 4.55 and 2.52, respectively which are higher than the acceptable factor of safety of 1.5 according to U.S. Army Corps of Engineers EM 1110-2-1902 (Engineering and Design Manual-Slope Stability). Therefore, it is concluded here that the proposed I-type wall is adequate against the deep-seated mode of failure described in EM 1110-2-2504. The detailed calculations are presented in Appendix K-4.

Foundation Type-2 Closed End Pipe Pile / H-Pile / Micro Pile (WP4~WP6, WP6~WP11 and WP26~WP43)

- WP4~WP6

For the section between WP4 and WP6 along 1st Place, a fixed flood wall has been proposed according to the Drawing SF301 and SF412 of the 95% Design Documents. The shorter portion of this wall between WP1 and WP4 is proposed to be supported by a spread footing, and the taller portion of this wall between WP4 and WP6 is proposed to be supported by cantilevered micropiles. For the micropile foundation between WP4 and WP6, the typical section is shown in Figure 11. The controlling load cases considered in the micropile design for this section are summarized in Figure 12.

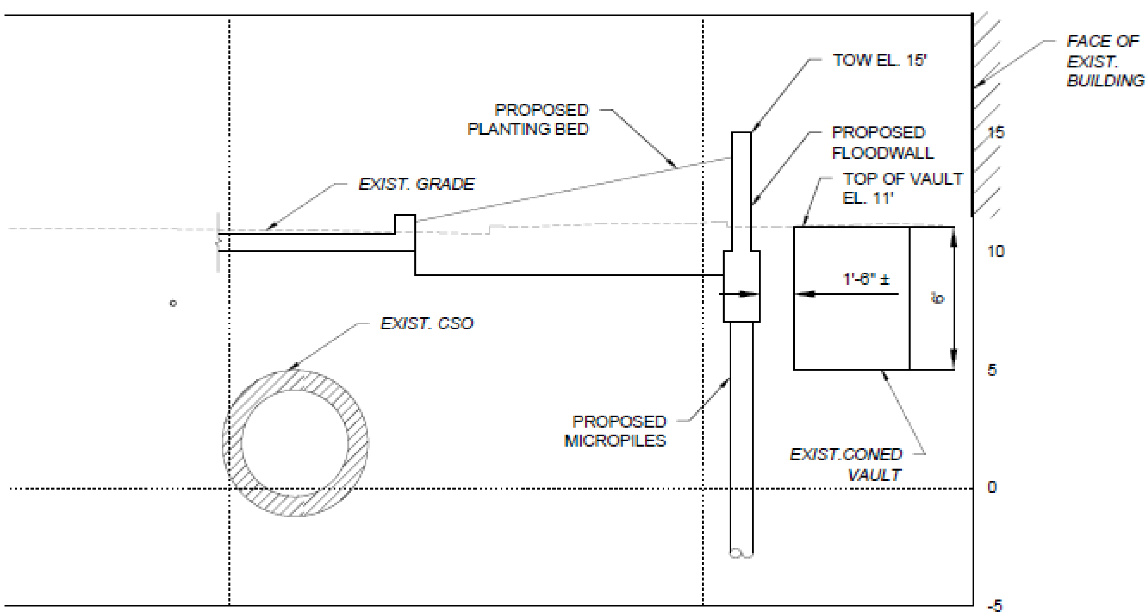


Figure 11: Typical Wall Section for WP4-WP6

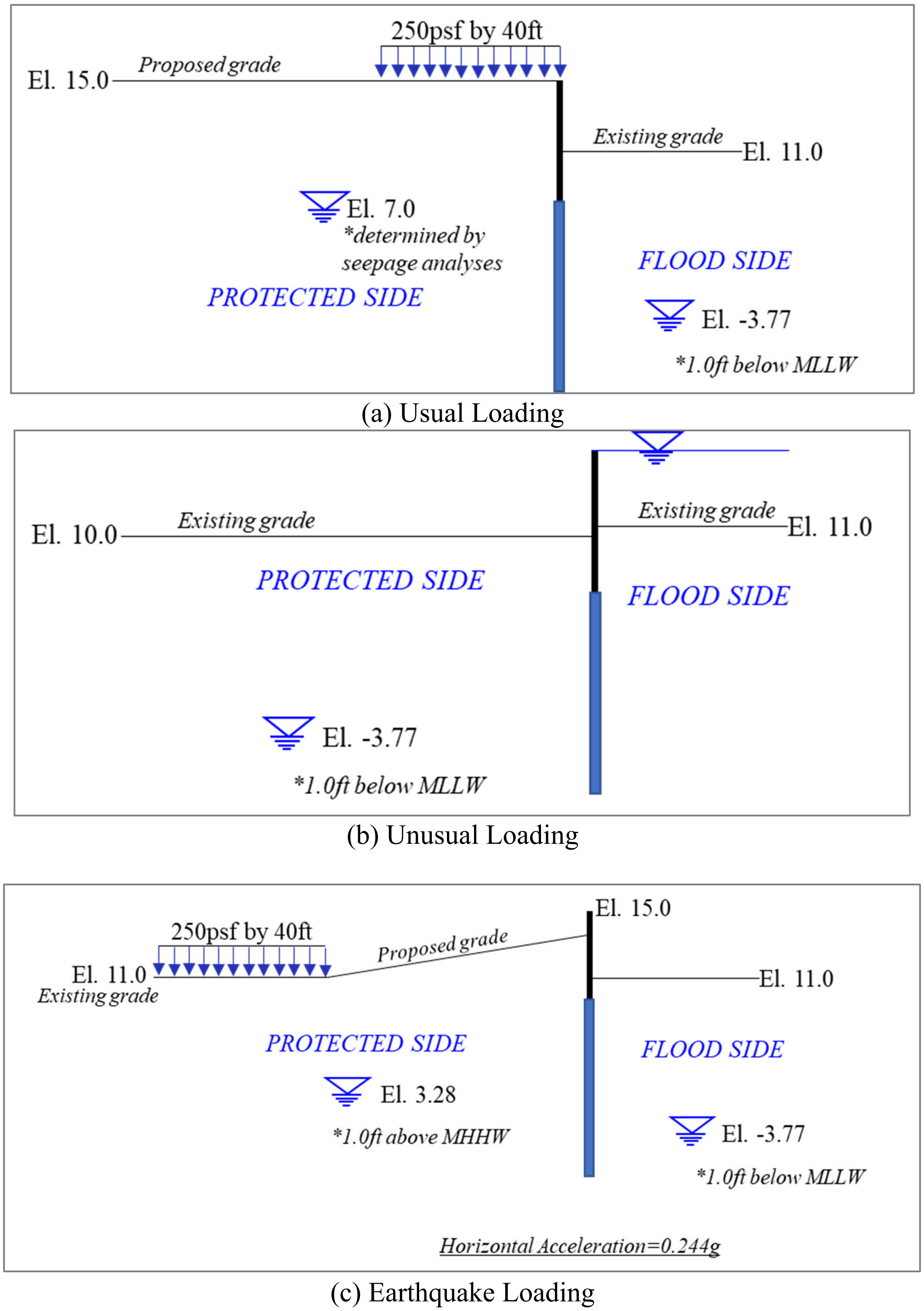


Figure 12: Controlling Load Cases for Floodwall along 1st Place Between WP4 and WP6

The selected micropile design in the analyses is micropile with O.D. = 9 5/8 inches and wall thickness = 0.5 inches, and on center-to-center spacing S = 8.0 feet. Based on the calculations, the required minimum section modulus of the above three load cases of usual loading, unusual loading and earthquake loading are 28.3 in^3/pile, 2.0 in^3/pile and 4.0 in^3/pile, respectively. As a result, the above selected pile section of O.D.= 9 $\frac{5}{8}$ inches and wall thickness of 0.5 inches with a section modulus of 31.1 in^3 satisfies the structural requirements. Micropiles shall have a rock socket no less than 3.0 ft. according to NYC Building Code and the recommended pile axial capacity are similar to that for pavilion (see Table 8). The detailed outputs are presented in Appendix I-3A.

- WP6~WP11 and WP26~WP43

Driven steel piles (closed End Pipe Pile and H-Pile) or micropile foundations combined with Jet Grouting are proposed from WP6 to WP11 and from WP26 to WP43. Proposed H-Piles and Closed End Pipe Piles should be founded on bedrock while the proposed micropi1le shall have a minimum rock socket of 3.0 feet according to NYC Building Code. The piles shall have recommended pile axial capacity similar to that for pavilion (see Table 8) but with different geotechnical lateral capacities, which are summarized in the following table (see Appendix I-3B for detailed calculations):

PILE TYPE	SIZE	GEOTECHNICAL LATERAL CAPACITY [1] [2]		
		WP6 ~ WP11 (Sta. 10+00 ~ 11+25)	**WP26 ~ WP33 Sta. 19+50 ~ 23+00**	**WP33 ~ WP43 Sta. 23+00 ~ 26+50**
Closed End Pipe Piles O.D. = 9 5/8	Casing Thickness = 0.5”	17.8 kips	14.2 kips	15.7 kips
	Casing Thickness = 0.545”	18.4 kips	14.6 kips	16.2 kips
H-Pile	HP12x53	27.7 kips	21.5 kips	24.5 kips
	HP12x63	30.0 kips	23.2 kips	26.5 kips
	HP12x74	32.6 kips	25.0 kips	28.9 kips
	HP12x84	34.9 kips	26.5 kips	30.8 kips
Micropile O.D. = 9 5/8	Casing Thickness = 0.5”	18.6 kips	14.8 kips	16.3 kips
	Casing Thickness = 0.545”	19.2 kips	15.2 kips	16.8 kips

Micropile (N80) O.D. = 11.875"	Casing Thickness = 0.582"	27.1 kips	21.2 kips	22.9 kips

Note: [1] Geotechnical lateral capacity refers to the lateral load applied to top of a single vertical pile which results in one-inch deflection at top of the pile. [2] Structural capacity in bending to be evaluated by others.

Due to the presence of cobbles and boulders encountered in boring B-9 and various obstructions encountered within the upper 10 ft. below existing grades at multiple locations for B-10, driving piles may be restricted in these areas. Micropiles which can penetrate such obstruction should be considered.

- ***Foundation Type-3 Spread Footing (WP1~WP4 and WP43 ~ WP55/Sta. 26+50~ Sta.30+04)***

A fixed flood wall supported by a spread footing and T type walls supported on spread footing in the fill materials have been proposed for the section between WP1 and WP4 and the section between WP43 and WP55, respectively. It is recommended that the footing be designed with a maximum allowable bearing pressure of no greater than 1.0 tsf per NYCBC 1804.2.3 providing the recommendations for subgrade preparation are implemented during construction. Settlements at each end of the wall are estimated to range from approximately 1.2 to 0.3 inches with maximum differential settlements under this load between segments estimated to be less than ½ an inch. See Appendix L for settlement estimates.

Estimated Site Settlements Due to Raised Grades

Settlements due to raised grades along the proposed floodwall were estimated based on the soil conditions and the latest floodwall and grading plan drawings received from AECOM (*75% Design)*. The areas along the proposed flood wall can divided into six sections based on the height of added fill and soil parameters. The loads used in the settlement estimation are summarized as follows:

Section 1: Working Points between WP1-WP19 (Along Museum of Jewish Heritage)

- Nearby soil borings: B-1 and B-2;
- Added loads due to raised grades: uniform load 0.5 ft. × 125 pcf = 62.5psf (0 ~ 1 ft. fill is required to reach the design grade with an average of thickness of fill of 0.5 ft.);

- Proposed flood wall foundation: Micropiles into bedrock + jet grouting.

Tables 14 and 15 present the estimated settlement under the added uniform load of 62.5psf based on soil borings B-1 and B-2, respectively.

Table 14: Estimated Settlement for Section Between WP1-WP19 Based on Soil Boring B-1

Settlement Under 0.5 ft. Fill (Uniform Load of 62.5psf) Based on B-1								
Depth Below Ground Surface (ft.)	Field SPT-Auto Hammer	Soil Type	SPT N_{60}	Recommended E_s/N[1],[2]	Es (tsf)	Layer thickness (ft.)	Elastic Settlement (inches)	Consolidation Settlement (inches)
2	27	GM/SM	35.1	8	280.8	4	0.01	0.00
6	32	SM	41.6	10	416	4.5	0.00	0.00
11	12	SP-SM	15.6	7	109.2	5	0.02	0.00
16	5	SP-SM	6.5	7	45.5	5	0.04	0.00
21	7	SP-SM	9.1	7	63.7	5	0.03	0.00
26	31	SP-SM	40.3	7	282.1	5	0.01	0.00
31	12	SP-SM	15.6	7	109.2	5	0.02	0.00
36	8	SC	10.4	5	52	5	0.04	0.00
41	12	SM	15.6	6	93.6	5	0.02	0.00
46	14	SP-SM	18.2	7	127.4	5	0.01	0.00
51	23	GP-GC	29.9	10	299	3	0.00	0.00
52	Bedrock							
					TOTAL (INCH)		**0.20**	**0.00**

Reference 1: Design Manual 7.01 P7.1-220: $E_s=4N_{60}$ for silts, sands silts, cohesive silt-sand mixtures, $E_s=7N_{60}$ for clean, fine to med, sands & slightly silty sands, $E_s=10N_{60}$ for coarse sands and sands with little gravel, and $E_s=12N_{60}$ for sandy gravels and gravel.

Reference 2: EPRI EL-6800 P5-17: $E/Pa=5\ N_{60}$ for sands with fines, $E/Pa=10N_{60}$ for clean NC sands.

Table 15: Estimated Settlement for Section Between WP1-WP19 Based on Soil Boring B-2

Settlement Under 0.5 ft. Fill (Uniform Load of 62.5psf) Based on B-2								
Depth Below Ground Surface (ft.)	Field SPT-Auto Hammer	Soil Type	SPT N_{60}	Recommended E_s/N [1],[2],[3]	Es (tsf)	Layer thickness (ft.)	Elastic Settlement (inches)	Consolidation Settlement (inches)
1	3	SM	3.9	5	19.5	2	0.04	0.00
6	20	SP-SM	26	7	182	5	0.01	0.00
11	15	SP-SM	19.5	7	136.5	5	0.01	0.00
16	15	SP	19.5	7	136.5	5	0.01	0.00
21	5	SP	6.5	7	45.5	5	0.04	0.00
26	8	SP	10.4	7	72.8	5	0.03	0.00
31	10	SP	13	7	91	5	0.02	0.00
36	9	SP	11.7	5	58.5	5	0.03	0.00
41	16	SM	20.8	6	124.8	5	0.02	0.00
46	14	SP-SM	18.2	7	127.4	5	0.01	0.00
51	10	SP	13	7	91	3.75	0.02	0.00
53.5	Bedrock							
					TOTAL (INCH)		**0.24**	**0.00**

Reference 1: Design Manual 7.01 P7.1-220: $E_s=4N_{60}$ for silts, sands silts, cohesive silt-sand mixtures, $E_s=7N_{60}$ for clean, fine to med, sands & slightly silty sands, $E_s=10N_{60}$ for coarse sands and sands with little gravel, and $E_s=12N_{60}$ for sandy gravels and gravel.
Reference 2: EPRI EL-6800 P5-17: E/Pa=5 N_{60} for sands with fines, E/Pa=$10N_{60}$ for clean NC sands.

Based on the above estimations, the estimated elastic and consolidation settlements along the proposed floodwall between WP1 and WP19 are 0.2 ~ 0.24 and 0.0, respectively. This is less than 0.4 inch which is the commonly considered as the threshold settlement for downdrag loads on piles, therefore, we concluded that the raised grades would have negligible impacts on the proposed floodwall foundation for this section.

Section 2: Working Points between WP19-WP26

- Nearby Soil Borings: B-3 and B-4;
- Added Loads Due to Raised Grades: uniform load 10ft.×125pcf = 1250psf (up to 10 feet fill is required to reach the design grades);

- Proposed Flood Wall Foundation: Sheet pile with tip at El.±-31' (bedrock is at ±-41.5').

Tables 16 and 17 present the estimated settlement under the added uniform load of 1250psf based on soil borings B-3 and B-4, respectively.

Table 16: Estimated Settlements for Section Between WP19-WP26 Based on Soil Boring B-3

Settlement Under 10 ft. Fill (Uniform Load of 1250psf) Based on Soil Boring B-3								
Depth Below Ground Surface (ft.)	Field SPT-Auto Hammer	Soil Type	SPT N_{60}	Recommended E_s/N [1],[2]	E_s(tsf) /Compression Ratio for Clay	Layer thickness (ft.)	Elastic Settlement (inches)	Consolida-tion Settlement (inches)
2	21	SM	27.3	5	136.5	4	0.22	0.00
6	10	SP	13	8	104	4.5	0.32	0.00
11	27	SM	35.1	5	175.5	5	0.21	0.00
16	24	SP	31.2	7	218.4	5	0.17	0.00
21	10	SP	13	7	91	5	0.41	0.00
26	5	SP	6.5	7	45.5	5	0.82	0.00
31	8	SP	10.4	7	72.8	5	0.52	0.00
36	21	SP	27.3	5	136.5	5	0.27	0.00
41	17	SM	22.1	6	132.6	5	0.28	0.00
46	4	CH	5.2		0.176[3]	5	-	1.5+1.0[4][5]
51	44	CH /MH	57.2	4	228.8	3.5	0.11	0.00
53	Bedrock							
					TOTAL (INCH)		**3.35**	**2.5**

Reference 1: Design Manual 7.01 P7.1-220: $E_s=4N_{60}$ for silts, sands silts, cohesive silt-sand mixtures, $E_s=7N_{60}$ for clean, fine to med, sands & slightly silty sands, $E_s=10N_{60}$ for coarse sands and sands with little gravel, and $E_s=12N_{60}$ for sandy gravels and gravel.

Reference 2: EPRI EL-6800 P5-17: E/Pa=5 N_{60} for sands with fines, E/Pa=10N_{60} for clean NC sands.

Reference 3: EPRI EL-6800 P6-6: Typical Range of Compression Ratio versus Water Content.
Note [4]: for the average WT at El.2.0, overburden pressure at middle of the clay layer=120*(11.5-2)+(120-62.4)*(46-9.5)=3.242ksf. The estimated primary settlement=0.176*5*12*log[(3.242+1.25)/3.242]=1.50 inches.
Note [5]: According to NAVFAC 7.1-144, coefficient of consolidation C_v for LL=98 is approximate of 0.0217ft^2/day and the coefficient of secondary compression is 0.0107 for w=54.6%. Therefore, considering the single drained condition, it would take approximate 977 days to complete the primary consolidation. The secondary settlement in 100 years after completion of construction would be approximate of 1.0 inches.

Table 17: Estimated Settlements for Section Between WP19-WP26 Based on Soil Boring B-4

Settlement Under 10 ft. Fill (Uniform Load of 1250psf) Based on Soil Boring B-4								
Depth Below Ground Surface (ft.)	Field SPT-Auto Hammer	Soil Type	SPT N_{60}	Recommended E_s/N [1],[2]	Es(tsf) /Compression Ratio for Clay	Layer thickness (ft.)	Elastic Settlement (inches)	Consolidation Settlement (inches)
1	3	SM	3.9	5	19.5	2	0.77	0.00
6	28	SP	36.4	7	254.8	5	0.15	0.00
11	17	SP	22.1	8	176.8	5	0.21	0.00
16	28	SP	36.4	7	254.8	5	0.15	0.00
21	8	SP	10.4	7	72.8	5	0.52	0.00
26	5	SP	6.5	7	45.5	5	0.82	0.00
31	11	SP	14.3	7	100.1	5	0.37	0.00
36	10	SP	13	7	91	5	0.41	0.00
41	9	SP	11.7	7	81.9	5	0.46	0.00
46	8	SP	10.4	7	72.8	5	0.52	0.00
51	15	GP	19.5	12	234	3.75	0.12	0.00
53.5	Bedrock							
					TOTAL (INCH)		**4.49**	**0.00**

Reference 1: Design Manual 7.01 P7.1-220: $E_s=4N_{60}$ for silts, sands silts, cohesive silt-sand mixtures, $E_s=7N_{60}$ for clean, fine to med, sands & slightly silty sands, $E_s=10N_{60}$ for coarse sands and sands with little gravel, and $E_s=12N_{60}$ for sandy gravels and gravel.

Reference 2: EPRI EL-6800 P5-17: $E/Pa=5\ N_{60}$ for sands with fines, $E/Pa=10N_{60}$ for clean NC sands.

Based on the above estimations, the total estimated settlements under the uniform load of up to 10 feet fill along the proposed floodwall between WP19 and WP26 consists of 3.35" ~ 4.49" elastic settlement which would take place during or immediately after raising grades and approximate 2.5 inches of consolidation settlement in 100 years after the completion of construction. Since the proposed sheet pile foundation is not founded on bedrock, the proposed floodwall would settle together with the surrounding soils. To minimum elastic settlements, the sheet pile can be installed after raising the grades. Consolidation settlements can be mitigated by slightly increasing the height of the wall or drive the sheet pile to the top of bedrock at elevation of -41.5. Flexible pipe and/or should be used for connections to manholes to minimize the effect of differential settlement between areas with and without raised grades.

Section 3: Working Points between WP26-WP33

- Nearby Soil Borings: B-7 and B-8;
- Added Loads Due to Raised Grades: uniform load 5ft×125pcf=625psf (up to 5 feet fill is required to the proposed grade);
- Proposed Flood Wall Foundation: H-Pile Founded on Bedrock + Jet Grouting.

Tables 18 and 19 present the estimated settlement under the added uniform load of 625 psf based on soil borings B-7 and B-8, respectively.

Table 18: Estimated Settlements for Section Between WP26-WP33 Based on Soil Boring B-7

Settlement Under 5 ft. Fill (Uniform Load of 625 psf) Based on Soil Boring B-7								
Depth Below Ground Surface (ft.)	Field SPT-Auto Hammer	Soil Type	SPT N_{60}	Recommended E_s/N [1],[2]	Es(tsf) /Compression Ratio for Clay	Layer thickness (ft.)	Elastic Settlement (inches)	Consolidation Settlement (inches)
2	13	SP-SM	16.9	10	169	4	0.09	0.00
6	10	SP-SM	13	7	91	4.5	0.19	0.00
11	3	SP-SM	3.9	7	27.3	5	0.69	0.00
16	2	SM	2.6	6	15.6	5	1.20	0.00
21	4	SP-SM	5.2	8	41.6	5	0.45	0.00
26	3	SP-SM	3.9	7	27.3	5	0.69	0.00
31	1	SC	1.3	5	6.5	5	2.88	0.00
36	24	CH/MH	31.2	4	124.8	4.5	0.14	0.00
40	Bedrock							
					TOTAL (INCH)		**6.32**	

Reference 1: Design Manual 7.01 P7.1-220: $E_s=4N_{60}$ for silts, sands silts, cohesive silt-sand mixtures, $E_s=7N_{60}$ for clean, fine to med, sands & slightly silty sands, $E_s=10N_{60}$ for coarse sands and sands with little gravel, and $E_s=12N_{60}$ for sandy gravels and gravel.

Reference 2: EPRI EL-6800 P5-17: $E/Pa=5\ N_{60}$ for sands with fines, $E/Pa=10N_{60}$ for clean NC sands.

Table 19: Estimated Settlements for Section Between WP26-WP33 Based on Soil Boring B-8

Settlement Under 5 ft. Fill (Uniform Load of 625psf) Based on Soil Boring B-8

Depth Below Ground Surface (ft.)	Field SPT-Auto Hammer	Soil Type	SPT N_{60}	Recommended E_s/N[1],[2]	Es(tsf) /Compression Ratio for Clay	Layer thickness (ft.)	Elastic Settlement (inches)	Consolidation Settlement (inches)
2	49	SP-SM	63.7	10	637	4	0.02	0.00
6	4	SP	5.2	7	36.4	4.5	0.46	0.00
11	4	SM	5.2	8	41.6	5	0.45	0.00
16	10	SM	13	8	104	5	0.18	0.00
21	16	GP-GM	20.8	11	228.8	5	0.08	0.00
26	4	SC	5.2	6	31.2	5	0.60	0.00
31	4	SP-SC	5.2	8	41.6	4.75	0.43	0.00
35.5	4	SP-SM	5.2	8	41.6	2.5	0.23	0.00
36	5	CH	6.5		0.195	2.75	[4]	0.68[7]
41	2	CH	2.6		0.195	4	[5]	0.92[7]
44	2	CH	2.6		0.195	2.5	[6]	0.55[7]
46	5	SM	6.5	5	32.5	3.5	0.40	0.00
51	6	SM	7.8	5	39	4.75	0.46	0.00
55.5	Bedrock							
					TOTAL (INCH)		**3.32**	**2.15+2.18 =4.33**

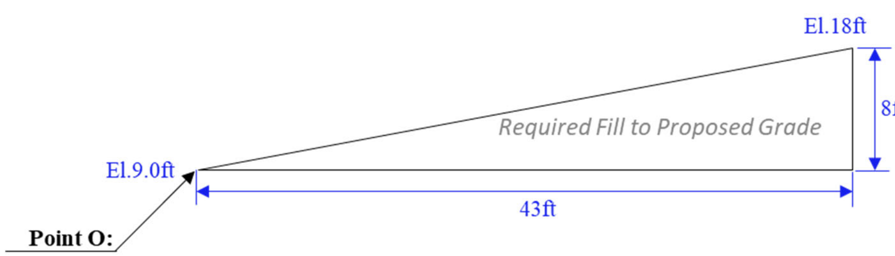
Reference 1: Design Manual 7.01 P7.1-220: E_s=4N_{60} for silts, sands silts, cohesive silt-sand mixtures, E_s=7N_{60} for clean, fine to med, sands & slightly silty sands, E_s=10N_{60} for coarse sands and sands with little gravel, and E_s=12N_{60} for sandy gravels and gravel.
Reference 2: EPRI EL-6800 P5-17: E/Pa=5 N_{60} for sands with fines, E/Pa=10N_{60} for clean NC sands.
Reference 3: EPRI EL-6800 P6-6: Typical Range of Compression Ratio versus Water Content.
Reference 4: for the average WT at El.2.0, overburden pressure at center of the subdivided clay layer=120*(5-2)+(120-62.4)*(36-3)=2.26ksf, the estimated primary settlement=0.195*2.75*12*log[(2.26+0.625)/2.26]=0.68 inches.
Reference 5: for the average WT at El.2.0, overburden pressure at center of the subdivided clay layer=2.26+(100-62.4)*(41-36)/1000=2.448ksf, the estimated primary settlement=0.195*4*12*log[(4.448+0.625)/2.448]=0.92 inches.
62.4)*(44-36)/1000=2.560ksf, the estimated primary settlement=0.195*2.5*12*log[(2.56+0.625)/2.56]=0.55 inches.
Note [7]: According to NAVFAC 7.1-144, coefficient of consolidation C_v for LL=92 is approximate of 0.027ft^2/day and the coefficient of secondary compression is 0.0115 for w=59.7%. Therefore, considering the double drained condition for the approximate 9 feet thick cohesive layer, it would take approximate 636 days to complete the primary consolidation. The secondary settlement in 100 years after completion of construction would be approximate of 2.18 inches.

Based on the above estimations, the estimated settlement under the uniform load of up to 5 feet fill along the proposed floodwall between WP26 and WP33 consists of 3.32" ~ 6.32" elastic settlement which would take place during or immediately after raising grades and approximate 4.3 inches of consolidation settlement within 100 years after the completion of construction. Since the proposed floodwall foundation of H-Piles are founded on bedrock, the proposed floodwall would not settle together with the surrounding soils. However, downdrag loads will be applied to the H-Piles and the jet grout seepage barrier. If downdrag loads are not accounted for in the design of the connection between the jet grouting and the wall, this settlement may cause separation at the connection. The jet grout barrier may also be continued to the top of bedrock, varying from El.-34.5 to El. -50.5, to minimize the impact of downdrag loads on the integrity of the proposed seepage barrier.

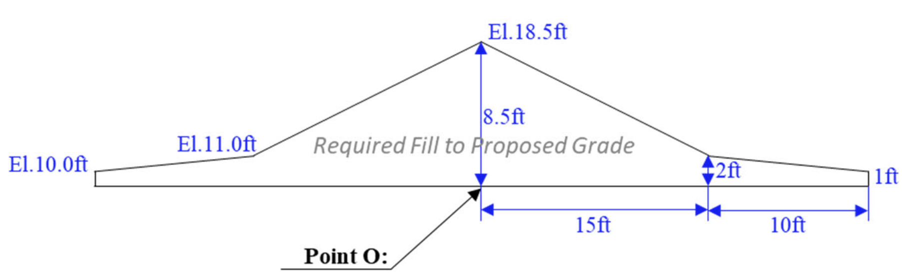
Section 4: Working Points between WP34-WP42

- Nearby Soil Borings: B-9;
- Added Loads Due to Raised Grades Along the Proposed Flood Wall (Assume Unit Weight of Fill = 125pcf):

  The Minimum Load (at Point O):



  The Maximum Load (at Point O):



- Proposed Flood Wall Foundation: H-Piles Founded on Bedrock + Jet Grouting.

Tables 20 and 21 present the estimated settlement under the minimum load and the maximum load based on soil boring B-9, respectively.

Table 20: Estimated Settlements for Section Between WP34-WP42 Based on Soil Boring B-9 Under the Minimum Loads

Settlement Under the Min. Loads Based on Soil Boring B-9								
Depth Below Ground Surface (ft.)	Filed SPT-Auto Hammer	Soil Type	SPT N_{60}	Recommended E_s/N [1],[2]	Es(tsf) /Compression Ratio for Clay	Layer thickness (ft.)	Elastic Settlement (inches)	Consolidation Settlement (inches)
1	9	SM	11.7	7	81.9	2	0.00	0.00
9	9	SM	11.7	7	81.9	7.5	0.03	0.00
16	36	SM	46.8	5	234	6	0.01	0.00
21	21	SM	27.3	5	136.5	5	0.02	0.00
26	13	SM	16.9	5	84.5	5	0.03	0.00
31	90	SM	117	5	585	5	0.00	0.00
36	100	SM	130	5	650	5	0.00	0.00
41	Bedrock							
					TOTAL (INCH)		**0.10**	**0.00**

Reference 1: Design Manual 7.01 P7.1-220: $E_s=4N_{60}$ for silts, sands silts, cohesive silt-sand mixtures, $E_s=7N_{60}$ for clean, fine to med, sands & slightly silty sands, $E_s=10N_{60}$ for coarse sands and sands with little gravel, and $E_s=12N_{60}$ for sandy gravels and gravel.

Reference 2: EPRI EL-6800 P5-17: $E/Pa=5\ N_{60}$ for sands with fines, $E/Pa=10N_{60}$ for clean NC sands.

Table 21: Estimated Settlements for Working Points Between WP34-WP42 Based on Soil Boring B-9 Under the Maximum Loads

Settlement Under the Max. Loads Based on Soil Boring B-9

Depth Below Ground Surface (ft.)	Filed SPT-Auto Hammer	Soil Type	SPT N_{60}	Recommended E_s/N [1],[2]	Es(tsf) /Compression Ratio for Clay	Layer thickness (ft.)	Elastic Settlement (inches)	Consolidation Settlement (inches)
1	9	SM	11.7	7	81.9	2	0.15	0.00
9	9	SM	11.7	7	81.9	7.5	0.41	0.00
16	36	SM	46.8	5	234	6	0.09	0.00
21	21	SM	27.3	5	136.5	5	0.11	0.00
26	13	SM	16.9	5	84.5	5	0.15	0.00
31	90	SM	117	5	585	5	0.02	0.00
36	100	SM	130	5	650	5	0.01	0.00
41	Bedrock							
					TOTAL (INCH)		**0.80**	**0.00**

Reference 1: Design Manual 7.01 P7.1-220: $E_s=4N_{60}$ for silts, sands silts, cohesive silt-sand mixtures, $E_s=7N_{60}$ for clean, fine to med, sands & slightly silty sands, $E_s=10N_{60}$ for coarse sands and sands with little gravel, and $E_s=12N_{60}$ for sandy gravels and gravel.

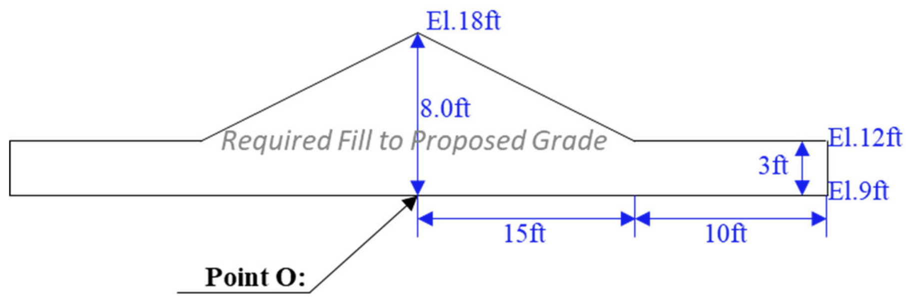
Reference 2: EPRI EL-6800 P5-17: E/Pa=5 N_{60} for sands with fines, E/Pa=$10N_{60}$ for clean NC sands.

Based on the above estimations, the estimated settlements under the added fill along the proposed floodwall between WP34 and WP42 range from 0.1 inches to 0.8 inches of elastic settlement, which is likely to cause downdrag on the proposed pile foundations and the jet grout seepage barrier. However, all induced settlements are to be elastic settlement and would take place during or immediately after raising grades. In order to minimize the impact of raised grades on the proposed floodwall, it is recommended to drive the pile and install the jet grout seepage barrier after completion of raising the grades, design the cut off to accommodate the downdrag or carry the jet grouting down to bedrock.

Section 5: Working Points between WP42-WP48

- Nearby Soil Borings: B-9;

- Added Loads Due to Raised Grades Along the Proposed Flood Wall (at Point O) (Assume Unit Weight of Fill = 125pcf):



- Proposed Flood Wall Foundation: Jet Grouting

Table 22 present the estimated settlement under the added loads due to raised grades based on the soil boring B-9.

Table 22: Estimated Settlements for Section Between WP42-WP48 Based on Soil Boring B-9

Settlement Based on Soil Boring B-9								
Depth Below Ground Surface (ft.)	Filed SPT-Auto Hammer	Soil Type	SPT N60	Recommended E_s/N [1],[2]	Es(tsf) /Compression Ratio for Clay	Layer thickness (ft.)	Elastic Settlement (inches)	Consolidation Settlement (inches)
1	9	SM	11.7	7	81.9	2	0.15	0.00
9	9	SM	11.7	7	81.9	7.5	0.43	0.00
16	36	SM	46.8	5	234	6	0.10	0.00
21	21	SM	27.3	5	136.5	5	0.13	0.00
26	13	SM	16.9	5	84.5	5	0.18	0.00
31	90	SM	117	5	585	5	0.02	0.00
36	100	SM	130	5	650	5	0.02	0.00
41	Bedrock							
					TOTAL (INCH)		**0.87**	**0.00**

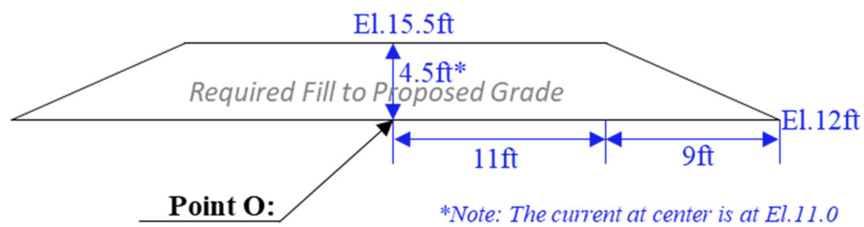
Reference 1: Design Manual 7.01 P7.1-220: $E_s=4N_{60}$ for silts, sands silts, cohesive silt-sand mixtures, $E_s=7N_{60}$ for clean, fine to med, sands & slightly silty sands, $E_s=10N_{60}$ for coarse sands and sands with little gravel, and $E_s=12N_{60}$ for sandy gravels and gravel.

Reference 2: EPRI EL-6800 P5-17: E/Pa=5 N_{60} for sands with fines, E/Pa=10N_{60} for clean NC sands.

Based on the above estimations, the estimated settlements under the added fill along the proposed floodwall between WP42 and WP48 is approximate 0.87 inches of elastic settlement, which would cause downdrag to the proposed jet grouting. However, estimated settlements are elastic and would occur during or immediately after raising the grades. In order to minimize the impact of raised grades on the proposed floodwall, it is recommended to install the jet grout seepage barrier after completion of raising the grades, design the cut off to accommodate the downdrag, or carry the jet grouting down to the bedrock.

Section 6: Working Points between WP46-WP55

- Nearby Soil Borings: B-9;
- Added Loads Due to Raised Grades (Assume Unit Weight of Fill=125pcf) Along the Proposed Flood Wall (at Point O):



- Proposed Flood Wall Foundation: Spreading Footing.

Table 23 present the estimated settlement under the added loads due to raised grades based on the soil boring B-9.

Table 23: Estimated Settlements for Section Between WP48-WP55 Based on Soil Boring B-9

Settlement Based on Soil Boring B-9								
Depth Below Ground Surface (ft.)	Filed SPT-Auto Hammer	Soil Type	SPT N60	Recommended E_s/N [1],[2]	Es(tsf) /Compression Ratio for Clay	Layer thickness (ft.)	Elastic Settlement (inches)	Consolidation Settlement (inches)
1	9	SM	11.7	7	81.9	2	0.08	0.00
9	9	SM	11.7	7	81.9	7.5	0.30	0.00
16	36	SM	46.8	5	234	6	0.08	0.00
21	21	SM	27.3	5	136.5	5	0.10	0.00
26	13	SM	16.9	5	84.5	5	0.14	0.00
31	90	SM	117	5	585	5	0.02	0.00
36	100	SM	130	5	650	5	0.01	0.00
41	Bedrock							
					TOTAL (INCH)		**0.65**	**0.00**

Reference 1: Design Manual 7.01 P7.1-220: $E_s=4N_{60}$ for silts, sands silts, cohesive silt-sand mixtures, $E_s=7N_{60}$ for clean, fine to med, sands & slightly silty sands, $E_s=10N_{60}$ for coarse sands and sands with little gravel, and $E_s=12N_{60}$ for sandy gravels and gravel.

Reference 2: EPRI EL-6800 P5-17: E/Pa=5 N_{60} for sands with fines, E/Pa=10N_{60} for clean NC sands.

Based on the above estimations, the estimated settlement along the floodwall between WP46 and WP53 is approximately 0.65 inches and all the settlements are elastic which would occur during or immediately after completion of the construction.

The proposed floodwall will traverse over two underground structures, the Battery Park Underpass and the Brooklyn Battery Tunnel. Based on available drawings the additional stresses due to raised grades applied to the top of the Battery Park Underpass and Brooklyn Battery Tunnel are estimated to range from 427psf to 446psf. To minimize the added stresses, light weight fill can be used as backfilling materials provided buoyancy effects are incorporated into the design. If no net additional load is necessary the floodwall can be supported on drilled in deep foundations on either side of the structures with a structural slab spanning between the supports.

Pier A Inlet

Slope stability analyses were performed for the existing and proposed conditions for the bulkhead at the Pier A inlet in accordance with EM 1110-2-1902 Slope Stability. Critical sections of the existing and proposed embankment sections were developed for the stability analyses based on AECOM Drawings SM304 and SM404 – for the Pier A Inlet bulkhead, as presented in Figure 13.

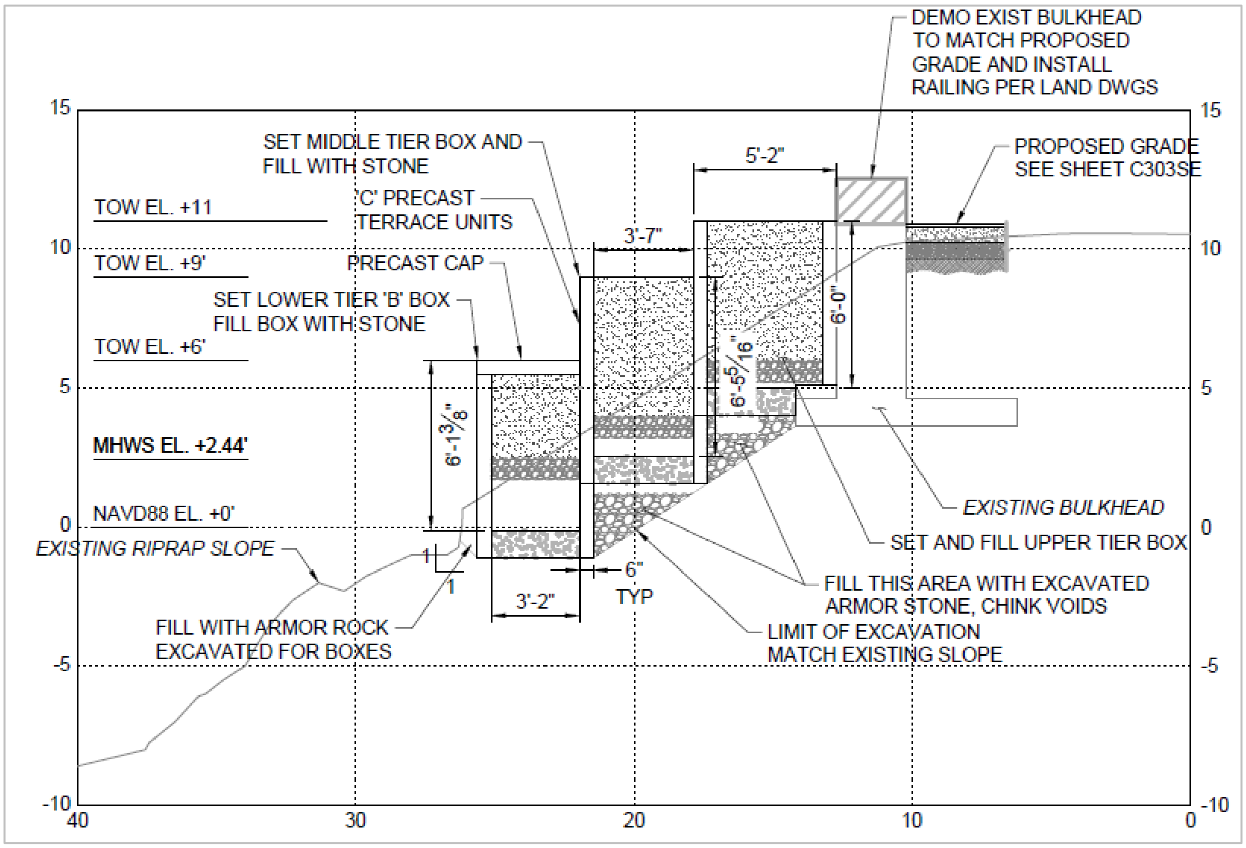


Figure 13: Section Selected for Slope Stability Analyses.

According to EM 1110-2-1902, two cases were analyzed for global slope stability. Case 1 is for the normal condition with water level at mean sea level of elevation 0.0, and Case 2 is for the rapid drawdown condition with water level dropping from mean high water at elevation 2.28 to mean low water at elevation -2.77. The estimated soil properties based on nearby borings B-7, B-8 and B-11, are summarized in Table 12 was used in the stability analyses. It was assumed that the existing slope was covered by approximate three feet of riprap stone which is corresponding to a uniform load of 480 psf. The added loads due to the proposed construction shown in the above

Figure 13 was estimated using an average unit weight of 130pcf for the precast terrace units, landscape fill and the drainage layer. The results of the slope stability analyses are summarized in Table 24:

Table 24: Summary of Slope Stability for Pier A Inlet Bulkhead

SLOPE \ CASE	CASE 1- Normal Condition with Water at Mean Sea Level	CASE 2- Rapid Drawdown with Water Dropped from Mean Higher High Water to Mean Lower Low Water Level
The Existing Slope	FS=1.31	FS=1.28
The Proposed Slope	FS=1.27	FS=1.23

For Case 1 which represents the long-term loading condition, the estimated factors of safety are slightly less than required minimum long-term factors of safety of 1.5 per EM 1110-2-1902 and DM 7.1. For Case 2, rapid drawdown condition, the estimated factors of safety are within the range of required factors of safety of 1.1 to 1.3 per EM 1110-2-1902. Based on the stability analyses, the calculated post-construction factor of safety for slope stability for both cases is almost the same as that of the existing slope. Therefore, it is concluded that the proposed construction will not reduce the stability of the slope any further. As soil properties were estimated from available boring information, more detailed analyses can be performed if additional borings are taken directly behind and in front of the bulkhead. The detailed calculations are presented in Appendix M. The proposed precast terrace units shown in Figure 13 will be supported on fill materials. The recommended allowable maximum bearing resistance is 1.5 ksf, provided subgrade preparation is performed in accordance with the requirements of this report.

Rigid Pavement Design

Four scenarios have been provided by client and considered in the selection of rigid pavement sections:

1) Pedestrian Paving;

2) Light Duty Vehicular Paving: Support for BPCA maintenance vehicle:
   - Load: Taylor Dunn ET-3000, 2475 base vehicle weight; Max. 3000 lbs. load capacity, Total weight of 5475 lbs.
   - Load Repetitions: more than 20 times per day.
3) Medium Duty Vehicular Paving: Support for BPCA stage vehicle:
   - Load: Stage Trailer (Fully Loaded): 7716 lbs., F-250: Max. GVRW-10,000 lbs., Total Weight of 17,716 lbs.
   - Load Repetitions: 2 times per day when deployed, unknown number of times deployed in a year.
4) Heavy Duty Vehicular Paving: Support for YC Fire Department Truck:
   - Load: 55,000 lbs. (*pending confirmation from NYC FD)* and the following assumed loads were considered in the design: a single front axle with a load of 24,000 lbs. and a single rear axle with a load of 31,000 lbs.).
   - Load Repetitions: 2 times per day as needed.

For Scenario 1, pedestrian paving, the minimum typical section of 4-inch Concrete over 6-inch gravel base can be selected per NYC DOT Drawing #H-1045.

For Scenarios 2-4, the selection of rigid pavement thickness is based on the Portland Cement Association Design Procedures for low volume traffic which is presented in reference: *Guide for Design and Construction of Concrete Parking Lots-ACI 330R-01*. The detailed calculations including the design parameters and assumptions considered for each scenario are presented in

Appendix N while the recommended pavement section is summarized as follows:

Scenarios	Design Life, Design Load and Load Repetition	Recommended Pavement Section
#1	Design Life = 30 years, Design Load = Pedestrian Paving.	4-inch Concrete over 6-inch gravel base.
#2	Design Life = 30 years, Design Load = rear axle load of 4.5 kips and the front axle load is also 4.5 kips; Load Repetition = 25 times per day.	4-inch thickness 3500psi concrete or better over 6-inch gravel base.
#3	Design Life = 30 years, Design Load = rear tandem-axle load of 8 kips and the front axle load of 10 kips; Load Repetition = 2 times per day.	4-inch thickness 4000psi concrete or better over 6-inch gravel base; or 5-inch thickness of 3500psi concrete or better over 6-inch gravel base.
#4	Design Life = 30 years, Design Load = ***single front axle*** with a load of 24,000 lbs. and a ***single rear axle*** with a load of 31,000 lbs.; Load Repetition = 2 times per day.	7-inch thickness of 5000psi concrete or better over 6-inch gravel base.

CONSTRUCTION RECOMMENDATIONS

General

This section of the report presents general geotechnical recommendations for construction of the proposed improvements.

Pile Foundations

Specifications for pile foundations should require the contractor to provide detailed drawings and installation procedures including the design properties of the materials to be used, and calculations indicating the proposed pile system will meet the design requirements for geotechnical and structural capacity. Field verification of design capacity will include the performance of load tests on a selected number of piles at each proposed structure depending on the quantity and configuration of the pile group. For the proposed pavilion with total footprint of 12,600 SF, at least two load tests shall be performed per NYC Building Code 1808.4.1.1.

Excavations

Local temporary soil excavations above the groundwater level can have slope sides as steep as 1.5 Horizontal (H) to 1.0 Vertical (V). Local excavations less than 2 feet below the groundwater level should be no steeper than 2H:1V. For vertical cuts or all other excavations below the groundwater level the design of excavation support systems should conform to pertinent OSHA and local safety regulations.

Subgrade Preparation

All subgrades should be observed by a geotechnical engineer to verify that subsurface conditions are similar to those encountered during the field investigation. Subgrades should be proof rolled under the observation of a geotechnical engineer prior to start of construction. Any depressions under the action of the compactor should be excavated and re-compacted with suitable backfill materials or backfilled with ¾ inch stone. As a minimum, excavations shall be brought up to grade in maximum 12" lifts and shall be compacted to 95% of the soils maximum dry density as determined by ASTM D 1557. All exposed subgrades should be compacted with a minimum of 6 overlapping passes with a 10-ton roller or for trenches and narrow excavations a smaller 2-ton roller.

Backfill and Compaction

Unless otherwise specified for drainage purposes, backfill materials should be granular soil free of debris such as organic material, cinder, brick, asphalt, ash, and other unsuitable materials and should contain less than 15% fines passing the No. 200 sieve. All backfill should be should be placed in lifts not exceeding 12 inches in loose thickness and each layer should be compacted to a minimum of 95% of maximum Modified Proctor density (ASTM D1557). If lightweight fills are utilized, follow the manufactures specifications regarding acceptable compaction effort to achieve the design requirements.

Construction Considerations

Driving sheet piles or foundation piles using an impact or vibratory hammer is not recommended within 50 feet of any sensitive structure. It is recommended that in sensitive areas, sheet piles be installed using the press-in method as described by GIKEN or an approved equivalent method. Deep foundations in sensitive areas can include micropiles, jet grouting, or other drilled-in methods. When jet grouting is used, it can produce additional pressures on existing adjacent underground structures. Construction documents should include requirements for a construction monitoring plan. The plan should be developed to include the requirements of all of the agencies with infrastructure in the vicinity of the project.

LIMITATIONS

The recommendations contained in this report are out best professional judgment as to the procedures to be followed in the construction of the proposed project in accordance with the information provided to us and our current understanding of the project. There may be subsurface conditions not disclosed by the explorations. However, in our opinion the explorations are adequate to define the subsurface conditions for the purpose of this study. If changes in location or character of this project are subsequently planned, or if during construction any differences are found between the report of the explorations and the actual subsurface conditions, they should be brought to our attention immediately so that the effect on our recommendations can be evaluated.

This Report has been prepared in accordance with generally accepted geotechnical engineering practices for the exclusive use of AECOM and their client for specific application to the South Battery Park City Resiliency Project at Manhattan, New York. No other warranty, expressed or implied, is made

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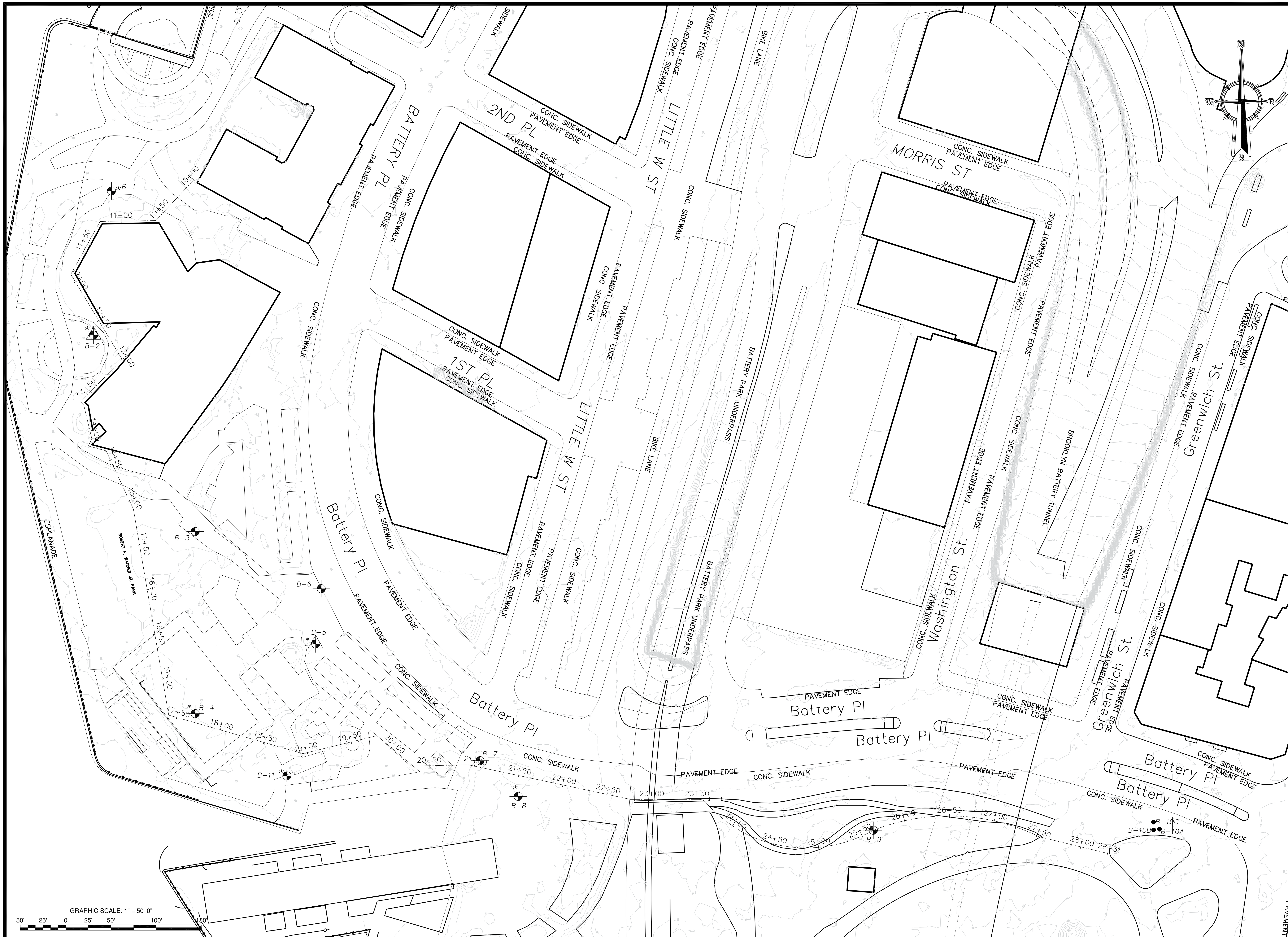
DRAWINGS



GENERAL NOTES:

1. GENERAL LAYOUT TAKEN FROM BASE MAP WITH CONTOURS DRAWING RECEIVED FROM AECOM FOR SOUTH BATTERY PARK RESILIANCY PROJECT
2. THIS DRAWING IS PART OF OWEIS ENGINEERING INC. REPORT No. 17-NY165-01 AND SHOULD BE READ TOGETHER WITH THE REPORT FOR COMPLETE EVALUATION.
3. BORING LOCATIONS APPROXIMATED IN FIELD BASED ON EXISTING SITE FEATURES.

LEGEND

- SOIL BORING WITH WELL INSTALLED
- SOIL BORING
- ATTEMPTED SOIL BORING LOCATIONS
- BORING WITH FIELD PERMEABILITY TEST
- 18.00 PROPOSED ALLIGNMENT & STATIONS

#	REVISION	DATE:

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS
100 EAST HANOVER AVE, SUITE 101, CEDAR KNOLLS, NEW JERSEY 07927
Phone: 973.539.4400 Fax: 973.539.1122 www.oweisengineering.com

SOUTH BATTERY PARK RESILIENCY
NEW YORK, N.Y.

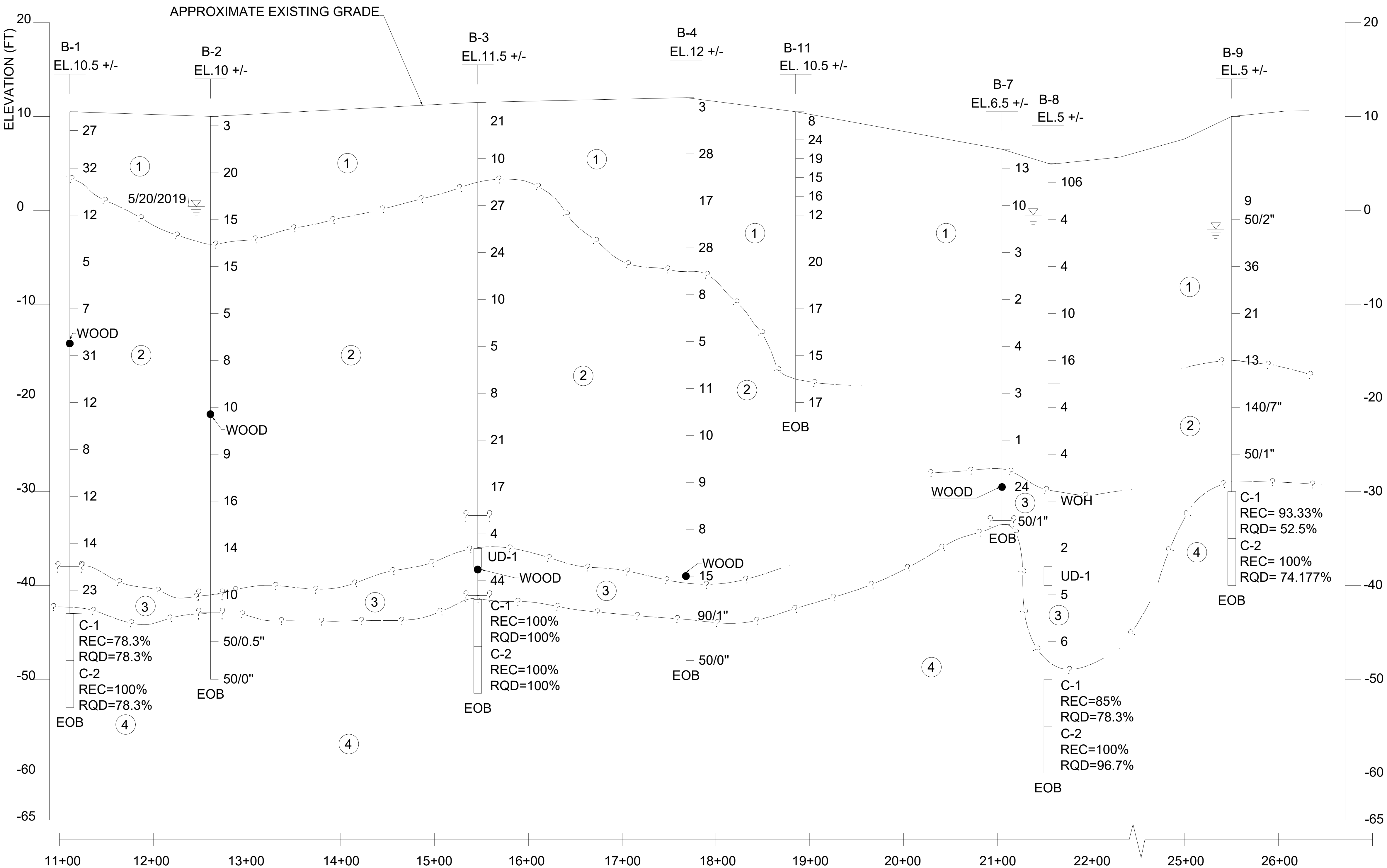
JAMES MALAK, N.Y. Professional Engineer

N.Y.P.E. No. Date

BORING LOCATIONS PLAN

SCALE 1" = 40'

DATE: 03-25-20	DES: MT	DRAWING
	DRN: JB	1 of 3
PROJECT NO. 17-NY165-01	CHK: JM	
	APV: JM	



GEOLOGIC SECTION

VERTICAL SCALE: 1" = 10'-0"

0 5' 10'

HORIZONTAL SCALE: 1" = 10'-0"

0 10' 20'

GENERAL NOTES

1. MATERIAL DESCRIPTIONS ARE GENERALIZED AND INCLUDE SAMPLES WITH A NATURAL DEGREE OF VARIATION. SEE BORING LOGS FOR DESCRIPTION OF INDIVIDUAL SAMPLES.

2. DEPTH AND THICKNESS OF SOIL STRATA BOUNDARIES ARE BASED ON INTERPRETATION OF BORINGS AND ARE SHOWN ONLY TO AID IN VISUALIZING GENERALIZED SUBSURFACE CONDITIONS. ACTUAL STRATA BOUNDARIES BETWEEN BORINGS MAY DIFFER FROM THE CONDITIONS SHOWN HERE.

3. BORINGS PROJECTED ALONG PROPOSED STATIONING.

LEGEND

B-1 — GEOTECHNICAL BORING DRILLED BY CRAIG GEOTECHNICAL DRILLING.

54 — N-VALUE DEFINED AS NUMBER OF BLOWS OF A 140-LB HAMMER FREE FALLING FOR 30 INCHES REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES AFTER INITIAL 6 INCH PENETRATION.

? — APPROXIMATE INTERFACE BEWEEN SOIL STRATA.

EOB — END OF BORING.

GROUND WATER TABLE OBSERVED IN TEMPORARY WELL AFTER 24 HOURS 12/20/2018 TO 1/14/2019.

(1) FILL

(2) BROWN TO GRAY SAND SOME TO TRACE OF SILT, CLAY

(3) DARK GRAY TO GRAY SILTY CLAY

(4) BEDROCK

GENERALIZED SOIL PROFILE SOUTH BATTERY PARK RESILIENCY FLOODWALL ALIGNMENT BOROUGH OF MANHATTAN NEW YORK	DRAWING 2/3
PROJECT NO. 17-NY165-01 | DATE: 06-04-2021 | DES: JM | DRN: RS | CHK: JM	APV: JM

100 EAST HANOVER AVE,
SUITE 101, CEDAR KNOLLS,
NEW JERSEY 07927
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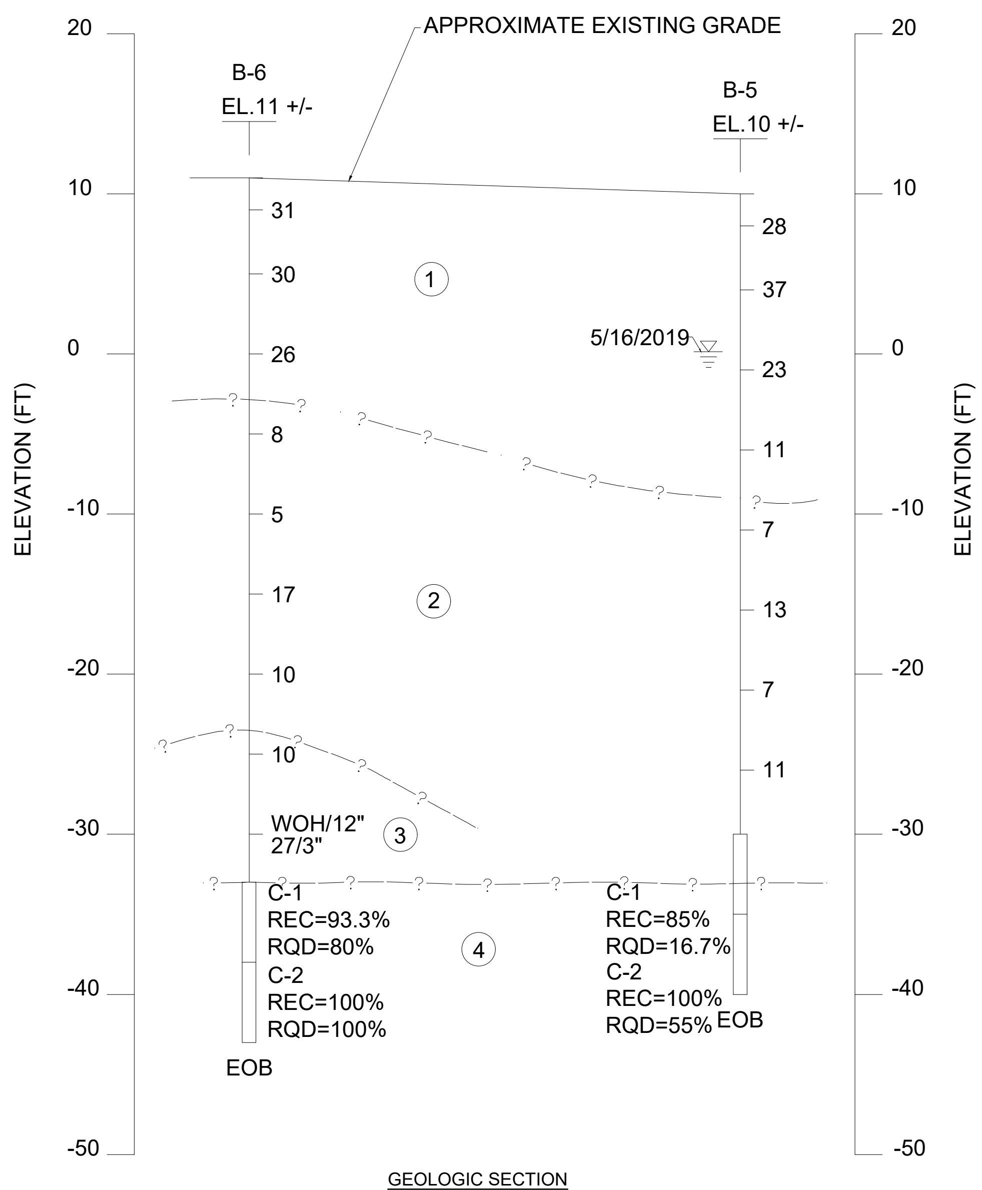
Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

File: S:\02 DRAWINGS\17-NY165 South Battery Park R Floodwall\Project Drawings\Soil Profile\Soil Profile 6-4-2021.dwg Layout: Longitudinal Soil Profile User: Drafting Jun 04, 2021 - 3:48pm



GEOLOGIC SECTION

VERTICAL SCALE: 1" = 10'-0"

0 5' 10'

HORIZONTAL SCALE: 1" = 10'-0"

0 10' 20'

LEGEND

1. FILL
2. BROWN TO GRAY SAND SOME TO TRACE OF SILT, CLAY
3. DARK GRAY TO GRAY SILTY CLAY
4. BEDROCK

GENERAL NOTES

1. MATERIAL DESCRIPTIONS ARE GENERALIZED AND INCLUDE SAMPLES WITH A NATURAL DEGREE OF VARIATION. SEE BORING LOGS FOR DESCRIPTION OF INDIVIDUAL SAMPLES.

2. DEPTH AND THICKNESS OF SOIL STRATA BOUNDARIES ARE BASED ON INTERPRETATION OF BORINGS AND ARE SHOWN ONLY TO AID IN VISUALIZING GENERALIZED SUBSURFACE CONDITIONS. ACTUAL STRATA BOUNDARIES BETWEEN BORINGS MAY DIFFER FROM THE CONDITIONS SHOWN HERE.

LEGEND

B-1 — GEOTECHNICAL BORING DRILLED BY CRAIG GEOTECHNICAL DRILLING.

54 — N-VALUE DEFINED AS NUMBER OF BLOWS OF A 140-LB HAMMER FREE FALLING FOR 30 INCHES REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES AFTER INITIAL 6 INCH PENETRATION.

—?— APPROXIMATE INTERFACE BEWEEN SOIL STRATA.

EOB — END OF BORING.

GROUND WATER TABLE OBSERVED IN TEMPORARY WELLS AFTER 24 HOURS 12/20/2018 TO 1/14/2019.

GENERALIZED SOIL PROFILE
SOUTH BATTERY PARK RESILIENCY
PAVILION
BOROUGH OF MANHATTAN
NEW YORK

DRAWING 3/3

PROJECT NO. 17-NY165-01 | DATE: 03-25-2020 | DES: JM | DRN: JB | CHK: JM | APV: JM

100 EAST HANOVER AVE, SUITE 101, CEDAR KNOLLS, NEW JERSEY 07927
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Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

APPENDIX A

BORING LOGS

OWEIS ENGINEERING INC.

PROJECT South Battery Park Resiliency
LOCATION Battery Park City, NY
CLIENT AECOM
BORING LOCATION see plan
EASTING **NORTHING**

BORING NO. B-1
SHEET NO. 1 OF 6
PROJECT NO. 17-NY165-01
SURFACE ELEV. 10.5+/-
VER. DATUM NAVD 88
HOR. DATUM

EQUIPMENT AND METHODS OF STABILIZING BOREHOLE

DRILLING RIG Track Rig CME 55
CASING
4 in. dia. 25 ft
dia.
ADVANCEMENT METHOD Clear Water Rotary
DRILL RODS NWJ
ROTARY BIT DIAMETER, IN. 3-7/8 in. Tricone
DRILLING MUD USED N/A
AUGER N/A
SAMPLERS
HAMMER TYPE Safety Hammer
WEIGHT 140 lb **DROP** 30'' **RATE** Auto
D-SAMPLER 2'' split spoon
U-SAMPLER N/A
OTHER N/A
ROCK CORING
CORING FEED Hydraulic
CORE BARREL NX
CORE BIT Diamond bit

REMARKS

1. Advance 5' casing into ground.
2. Add 5' casing.
3. Add 5' casing.
4. Add 5' casing.
5. Add 5'casing.

LEGEND

TV = Torvane Shear Strength, TSF
CT = Coring Time, minutes/foot
CB = Casing Blows Per Foot
OLT = Other Lab Testing Performed
PP = Pocket Penetrometer
Unconfined Compressive Strength, TSF

REMARK TYPES

LC = Lost Circulation
HD = Hard Drilling
RC = Rig Chatter
CBJ = Core Barrel Jam
PO = Petroleum Odor
CW = Change in Wash
SS = Slickensided
EOB = End Of Boring
ML = Mudline

WATER LEVEL OBSERVATIONS IN BOREHOLE

DATE	TIME	DEPTH OF HOLE	DEPTH OF CASING	DEPTH TO WATER	CONDITIONS OF OBSERVATIONS

PIEZOMETER__ MONITORING WELL__ INSTALLED no
SKETCH SHOWN ON NO

PAY QUANTITIES

2" DIA. SAMPLE BORING **LIN. FT.** 53.5 ft
CORE DRILLING IN ROCK **LIN. FT.** 10 ft
NO. OF 3" UNDISTURBED SAMPLES N/A
OTHER N/A
BORING CONTRACTOR Craig Test Boring Co.
DRILLER Mike Tarter **HELPER(S):** Jimmy
OEI OBSERVER Jinfu Xiao **DATE:** 5/20/2019
CLASSIFICATION CHECK Burmister Soil Classification System

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

BORING LOG

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency
BORING NO. B-1
SHEET 2 OF 6
GROUND ELEVATION 10.5+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
5/20/19						2'' Paving Stone					
8:55			1				Road	1			
JX		S-1A				5'' Gray cm GRAVEL, little mf Sand, trace Silt	Base				
			2	35-17	17.0			2	M		
		S-1B		10-8		12'' Brown cmf SAND, some mf Gravel/Brick, little Silt	FILL				
			3			(Class 7)		3			
											①
			4					4			
			5					**5**			
						8'' Brown mf SAND, little Silt			VM		
		S-2A	6	5-9	10.0		FILL	6			
		S-2B		23-23		2'' Gray cm GRAVEL, little mf Sand, trace Silt			D		
			7					7			
											②
			8					8			
			9					9			
			10					**10**			
		S-3	11	5-6				11			
				6-8	10.0	Brown mf SAND, trace Silt, trace mf Gravel (Class 7)	FILL				
			12					12			③
			13					13			
			14					14			
			15					**15**			
Perm.		S-4	16	4-2				16			
Test				3-3	6.0	Brown f SAND, trace Silt (Class 7)	FILL				
			17					17			④
			18					18			
			19					19			
			20					**20**			
		S-5	21	3-3	6.0	Gray-brown f SAND, trace Silt, with plastic fragment	FILL	21			
				4-4		(Class 7)					
			22					22			

DOCUMENT 30008
REV 1 3/2015

BORING LOG

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency
BORING NO. B-1
SHEET 3 OF 6
GROUND ELEVATION 10.5+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
			23					23			
			24					24			
			25					25			
		S-6A	26	2-8	12.0	Same (Class 7)	FILL	26			
		S-6B	27	23-4		4'' Decomposed wood	Wood	**27**			⑤
			28					28			
			29					29			
			30					30			
		S-7	31	6-5	10.0	Brown f- SAND, trace Silt (Class 3b)	SP	31			
			32	7-6				**32**			
			33					33			
			34			------------------------------		34			
			35					35			
		S-8	36	2-4	14.0	Reddish Brown mf SAND, some Silty Clay, trace mf Gravel (Class 4c)	SC	36			
			37	4-5				**37**			
			38					38			
			39			------------------------------		39			
			40					40			
		S-9	41	5-6	6.0	Brown mf SAND, little Silt (Class 3b)	SM	41			
			42	6-7				**42**			

BORING LOG

Oweis ENGINEERING INC. INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT	South Battery Park Resiliency	**BORING NO.**	B-1
PROJECT NO.	17-NY165-01	**SHEET**	4 OF 6
LOCATION	South Battery Park Resiliency	**GROUND ELEVATION**	10.5+/-
		OEI OBSERVER	JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
			43					43			
			44					44			
			45					45			
		S-10	46	5-7	12.0	Reddish Brown mf SAND, trace Silt, trace f Gravel	SP-SM	46			
				7-8		(Class 3b)					
			47					**47**			
			48					48			
						--					
			49					49			RC
			50			10'' Gray mf GRAVEL, and cmf Sand, little silty Clay		50			
						(Class2b)	GP				Spoon
		S-11A	51	90-15	12.0			51			Bounce
		S-11B		8-20/4''		2'' Black organic SILT, trace f Sand (Class 5b)	ML				
			52					**52**			Spoon
											Bounce
			53					53			RC
											RC
			54	30:30		Approx. top of bedrock		54			LC
			55	4:20		Gray hard, very slightly fractured, very slightly weathered		55			
						schist (Class 1b)					
		C-1	56	3:15		Rec=(47"/60")x100%=78.3%		56			
						RQD=(47''/60'')x100%=78.3%					
			57	3:15				**57**			
			58	3:15				58			
			59	3:15				59			
			60	3:15		Same		60			
		C-2	61	3:37		Rec=(60''/60'')x100%=100%		61			
						RQD=(47''/60'')x100%=78.3%					
			62	3:00				**62**			

OWEIS ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency
BORING NO. B-1
SHEET 5 OF 6
GROUND ELEVATION 10.5+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
5/20/19 11:30 JX		C-2	63	3:20				63			
			64			End of boring at 63.5' bgs.		64			
			65					65			
			66					66			
			67					67			
			68					68			
			69					69			
			70					70			
			71					71			
			72					72			
			73					73			
			74					74			
			75					75			
			76					76			
			77					77			
			78					78			
			79					79			
			80					80			
			81					81			
			82					82			

OWEIS ENGINEERING INC.

ROCK CORE SKETCH

PROJECT South Battery Park Resiliency

PROJECT NO. 17-NY165-01

LOCATION Battery Park City, NY

BORING NO. B-1

SHEET NO 6 OF 6

SURFACE NO. 10.5+/-

OEI REP. J. Xiao

Run #	Start Depth	End Depth	Rec	RQD
C-1	53.5'	58.5'	78.3%	78.3%
C-2	58.5'	63.5'	100%	78.3%

C-1: Gray hard, very slightly fractured, veryslightly weathered schist

M
M
M
M
M

1.0
2.0
3.0
4.0

C-2: Gray hard, very slightly fractured, very slightly weathered schist

M

1.0
2.0
3.0
4.0

1.0
2.0
3.0
4.0

LEGEND

DISCONTINUITY (DISCONT.)
- F - Fault or Shear
- J - Joint
- Fo - Foliation
- V - Vein
- B - Bedding
- MB - Mechanical Break

SURFACE SHAPE OF DISCONT.
- Wa - Wavy
- Pl - Planar
- St - Stepped
- Ir - Irregular

ROUGHNESS OF DISCONT.
- Slk - Slickensided
- S - Smooth
- Sr - Slightly Rough
- R - Rough
- VR - Very Rough

INFILLING OR WEATHERED DISCONT.
- w - Weathered discont.
- fe - Iron stained discont.
- min - Mineral coated discont. or mineral infilling
- cl - Clay coated discont.

SKETCH SYMBOLS
- Discontinuity
- Healed Joint
- Broken
- Part of Core Not Recovered or Noticable Drop During Drilling
- Vesicles, Vugs, or Amygdules
- Clay
- Sand
- Empty Space

OWEIS ENGINEERING INC.

PROJECT South Battery Park Resiliency
LOCATION Battery Park City, NY
CLIENT AECOM
BORING LOCATION see plan
EASTING **NORTHING**

BORING NO. B-2
SHEET NO. 1 OF 4
PROJECT NO. 17-NY165-01
SURFACE ELEV. 10+/-
VER. DATUM NAVD 88
HOR. DATUM

EQUIPMENT AND METHODS OF STABILIZING BOREHOLE

DRILLING RIG Track Rig CME 55
CASING
4 in. dia. 50 ft
dia.
ADVANCEMENT METHOD Clear Water Rotary
DRILL RODS NWJ
ROTARY BIT DIAMETER, IN. 3-7/8 in. Tricone
DRILLING MUD USED N/A
AUGER N/A
SAMPLERS
HAMMER TYPE Safety Hammer
WEIGHT 140 lb **DROP** 30'' **RATE** Auto
D-SAMPLER 2'' split spoon
U-SAMPLER N/A/

OTHER 3'' Spoon
ROCK CORING
CORING FEED N/A
CORE BARREL N/A
CORE BIT N/A

REMARKS

1. Advance 5' casing into ground.
2. Add 5' casing.
3. Add 5' casing.
4. Add 5' casing.
5. Add 5'casing.
6. Add 5' casing.
7. Add 5' casing. Hard to advance casing.
8. Add 5' casing.
9. Add 5' casing.
10. Add 5' casing.

LEGEND

TV = Torvane Shear Strength, TSF
CT = Coring Time, minutes/foot
CB = Casing Blows Per Foot
OLT = Other Lab Testing Performed
PP = Pocket Penetrometer
Unconfined Compressive Strength, TSF

REMARK TYPES

LC = Lost Circulation
HD = Hard Drilling
RC = Rig Chatter
CBJ = Core Barrel Jam
PO = Petroleum Odor
CW = Change in Wash
SS = Slickensided
EOB = End Of Boring
ML = Mudline

WATER LEVEL OBSERVATIONS IN BOREHOLE

DATE	TIME	DEPTH OF HOLE	DEPTH OF CASING	DEPTH TO WATER	CONDITIONS OF OBSERVATIONS
5/20/2019	8:19	26.4ft bgs.	N/A	9.6ft bgs.	17ft PVC Pipe+10ft screen.
5/21/2019	7:55	26.4ft bgs.	N/A	10.4ft bgs.	17ft PVC Pipe+10ft screen.

PIEZOMETER__ MONITORING WELL__ INSTALLED yes **SKETCH SHOWN ON** NO

PAY QUANTITIES

2" DIA. SAMPLE BORING **LIN. FT.** 60 ft **NO. OF 3" UNDISTURBED SAMPLES** N/A
CORE DRILLING IN ROCK **LIN. FT.** N/A **OTHER** N/A
BORING CONTRACTOR Craig Test Boring Co.
DRILLER Mike Tarter **HELPER(S):** Jimmy
OEI OBSERVER Jinfu Xiao **DATE:** 5/18/2019
CLASSIFICATION CHECK Burmister Soil Classification System

BORING LOG

DOCUMENT 30008
REV 1 3/2015

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency | **BORING NO.** B-2
PROJECT NO. 17-NY165-01 | **SHEET** 2 OF 4
LOCATION South Battery Park Resiliency | **GROUND ELEVATION** 10+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
5/18/19 8:45 JX		S-1A	1	1-2	16.0	12'' Dark brown mf SAND, some Silt with roots (Class 7)	Top	1	M		
			2	1-2			Soil				
		S-1B				4'' Yellow brown mf SAND, little Silt (Class 7)	FILL	2			
			3					3			①
			4					4			
			5					**5**			
		S-2	6	8-9	13.0	Brown cmf SAND, little mf Gravel/Brick, trace silt	FILL	6	W		
			7	11-13		(Class 7)		7			
			8					8			②
			9					9			
			10					**10**			
		S-3	11	6-6	12.0	Brown mf SAND, little Silt	FILL	11			
			12	9-11		(Class 7)		12			③
			13					13			
			14					14			
			15					**15**			
		S-4	16	6-8	10.0	Gray mf SAND, trace Silt (Class 7)		16			
			17	7-7				17			④
			18					18			
			19				FILL	19			
			20					**20**			
		S-5	21	2-2	4.0	Same (Class 7)		21			
			22	3-4				22			⑤

BORING LOG

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency
BORING NO. B-2
SHEET 3 OF 4
GROUND ELEVATION 10+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
			23					23			
			24					24			
			25					25			
		S-6	26	3-4	10.0	Same with shells (Class 7)	FILL	26			
			27	4-4				**27**			⑥
			28					28			
			29					29			
			30					30			
		S-7A	31	5-5	23.0	15'' same (Class 7)		31			
		S-7B	32	5-38		8'' decomposed wood	Wood	**32**			
			33					33			RC ⑦
			34					34			
			35					35			
		S-8	36	5-5	4.0	Brown c-mf- SAND, trace Silt		36			
			37	4-6		(Class 6)		**37**			
			38					38			⑧
			39				SM	39			
			40					40			
		S-9	41	3-7	8.0	Brown mf SAND, little Silty Clay, trace mf Gravel		41			
			42	9-10		(Class 3b)		**42**			⑨

BORING LOG

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency **BORING NO.** B-2
PROJECT NO. 17-NY165-01 **SHEET** 4 OF 4
LOCATION South Battery Park Resiliency **GROUND ELEVATION** 10+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	BLOWS/6"	REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
			43					43			
			44					44			
			45					45			
Perm.		S-10	46	4-5	17.0	Brown mf SAND, trace Silt, trace f Gravel	SP-SM	46			
Test				9-14		(Class 3b)					
			47					**47**			⑩
			48					48			
			49					49			
			50					50			
Perm.		S-11A	51	3-4	24.0	20'' Brown mf SAND, trace Silt (Class 3b)	SP	51			
Test				6-25							
		S-11B	52			4'' Dark brown mf SAND, little Silty Clay (Class 3a)	SM	**52**			
			53					53			
			54			------------------------------ Approx. top of bedrock		54			
			55					55			
		S-12	56	50/0.5''	0.5	Decomposed schist		56			spoon
						(Class 1d)					bounce
			57					**57**			
			58					58			
5/18/19			59					59			
4:30											spoon
JX			60	50/0''	NR	Same		60			bounce
						End of boring at 60ft bgs.					
			61					61			
			62					**62**			

OWEIS ENGINEERING INC.

PROJECT South Battery Park Resiliency
LOCATION Battery Park City, NY
CLIENT AECOM
BORING LOCATION see plan
EASTING **NORTHING**

BORING NO. B-3
SHEET NO. 1 OF 6
PROJECT NO. 17-NY165-01
SURFACE ELEV. 11.5+/-
VER. DATUM NAVD 88
HOR. DATUM

EQUIPMENT AND METHODS OF STABILIZING BOREHOLE

DRILLING RIG Truck Rig CME 75
CASING
4 in. dia. 40 ft
dia.
ADVANCEMENT METHOD Clear Water Rotary
DRILL RODS NWJ
ROTARY BIT DIAMETER, IN. 3-7/8 in. Tricone/ 2-15/16 in. Tricone
DRILLING MUD USED N/A
AUGER N/A
SAMPLERS
HAMMER TYPE Safety Hammer
WEIGHT 140 lb **DROP** 30'' **RATE** Auto
D-SAMPLER 2'' split spoon
U-SAMPLER Shelby Tube
OTHER 3'' Spoon
ROCK CORING
CORING FEED Hydraulic
CORE BARREL NX
CORE BIT Diamond bit

REMARKS
① Advance 10' casing into ground.
② Add 15' casing.
③ Add 5' casing.
④ Add 10' casing. Spoon bending.

LEGEND
TV = Torvane Shear Strength, TSF
CT = Coring Time, minutes/foot
CB = Casing Blows Per Foot
OLT = Other Lab Testing Performed
PP = Pocket Penetrometer
Unconfined Compressive Strength, TSF

REMARK TYPES
LC = Lost Circulation
HD = Hard Drilling
RC = Rig Chatter
CBJ = Core Barrel Jam
PO = Petroleum Odor
CW = Change in Wash
SS = Slickensided
EOB = End Of Boring
ML = Mudline

WATER LEVEL OBSERVATIONS IN BOREHOLE

DATE	TIME	DEPTH OF HOLE	DEPTH OF CASING	DEPTH TO WATER	CONDITIONS OF OBSERVATIONS

PIEZOMETER__ MONITORING WELL__ INSTALLED no
SKETCH SHOWN ON NO

PAY QUANTITIES
2" DIA. SAMPLE BORING **LIN. FT.** 53 ft
NO. OF 3" UNDISTURBED SAMPLES 1
CORE DRILLING IN ROCK **LIN. FT.** 10 ft
OTHER N/A
BORING CONTRACTOR Craig Test Boring Co.
DRILLER Joe **HELPER(S):** Garrett
OEI OBSERVER Jinfu Xiao **DATE:** 5/13/2019
CLASSIFICATION CHECK Burmister Soil Classification System

BORING LOG

DOCUMENT 30008
REV 1 3/2015

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency
BORING NO. B-3
SHEET 2 OF 6
GROUND ELEVATION 11.5+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
5/13/19 8:20 JX			1			2'' Pavement Stone		1			
		S-1	2	11-10	12.0	Yellow brown mf SAND, little Silt (Class 7)	FILL	2	M		
			3	11-11				3			
			4					4			
			5					**5**			
		S-2	6	4-4	2.0	Brown mf SAND, little mf Gravel, trace Silt (Class 7)	FILL	6	W		
			7	6-14				7			
			8					8			①
			9			------------------------------------		9			
			10					**10**			
		S-3	11	11-14	12.0	Brown mf SAND, little Silt, trace shell fragments (Class 7)	FILL	11			
			12	13-18				12			
			13					13			
			14			------------------------------------		14			
			15					**15**			
		S-4	16	12-12	10.0	Gray mf SAND, trace Silt, trace shell fragments (Class 7)		16			
			17	12-14				17			
			18					18			
			19				FILL	19			
			20					**20**			
		S-5	21	3-5	12.0	Gray-brown f SAND, trace silt (Class 7)		21			
			22	5-5				22			②

BORING LOG

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency | **BORING NO.** B-3
PROJECT NO. 17-NY165-01 | **SHEET** 3 OF 6
LOCATION South Battery Park Resiliency | **GROUND ELEVATION** 11.5+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	BLOWS/6"	REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
			23					23			
			24					24			
			25					25			
		S-6	26	2-2	6.0	Same	FILL	26			
			27	3-3		(Class 7)		**27**			
			28					28			③
			29					29			
			30					30			
		S-7	31	4-4	12.0	Gray-brown mf SAND, trace silt (Class 7)	FILL	31			
			32	4-7				**32**			
			33					33			
			34					34			
			35					35			
		S-8	36	8-9	12.0	Same (Class 7)	FILL	36			
			37	12-17				**37**			
			38					38			
			39			- - - - - - - - - -		39			
			40					40			
		S-9	41	6-8	14.0	Black mf SAND, little organic Silt	SM	41			
			42	9-11		(Class 3b)		**42**			

BORING LOG

Oweis ENGINEERING INC. — INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency **BORING NO.** B-3
PROJECT NO. 17-NY165-01 **SHEET** 4 OF 6
LOCATION South Battery Park Resiliency **GROUND ELEVATION** 11.5+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMB OL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
			43					43			
			44			----------		44			
			45					45			
		S-10	46	5-2	20.0	Dark gray Silty CLAY, little mf Gravel, trace mf Sand	POSS	46			
			47	2-3		(Class 6)	FILL	**47**			
			48					48			
		UD-1	49	PUSH 17"	6.0	Decomposed wood at tube bottom; Tube damaged.		49			
			50					50			
		S-11	51	23-28	2.0	---------- Dark gray Silty CLAY, trace c Gravel, trace mf Sand	CH	51			
			52	16-32		(Class 4a)		**52**			④
			53					53			RC
		C-1	54	3:00		Approx. Top of Bedrock		54			
			55	2:30		Gray, hard, slightly fractured, slightly weathered Schist		55			
			56	2:30		(Class 1b) Rec=(60''/60'')x100%=100%		56			
			57	2:30		RQD=(60''/60'')x100%=100%		**57**			
			58	2:00				58			
		C-2	59	2:15				59			
			60	2:30		Same		60			
			61	2:00		Rec=(60''/60'')x100%=100%		61			
			62	2:00		RQD=(60''/60'')x100%=100%		**62**			

BORING LOG

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency

BORING NO. B-3
SHEET 5 OF 6
GROUND ELEVATION 11.5+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
11:30 JX		C-2	63	2:00				63			
			64			End of boring at 63' bgs.		64			
			65					65			
			66					66			
			67					**67**			
			68					68			
			69					69			
			70					70			
			71					71			
			72					**72**			
			73					73			
			74					74			
			75					75			
			76					76			
			77					**77**			
			78					78			
			79					79			
			80					80			
			81					81			
			82					**82**			

OWEIS ENGINEERING INC.

ROCK CORE SKETCH

PROJECT	South Battery Park Resiliency	**BORING NO.**	B-3
PROJECT NO.	17-NY165-01	**SHEET NO**	6 OF 6
LOCATION	Battery Park City, NY	**SURFACE NO.**	11.5+/-
		OEI REP.	J. Xiao

Run #	Start Depth	End Depth	Rec	RQD
C-1	53'	58'	100%	100%
C-2	58'	63'	100%	100%

C-1: Gray hard, slightly fractured, slightly weathered schist

Discontinuities: M, M, M, M, M, M

C-2: Gray hard, slightly fractured, slightly weathered schist

Discontinuities: M

Scale: 1.0, 2.0, 3.0, 4.0

LEGEND

DISCONTINUITY (DISCONT.)
- F - Fault or Shear
- J - Joint
- Fo - Foliation
- V - Vein
- B - Bedding
- MB - Mechanical Break

SURFACE SHAPE OF DISCONT.
- Wa - Wavy
- Pl - Planar
- St - Stepped
- Ir - Irregular

ROUGHNESS OF DISCONT.
- Slk - Slickensided
- S - Smooth
- Sr - Slightly Rough
- R - Rough
- VR - Very Rough

INFILLING OR WEATHERED DISCONT.
- w - Weathered discont.
- fe - Iron stained discont.
- min - Mineral coated discont. or mineral infilling
- cl - Clay coated discont.

SKETCH SYMBOLS
- Discontinuity
- Healed Joint
- Broken
- Part of Core Not Recovered or Noticable Drop During Drilling
- Vesicles, Vugs, or Amygdules
- Clay
- Sand
- Empty Space

OWEIS ENGINEERING INC.

PROJECT South Battery Park Resiliency
LOCATION Battery Park City, NY
CLIENT AECOM
BORING LOCATION see plan
EASTING **NORTHING**

BORING NO. B-4
SHEET NO. 1 OF 4
PROJECT NO. 17-NY165-01
SURFACE ELEV. 12+/-
VER. DATUM NAVD 88
HOR. DATUM

EQUIPMENT AND METHODS OF STABILIZING BOREHOLE

DRILLING RIG Track Rig CME 55
CASING
4 in. dia. 30 ft
dia.
ADVANCEMENT METHOD Clear Water Rotary
DRILL RODS NWJ
ROTARY BIT DIAMETER, IN. 3-7/8 in. Tricone
DRILLING MUD USED N/A
AUGER N/A
SAMPLERS
HAMMER TYPE Safety Hammer
WEIGHT 140 lb **DROP** 30'' **RATE** Auto
D-SAMPLER 2'' split spoon
U-SAMPLER N/A/

OTHER 3'' Spoon
ROCK CORING
CORING FEED N/A
CORE BARREL N/A
CORE BIT N/A

REMARKS

① Advance 5' casing into ground.
② Add 5' casing.
③ Add 5' casing.
④ Add 5' casing.
⑤ Add 5'casing.

LEGEND

TV = Torvane Shear Strength, TSF
CT = Coring Time, minutes/foot
CB = Casing Blows Per Foot
OLT = Other Lab Testing Performed
PP = Pocket Penetrometer
Unconfined Compressive Strength, TSF

REMARK TYPES

LC = Lost Circulation
HD = Hard Drilling
RC = Rig Chatter
CBJ = Core Barrel Jam
PO = Petroleum Odor
CW = Change in Wash
SS = Slickensided
EOB = End Of Boring
ML = Mudline

WATER LEVEL OBSERVATIONS IN BOREHOLE

DATE	TIME	DEPTH OF HOLE	DEPTH OF CASING	DEPTH TO WATER	CONDITIONS OF OBSERVATIONS

PIEZOMETER__ MONITORING WELL__ INSTALLED no
SKETCH SHOWN ON NO

PAY QUANTITIES

2" DIA. SAMPLE BORING **LIN. FT.** 60 ft
CORE DRILLING IN ROCK **LIN. FT.** N/A
NO. OF 3" UNDISTURBED SAMPLES N/A
OTHER N/A
BORING CONTRACTOR Craig Test Boring Co.
DRILLER Nick Beehler **HELPER(S):** Miles
OEI OBSERVER Jinfu Xiao **DATE:** 5/16/2019
CLASSIFICATION CHECK Burmister Soil Classification System

BORING LOG

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT	South Battery Park Resiliency	**BORING NO.**	B-4
PROJECT NO.	17-NY165-01	**SHEET**	2 OF 4
LOCATION	South Battery Park Resiliency	**GROUND ELEVATION**	12+/-
		OEI OBSERVER	JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
5/16/19 9:20 JX		S-1A	1	1-2 1-3	19.0	Dark brown mf SAND, some Silt with roots (Class 7)	Top Soil	1	M		
		S-1B	2			Light brown mf SAND, trace Silt (Class 6)	FILL	2			
			3					3			①
			4					4			
			5					**5**			
		S-2	6	7-12 16-17	16.0			6	W		
			7			4'' Brown f SAND, trace Silt (Class 7)		7			
			8					8			
			9					9			
			10					**10**			
		S-3	11	9-7 10-9	15.0	Brown f SAND, little mf Gravel, trace Silt (Class 7)	FILL	11			
			12					12			②
			13					13			
			14					14			
			15					**15**			
Perm. Test		S-4	16	8-12 16-13	17.0	Brown f SAND,trace Silt (Class 7)		16			
			17					17			③
			18					18			
			19					19			
			20					**20**			
		S-5	21	3-3 5-4	15.0	Gray f+ SAND, trace Silt, trace gravel (Class 6)	FILL	21			
			22					22			④

BORING LOG

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency
BORING NO. B-4
SHEET 3 OF 4
GROUND ELEVATION 12+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	DEPTH (ft)	BLOWS/6"	REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
			23					23			
			24					24			
			25					25			
		S-6	26	2-2	2.0	Same (Class 7)	FILL	26			
			27	3-4				**27**			⑤
			28					28			
			29					29			
			30					30			
Perm.		S-7	31	4-4	12.0	Gray f SAND, trace Silt (Class 7)	FILL	31			
Test			32	7-7				**32**			
			33					33			
			34					34			
			35					35			
		S-8	36	6-6	19.0	Same (Class 7)	FILL	36			
			37	4-5				**37**			
			38					38			
			39					39			
			40					40			
		S-9A	41	4-4	15.0	6'' Same (Class 7)		41			
		S-9B	42	5-6		9'' Brown mf SAND, trace Silt (Class 6)	SP	**42**			

BORING LOG

DOCUMENT 30008
REV 1 3/2015

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT	South Battery Park Resiliency	BORING NO.	B-4
PROJECT NO.	17-NY165-01	SHEET	4 OF 4
LOCATION	South Battery Park Resiliency	GROUND ELEVATION	12+/-
		OEI OBSERVER	JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	BLOWS/6"	REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
			43					43			
			44					44			
			45					45			
		S-10	46	5-3	17.0	Brown cmf SAND, trace Silt, trace f Gravel (Class 6)	SP	46			
			47	5-5				**47**			⑩
			48					48			
			49					49			
			50					50			
		S-11	51	47-8	4.0	Wood Gray mf Gravel (Class 2b)	Wood GP	51			
			52	7-10				**52**			RC
			53					53			
			54			Approx. Top of Bedrock		54			
			55					55			
		S-12	56	90/1''	1.0	Gray decomposed schist (Class 1d)	DR	56			spoon bounce
			57					**57**			RC
			58					58			
5/16/19			59					59			
14:00 JX			60	50/0''				60			spoon bounce
			61			End of boring at 60ft bgs.		61			
			62					**62**			

OWEIS ENGINEERING INC.

PROJECT South Battery Park Resiliency
LOCATION Battery Park City, NY
CLIENT AECOM
BORING LOCATION see plan
EASTING **NORTHING**

BORING NO. B-5
SHEET NO. 1 OF 5
PROJECT NO. 17-NY165-01
SURFACE ELEV. 11+/-
VER. DATUM NAVD 88
HOR. DATUM

EQUIPMENT AND METHODS OF STABILIZING BOREHOLE

DRILLING RIG Truck Rig CME 75
CASING
4 in. dia. 30 ft
dia.
ADVANCEMENT METHOD Clear Water Rotary
DRILL RODS NWJ
ROTARY BIT DIAMETER, IN. 3-7/8 in. Tricone/ 2-15/16 in. Tricone
DRILLING MUD USED N/A
AUGER N/A
SAMPLERS
HAMMER TYPE Safety Hammer
WEIGHT 140 lb **DROP** 30'' **RATE** Auto
D-SAMPLER 2'' split spoon
U-SAMPLER N/A
OTHER 3'' Spoon
ROCK CORING
CORING FEED Hydraulic
CORE BARREL NX
CORE BIT Diamond bit

REMARKS
① Advance 10' casing into ground.
② Add 5' casing.
③ Add 5' casing.
④ Add 5' casing.
⑤ Add 5' casing.

LEGEND
TV = Torvane Shear Strength, TSF
CT = Coring Time, minutes/foot
CB = Casing Blows Per Foot
OLT = Other Lab Testing Performed
PP = Pocket Penetrometer
Unconfined Compressive Strength, TSF

REMARK TYPES
LC = Lost Circulation
HD = Hard Drilling
RC = Rig Chatter
CBJ = Core Barrel Jam
PO = Petroleum Odor
CW = Change in Wash
SS = Slickensided
EOB = End Of Boring
ML = Mudline

WATER LEVEL OBSERVATIONS IN BOREHOLE

DATE	TIME	DEPTH OF HOLE	DEPTH OF CASING	DEPTH TO WATER	CONDITIONS OF OBSERVATIONS
5/13/2019	11:30	28.1ft	N/A	10.3ft bgs.	PVC Well; 20' Pipe + 10' Screen
5/16/2019	7:45	28.1ft	N/A	9.85ft bgs.	PVC Well; 20' Pipe + 10' Screen
5/17/2019	7:30	28.1ft	N/A	9.9ft bgs.	PVC Well; 20' Pipe + 10' Screen
5/20/2019	8:25	28.1ft	N/A	10.4ft bgs.	PVC Well; 20' Pipe + 10' Screen
5/21/2019	8:00	28.1ft	N/A	10.7ft bgs.	PVC Well; 20' Pipe + 10' Screen

PIEZOMETER__ MONITORING WELL__ INSTALLED Yes **SKETCH SHOWN ON** N/A no

PAY QUANTITIES
2" DIA. SAMPLE BORING **LIN. FT.** 40 ft **NO. OF 3" UNDISTURBED SAMPLES** N/A
CORE DRILLING IN ROCK **LIN. FT.** 10 ft **OTHER** N/A
BORING CONTRACTOR Craig Test Boring Co.
DRILLER Joe **HELPER(S):** Garrett
OEI OBSERVER Jinfu Xiao **DATE:** 5/10/2019
CLASSIFICATION CHECK Burmister Soil Classcification System

BORING LOG

DOCUMENT 30008
REV 1 3/2015

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency
BORING NO. B-5
SHEET 2 OF 5
GROUND ELEVATION 11+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
5/10/19						2'' Pavement Stone					
8:45			1			Gray cmf SAND, trace Silt (Class 7)	FILL	1			
JX											
		S-1A	2	13-11	19.0			2	M		
		S-1B		17-24		Brown mf+ SAND, little Silt, little m Gravel (Class 7)	FILL				
			3					3			
			4					4			
			5					**5**			
		S-2	6	9-14	12.0	Brown f SAND, trace Silt (Class 7)	FILL	6	W		
				23-23							
			7					7			
			8					8			①
			9					9			
			10					**10**			
		S-3	11	13-16	12.0	Same (Class 7)	FILL	11			
				17-19							
			12					12			
			13					13			②
			14					14			
			15					**15**			
		S-4	16	6-5	6.0	Same (Class 7)	FILL	16			
				6-5							
			17					17			③
			18					18			
			19			- - - - - - - - - -		19			
			20					**20**			
		S-5	21	3-3	7.0	Gray f SAND, trace Silt (Class 6)	SP	21			
				4-7							
			22					22			④

BORING LOG

DOCUMENT 30008
REV 1 3/2015

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency

BORING NO. B-5
SHEET 3 OF 5
GROUND ELEVATION 11+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
			23					23			
			24					24			
			25					25			
Perm.		S-6	26	5-8	8.0	Same (Class 3b)		26			
Test			27	5-7				**27**			
			28					28			⑤
			29					29			
			30					30			
		S-7	31	3-4	10.0	Same (Class 6)	SP	31			
			32	3-4				**32**			
			33					33			
			34					34			
			35					35			
		S-8	36	6-5	10.0	Same (Class 3b)		36			
			37	6-8				**37**			
			38					38			
			39					39			
			40					40			
		C-1	41	2:30		Approx. Top of Bedrock		41			
			42	2:30				**42**			

BORING LOG

Oweis ENGINEERING INC. INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency
BORING NO. B-5
SHEET 4 OF 5
GROUND ELEVATION 11+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
						White mottled very hard, intensively fractured,					
			43	2:30		intensively weathered Granite		43			
		C-1									
			44	3:00		Rec=(51''/60'')X100%=85%		44			
						RQD=(10''/60'')X100%=16.7%					
			45	3:00		(Class 1d)		45			
			46	2:30				46			
			47	2:00		Same		**47**			
		C-2									
			48	2:00		Rec=(60''/60'')X100%=100%		48			
						RQD=(33''/60'')X100%=55%					
5/10/19			49	2:00		(Class 1b)		49			
13:00											
JX			50	2:00				50			
						End of boring at 50' bgs.					
			51					51			
			52					**52**			
			53					53			
			54					54			
			55					55			
			56					56			
			57					**57**			
			58					58			
			59					59			
			60					60			
			61					61			
			62					**62**			

OWEIS ENGINEERING INC.

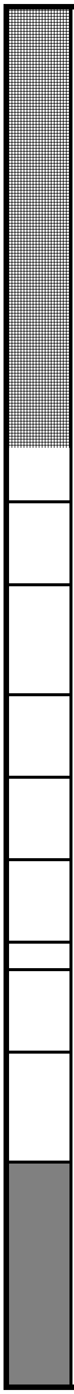
ROCK CORE SKETCH

PROJECT	South Battery Park Resiliency	**BORING NO.**	B-5
PROJECT NO.	17-NY165-01	**SHEET NO**	5 OF 5
LOCATION	Battery Park City, NY	**SURFACE NO.**	11+/-
		OEI REP.	J. Xiao

Run #	Start Depth	End Depth	Rec	RQD
C-1	40'	45'	85%	16.7%

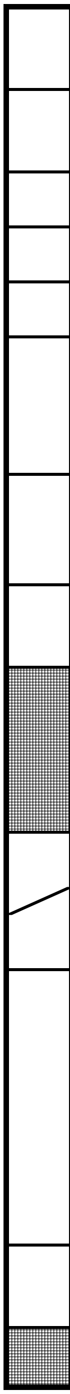
Run #	Start Depth	End Depth	Rec	RQD
C-2	45'	50'	100%	55%

Run #	Start Depth	End Depth	Rec	RQD



White mottled very hard, intensively fractured, intensively weathered granite

1.0 2.0 3.0 4.0



White mottled very hard, intensively fractured, intensively weathered granitet

1.0 2.0 3.0 4.0

1.0 2.0 3.0 4.0

LEGEND

DISCONTINUITY (DISCONT.)

F - Fault or Shear
J - Joint
Fo - Foliation
V - Vein
B - Bedding
MB - Mechanical Break

SURFACE SHAPE OF DISCONT.

Wa - Wavy
Pl - Planar
St - Stepped
Ir - Irregular

ROUGHNESS OF DISCONT.

Slk - Slickensided
S - Smooth
Sr - Slightly Rough
R - Rough
VR - Very Rough

INFILLING OR WEATHERED DISCONT.

w - Weathered discont.
fe - Iron stained discont.
min - Mineral coated discont. or mineral infilling
cl - Clay coated discont.

SKETCH SYMBOLS

Discontinuity
Healed Joint
Broken
Part of Core Not Recovered or Noticable Drop During Drilling
Vesicles, Vugs, or Amygdules
Clay
Sand
Empty Space

OWEIS ENGINEERING INC.

PROJECT South Battery Park Resiliency
LOCATION Battery Park City, NY
CLIENT AECOM
BORING LOCATION see plan
EASTING **NORTHING**

BORING NO. B-6
SHEET NO. 1 OF 5
PROJECT NO. 17-NY165-01
SURFACE ELEV. 10+/-
VER. DATUM NAVD 88
HOR. DATUM

EQUIPMENT AND METHODS OF STABILIZING BOREHOLE

DRILLING RIG Truck Rig CME 75
CASING
4 in. dia. 30 ft
dia.
ADVANCEMENT METHOD Mud rotary
DRILL RODS NWJ
ROTARY BIT DIAMETER, IN. 3-7/8 in. Tricone/ 2-15/16 in. Tricone
DRILLING MUD USED QUIK-GEL
AUGER N/A
SAMPLERS
HAMMER TYPE Safety Hammer
WEIGHT 140 lb **DROP** 30'' **RATE** Auto
D-SAMPLER 2'' split spoon
U-SAMPLER N/A

OTHER N/A
ROCK CORING
CORING FEED Hydraulic
CORE BARREL NX
CORE BIT Diamond bit

REMARKS
① Advance 10' casing into ground.
② Add 20' casing.

LEGEND
TV = Torvane Shear Strength, TSF
CT = Coring Time, minutes/foot
CB = Casing Blows Per Foot
OLT = Other Lab Testing Performed
PP = Pocket Penetrometer
Unconfined Compressive Strength, TSF

REMARK TYPES
LC = Lost Circulation
HD = Hard Drilling
RC = Rig Chatter
CBJ = Core Barrel Jam
PO = Petroleum Odor
CW = Change in Wash
SS = Slickensided
EOB = End Of Boring
ML = Mudline

WATER LEVEL OBSERVATIONS IN BOREHOLE

DATE	TIME	DEPTH OF HOLE	DEPTH OF CASING	DEPTH TO WATER	CONDITIONS OF OBSERVATIONS

PIEZOMETER__ **MONITORING WELL**__ **INSTALLED** no **SKETCH SHOWN ON** NO

PAY QUANTITIES
2" DIA. SAMPLE BORING **LIN. FT.** 44 ft **NO. OF 3" UNDISTURBED SAMPLES** 0
CORE DRILLING IN ROCK **LIN. FT.** 10 ft **OTHER** N/A
BORING CONTRACTOR Craig Test Boring Co.
DRILLER Joe **HELPER(S):** Garrett
OEI OBSERVER Jinfu Xiao **DATE:** 5/7/2019
CLASSIFICATION CHECK Burmister Soil Classification System

DOCUMENT 30008
REV 1 3/2015

BORING LOG

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency
BORING NO. B-6
SHEET 2 OF 5
GROUND ELEVATION 10+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
5/7/19 9:00 JX			1			2'' Pavement Stone		1			
		S-1	2	21-16	17.0	Dark brown mf SAND, little mf Gravel/brick fragments	FILL	2	M		
			3	15-15		trace Silt (Class 7)		3			
			4					4			
			5					**5**			
		S-2	6	13-15	10.0	Brown mf SAND, trace Silt (Class 7)	FILL	6	M		
			7	15-15				7			
			8					8			①
			9					9			
			10					**10**			
		S-3	11	12-14	10.0	Same (Class 7)	FILL	11	W		
			12	12-13				12			
			13					13			
			14			- - - - - - - -		14			
			15					**15**			
		S-4	16	4-3	7.0	Gray f SAND, trace Silt		16			
			17	5-4		(Class 6)		17			
			18					18			
			19					19			
			20				SP	**20**			
		S-5	21	3-2	11.0	Same		21			
			22	3-3		(Class 6)		22			

BORING LOG

DOCUMENT 30008
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Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency
BORING NO. B-6
PROJECT NO. 17-NY165-01
SHEET 3 OF 5
LOCATION South Battery Park Resiliency
GROUND ELEVATION 10+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
			23					23			
			24					24			
			25					25			
		S-6	26	8-8	11.0	Same	SP	26			
			27	9-12		(Class 3b)		**27**			
			28					28			②
			29					29			
			30				SP-SM	30			
		S-7	31	3-4	11.0	Gray f SAND, trace Silt, trace Gravel		31			
			32	6-7		(Class 3b)		**32**			
			33					33			
			34			------------------------------		34			
			35					35			
		S-8A	36	3-4	12.0	6'' Black mf SAND, some organic Silt&Clay (Class 6)	SM	36			
		S-8B	37	6-6		6'' Brown cmf SAND, trace Silt (Class 3b)	SM/SP	**37**			
			38					38			
			39			------------------------------		39			
			40					40			
		S-9	41	WOH/12''	15.0	Black organic Silty CLAY, some cm Gravel (Class 6)	CH	41			
			42	27/3''		(decomposed rock)		**42**			RC

BORING LOG

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency
BORING NO. B-6
SHEET 4 OF 5
GROUND ELEVATION 10+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	DEPTH (ft)	BLOWS/6"	REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
			43					43			
			44					44			
			45	2:15		Approx. top of bedrock		45			
			46	3:30		Gray hard, slightly weathered, slightly fractured schist		46			
		C-1	47	3:30		(Class 1b) Rec=(56''/60'')x100%=93.3%		**47**			
			48	3:00		RQD=(48''/60'')x100%=80%		48			
			49	3:00				49			
			50	3:00				50			
			51	3:00		Same		51			
		C-2	52	2:30		Rec=(60''/60'')x100%=100%		**52**			
5/7/19			53	2:30		RQD=(60''/60'')x100%=100% (Class 1a)		53			
11:40 JX			54	2:30				54			
			55			End of boring at 54' bgs.		55			
			56					56			
			57					**57**			
			58					58			
			59					59			
			60					60			
			61					61			
			62					**62**			

OWEIS ENGINEERING INC.

ROCK CORE SKETCH

PROJECT	South Battery Park Resiliency	**BORING NO.**	B-6
PROJECT NO.	17-NY165-01	**SHEET NO**	5 OF 5
LOCATION	Battery Park City, NY	**SURFACE NO.**	10+/-
		OEI REP.	J. Xiao

Run #	Start Depth	End Depth	Rec	RQD
C-1	44'	49'	93.3%	80%
C-2	49'	54'	100%	100%

Run C-1: Gray hard, slightly weathered, slightly fractured schistt

M
M
M
M

1.0
2.0
3.0
4.0

Run C-2: Gray hard, slightly weathered, slightly fractured schist

M
M
M
M

1.0
2.0
3.0
4.0

1.0
2.0
3.0
4.0

LEGEND

DISCONTINUITY (DISCONT.)
F - Fault or Shear
J - Joint
Fo - Foliation
V - Vein
B - Bedding
MB - Mechanical Break

SURFACE SHAPE OF DISCONT.
Wa - Wavy
Pl - Planar
St - Stepped
Ir - Irregular

ROUGHNESS OF DISCONT.
Slk - Slickensided
S - Smooth
Sr - Slightly Rough
R - Rough
VR - Very Rough

INFILLING OR WEATHERED DISCONT.
w - Weathered discont.
fe - Iron stained discont.
min - Mineral coated discont. or mineral infilling
cl - Clay coated discont.

SKETCH SYMBOLS
Discontinuity
Healed Joint
Broken
Part of Core Not Recovered or Noticable Drop During Drilling
Vesicles, Vugs, or Amygdules
Clay
Sand
Empty Space

OWEIS ENGINEERING INC.

DOCUMENT 30008
REV 1 3/2015

PROJECT	South Battery Park Resiliency	**BORING NO.**	B-7
LOCATION	Battery Park City, NY	**SHEET NO.**	1 OF 3
CLIENT	AECOM	**PROJECT NO.**	17-NY165-01
BORING LOCATION	see plan	**SURFACE ELEV.**	6.5+/-
EASTING	**NORTHING**	**VER. DATUM**	NAVD 88
		HOR. DATUM	

EQUIPMENT AND METHODS OF STABILIZING BOREHOLE

DRILLING RIG Truck Rig CME 75

CASING

4 in. dia. 40 ft

dia.

ADVANCEMENT METHOD Clear Water Rotary

DRILL RODS NWJ

ROTARY BIT DIAMETER, IN. 3-7/8 in. Tricone/ 2-15/16 in. Tricone

DRILLING MUD USED N/A

AUGER N/A

SAMPLERS

HAMMER TYPE Safety Hammer

WEIGHT 140 lb **DROP** 30'' **RATE** Auto

D-SAMPLER 2'' split spoon

U-SAMPLER N/A

OTHER 3'' Spoon

ROCK CORING

CORING FEED Hydraulic

CORE BARREL NX

CORE BIT Diamond bit

REMARKS

① Advance 10' casing into ground.
② Add 5' casing.
③ Add 5' casing.
④ Add 5' casing.
⑤ Add 5' casing.
⑥ Add 5' casing.
⑦ Add 5' casing.

LEGEND

TV = Torvane Shear Strength, TSF
CT = Coring Time, minutes/foot
CB = Casing Blows Per Foot
OLT = Other Lab Testing Performed
PP = Pocket Penetrometer
Unconfined Compressive Strength, TSF

REMARK TYPES

LC = Lost Circulation
HD = Hard Drilling
RC = Rig Chatter
CBJ = Core Barrel Jam
PO = Petroleum Odor
CW = Change in Wash
SS = Slickensided
EOB = End Of Boring
ML = Mudline

WATER LEVEL OBSERVATIONS IN BOREHOLE

DATE	TIME	DEPTH OF HOLE	DEPTH OF CASING	DEPTH TO WATER	CONDITIONS OF OBSERVATIONS

PIEZOMETER__ **MONITORING WELL**__ **INSTALLED** no **SKETCH SHOWN ON** NO

PAY QUANTITIES

2" DIA. SAMPLE BORING **LIN. FT.** 40 ft **NO. OF 3" UNDISTURBED SAMPLES** 0

CORE DRILLING IN ROCK **LIN. FT.** 1 ft **OTHER** N/A

BORING CONTRACTOR Craig Test Boring Co.

DRILLER Joe **HELPER(S):** Garrett

OEI OBSERVER Jinfu Xiao **DATE:** 5/9/2019 to 5/10/2019

CLASSIFICATION CHECK Burmister Soil Classification System

BORING LOG

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency

BORING NO. B-7
SHEET 2 OF 3
GROUND ELEVATION 6.5+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
5/9/19						2'' Pavement Stone					
11:00			1					1			
JX		S-1	2	4-5	10.0	Brown cmf SAND, some mf Gravel/Brick fragments	FILL	2	M		
				8-11		(Class 7)					
			3					3			
			4					4			
			5					**5**			
		S-2	6	3-6	6.0	Same with brick fragments (Class 7)	FILL	6	W		
				4-5							
			7					7			
			8					8			①
			9					9			
			10					**10**			
		S-3	11	3-2	2.0	Same (Class 7)	FILL	11			
				1-3							
			12					12			②
			13					13			

			14					14			
			15					**15**			
		S-4	16	3-1	6.0	Black mf SAND, some Silt, little f Gravel	FILL	16			
				1-1		(Class 7)					
			17					17			
			18					18			③
			19					19			
			20					**20**			
		S-5	21	4-2	6.0	Brown mf SAND, little cmf Gravel/Brick fragments	FILL	21			
				2-2		(caved in material) (Class 7)					
			22					22			④

BORING LOG

Oweis ENGINEERING INC. — INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT	South Battery Park Resiliency	**BORING NO.**	B-7
PROJECT NO.	17-NY165-01	**SHEET**	3 OF 3
LOCATION	South Battery Park Resiliency	**GROUND ELEVATION**	6.5+/-
		OEI OBSERVER	JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
			23					23			
			24					24			
			25					25			
		S-6	26	3-1	0.0			26			
			27	2-1				**27**			
			28					28			⑤
			29					29			
			30					30			
		S-7	31	WOH/12''	4.0	Black f SAND, some Silty Clay, trace f Gravel	FILL	31			
			32	1-1		(Class 7)		**32**			⑥
			33					33			
			34			-------------------------------		34			
			35					35			
		S-8	36	11-13	4.0	Decomposed wood with Silty Clay	CL-ML	36			
			37	11-18		(Class 6)		**37**			⑦
			38					38			
5/9/19			39					39			
13:30 JX			40			Approx. top of bedrock		40			
5/10/19 JX		C-1	41	11 - 50/3"	9.0	Fractured schist (Class 1c)		41			
			42			End of boring at 41' bgs.		**42**			

OWEIS ENGINEERING INC.

PROJECT South Battery Park Resiliency
LOCATION Battery Park City, NY
CLIENT AECOM
BORING LOCATION see plan
EASTING **NORTHING**

BORING NO. B-8
SHEET NO. 1 OF 6
PROJECT NO. 17-NY165-01
SURFACE ELEV. 5+/-
VER. DATUM NAVD 88
HOR. DATUM

EQUIPMENT AND METHODS OF STABILIZING BOREHOLE

DRILLING RIG Truck Rig CME 75
CASING
4 in. dia. 30 ft
dia.
ADVANCEMENT METHOD Clear Water Rotary
DRILL RODS NWJ
ROTARY BIT DIAMETER, IN. 3-7/8 in. Tricone/ 2-15/16 in. Tricone
DRILLING MUD USED N/A
AUGER N/A
SAMPLERS
HAMMER TYPE Safety Hammer
WEIGHT 140 lb **DROP** 30'' **RATE** Auto
D-SAMPLER 2'' split spoon
U-SAMPLER Shelby Tube
OTHER 3'' Spoon
ROCK CORING
CORING FEED Hydraulic
CORE BARREL NX
CORE BIT Diamond bit

REMARKS

① Advance 10' casing into ground.
② 3'' spoon sampling
③ Add 5' casing.
④ 3'' spoon sampling.
⑤ Add 5' casing.
⑥ Add 5' casing.
⑦ Add 5' casing.
⑧ lost 5' casing at about 29' bgs.
⑨ Redrill B-8 next to original location. advance 30' casing into ground.
⑩ Switch to core barrel.

LEGEND

TV = Torvane Shear Strength, TSF
CT = Coring Time, minutes/foot
CB = Casing Blows Per Foot
OLT = Other Lab Testing Performed
PP = Pocket Penetrometer
Unconfined Compressive Strength, TSF

REMARK TYPES

LC = Lost Circulation
HD = Hard Drilling
RC = Rig Chatter
CBJ = Core Barrel Jam
PO = Petroleum Odor
CW = Change in Wash
SS = Slickensided
EOB = End Of Boring
ML = Mudline

WATER LEVEL OBSERVATIONS IN BOREHOLE

DATE	TIME	DEPTH OF HOLE	DEPTH OF CASING	DEPTH TO WATER	CONDITIONS OF OBSERVATIONS

PIEZOMETER__ **MONITORING WELL**__ **INSTALLED** no **SKETCH SHOWN ON** NO

PAY QUANTITIES

2" DIA. SAMPLE BORING **LIN. FT.** 55 ft **NO. OF 3" UNDISTURBED SAMPLES** 1
CORE DRILLING IN ROCK **LIN. FT.** 10 ft **OTHER** N/A
BORING CONTRACTOR Craig Test Boring Co.
DRILLER Joe **HELPER(S):** Garrett
OEI OBSERVER Jinfu Xiao **DATE:** 5/8/2019
CLASSIFICATION CHECK Burmister Soil Classification System

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

BORING LOG

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency
BORING NO. B-8
SHEET 2 OF 6
GROUND ELEVATION 5+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
5/8/19 8:15 JX			1			2'' Paving Stone		1			
		S-1	2	21-78	12.0	Brown/Gray mf SAND, little mf Gravel/ Brick fragments		2	M		
			3	28-21		trace Silt (Class 7)		3			
			4					4			
			5					**5**			
		S-2	6	5-2	3.0	Gray cmf SAND with brick fragments, trace Silt		6	W		
			7	2-3		(Class 7)		7			
			8					8			①
			9					9			
			10					**10**			
		S-3	11	1-3	1.0	Brown mf SAND, little Silt, little cmf Gravel	FILL	11			
			12	1-2		(Class 7)		12			② ③
			13					13			
			14					14			
			15					**15**			
		S-4	16	5-4	2.0	Gray mf SAND, little Silt, little cm Gravel/ Brick fragments		16			
			17	6-2		(Class 7)		17			④ ⑤
			18					18			
			19					19			
			20					**20**			
		S-5	21	7-9	8.0	mf Gravel/ Brick fragments, and Gray mf SAND,	FILL	21			
			22	7-6		little Silt (Class 7)		22			⑥

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BORING LOG

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency | **BORING NO.** B-8
PROJECT NO. 17-NY165-01 | **SHEET** 3 OF 6
LOCATION South Battery Park Resiliency | **GROUND ELEVATION** 5+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	BLOWS/6"	REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
			23					23			
			24			------------------------------		24			
			25					25			
Perm. Test		S-6	26	4-2	8.0	Dark gray cmf SAND, some cmf Gravel, little Silty Clay, organic odor (Class 6)	SP-SC	26			
			27	2-3				**27**			⑦
			28					28			
5/8/19			29					29			⑧
12:30 JX			30					30			
5/9/19 8:00 JX		S-7	31	1-2	6.0	Same (Class 6)	SP-SC	31			⑨
			32	2-1				**32**			
			33					33			
			34					34			
			35					35			
		S-8A				6'' Brown f SAND, little Silt (Class 6)	SP-SM				
			36	WOH/18''	24.0			36			
		S-8B		10		18'' Dark gray Silty CLAY with shell fragments, organic (Class 6)	CH				
			37					**37**			
			38					38			
			39					39			
			40					40			
		S-9	41	1-1	14.0	Same (Class 6)	CH	41			
			42	1-3				**42**			

BORING LOG

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT	South Battery Park Resiliency	**BORING NO.**	B-8
PROJECT NO.	17-NY165-01	**SHEET**	4 OF 6
LOCATION	South Battery Park Resiliency	**GROUND ELEVATION**	5+/-
		OEI OBSERVER	JX

DAILY PROGRESS	SYMB OL	SAMPLE NO.	DEPTH (ft)	BLOWS/6"	REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
			43					43			
		UD-1	44	PUSH	24.0	Same (Class 6)	CL-ML	44			
						Gray cmf- SAND, trace Silt at tube bottom					
			45					45			
		S-10	46	2-3	12.0	Same (Class 6)	SM	46			
				2-3							
			47					**47**			
			48					48			
			49					49			
			50					50			
		S-11	51	4-3	6.0	Gray mf- SAND, little Silty Clay, trace C Gravel (Class 6)	SM	51			
				3-3							
			52					**52**			
			53					53			
			54					54			
			55					55			
			56	2:20		Approx. top of bedrock		56			
						Gray hard, slightly fractured, slightly weathered schist					
			57	2:15		(Class 1b)		**57**			
		C-1				Rec=(51''/60'')x100%=85%					
			58	2:30		RQD=(47''/60'')x100%=78.3%		58			
			59	2:30				59			
			60	2:00				60			
			61	2:30		Gray m hard, m fractured, m weathered schist		61			
		C-2				(Class 1c)					
			62	2:30				**62**			

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BORING LOG

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency
BORING NO. B-8
SHEET 5 OF 6
GROUND ELEVATION 5+/-
OEI OBSERVER JX

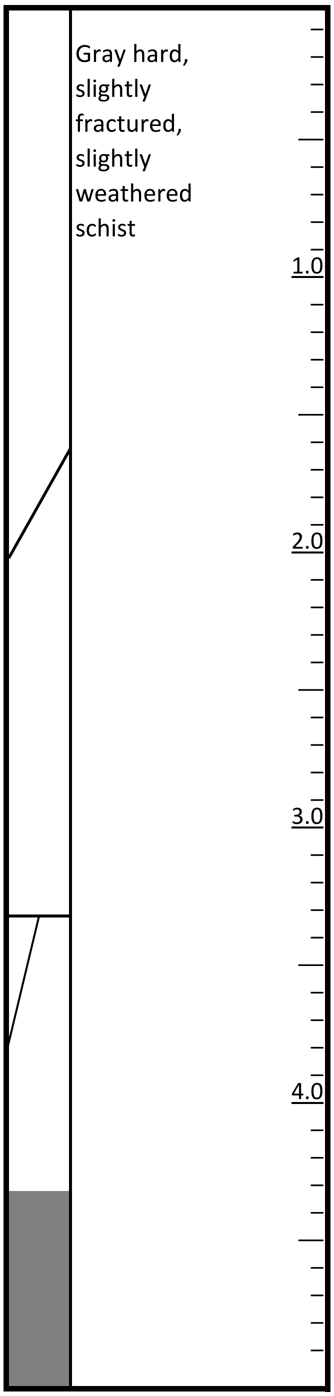
DAILY PROGRESS	SYMBOL	SAMPLE NO.	DEPTH (ft)	BLOWS/6"	REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
			63	2:10		Rec=(60''/60'')x100%=100%		63			
		C-2				RQD=(58''/60'')x100%=96.7%					
5/9/19			64	2:30		(Class 1a)		64			
11:00											
JX			65	2:30				65			
						End of boring at 65' bgs.					
			66					66			
			67					**67**			
			68					68			
			69					69			
			70					70			
			71					71			
			72					**72**			
			73					73			
			74					74			
			75					75			
			76					76			
			77					**77**			
			78					78			
			79					79			
			80					80			
			81					81			
			82					**82**			

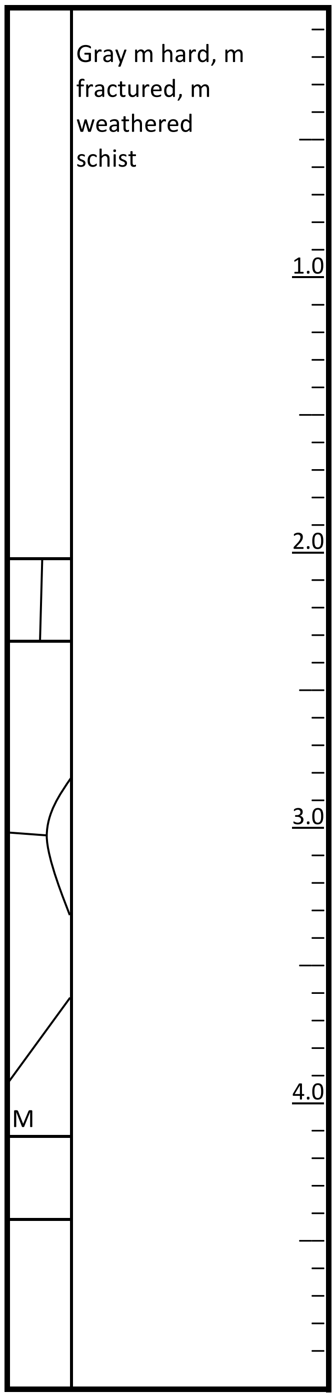
OWEIS ENGINEERING INC.

ROCK CORE SKETCH

PROJECT	South Battery Park Resiliency	**BORING NO.**	B-8
PROJECT NO.	17-NY165-01	**SHEET NO**	6 OF 6
LOCATION	Battery Park City, NY	**SURFACE NO.**	5+/-
		OEI REP.	J. Xiao

Run #	Start Depth	End Depth	Rec	RQD
C-1	55'	60'	85%	78.3%
C-2	60'	65'	100%	96.7%





LEGEND

DISCONTINUITY (DISCONT.)
- F - Fault or Shear
- J - Joint
- Fo - Foliation
- V - Vein
- B - Bedding
- MB - Mechanical Break

SURFACE SHAPE OF DISCONT.
- Wa - Wavy
- Pl - Planar
- St - Stepped
- Ir - Irregular

ROUGHNESS OF DISCONT.
- Slk - Slickensided
- S - Smooth
- Sr - Slightly Rough
- R - Rough
- VR - Very Rough

INFILLING OR WEATHERED DISCONT.
- w - Weathered discont.
- fe - Iron stained discont.
- min - Mineral coated discont. or mineral infilling
- cl - Clay coated discont.

SKETCH SYMBOLS
- Discontinuity
- Healed Joint
- Broken
- Part of Core Not Recovered or Noticable Drop During Drilling
- Vesicles, Vugs, or Amygdules
- Clay
- Sand
- Empty Space

OWEIS ENGINEERING INC.

DOCUMENT 30008
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PROJECT South Battery Park Resiliency
LOCATION Battery Park City, NY
CLIENT AECOM
BORING LOCATION see plan
EASTING **NORTHING**

BORING NO. B-9
SHEET NO. 1 OF 5
PROJECT NO. 17-NY165-01
SURFACE ELEV. 10±ft
VER. DATUM NAVD 88
HOR. DATUM

EQUIPMENT AND METHODS OF STABILIZING BOREHOLE

DRILLING RIG CME 55 LC Track rig
CASING
4 in. dia. 30 ft
dia.
ADVANCEMENT METHOD Rotary Drilling (water)
DRILL RODS NWJ
ROTARY BIT DIAMETER, IN. 3-7/8 in. Tricone/
DRILLING MUD USED N/A
AUGER N/A
SAMPLERS
HAMMER TYPE Automatic Hammer
WEIGHT 140 lb **DROP** 30'' **RATE** Auto
D-SAMPLER 2'' split spoon
U-SAMPLER N/A
OTHER 3'' Spoon
ROCK CORING
CORING FEED Hydraulic
CORE BARREL NX
CORE BIT Diamond bit

REMARKS

①Vaccume cleared the hole upto 8ft. hence the Drilled down to 8ft before starting sampling
②Drove 4 inch casing to 8ft and strarted water
③Drove casing to 15ft bgs.
④100% fluid loss.
⑤Attempted rock core barrell.
⑥The rods fell as they moved thoufh the soil indicating a boulder packing similar to a riprap.
⑦Drove 4 in. casing to 20ft bgs.
⑧The drill rod went down easitly during drilling
⑨Drove 4 in. casing to 25ft.
⑩Encountered a boulder(~29.5ft - 30.5ft) hence drilled down to 31ft before sampling and drove casing to 30ft.
⑪ The hammer started bouncing
⑫ Started taking rock core samples

LEGEND

TV = Torvane Shear Strength, TSF
CT = Coring Time, minutes/foot
CB = Casing Blows Per Foot
OLT = Other Lab Testing Performed
PP = Pocket Penetrometer
Unconfined Compressive Strength, TSF

REMARK TYPES

LC = Lost Circulation
HD = Hard Drilling
RC = Rig Chatter
CBJ = Core Barrel Jam
PO = Petroleum Odor
CW = Change in Wash
SS = Slickensided
EOB = End Of Boring
ML = Mudline

WATER LEVEL OBSERVATIONS IN BOREHOLE

DATE	TIME	DEPTH OF HOLE	DEPTH OF CASING	DEPTH TO WATER	CONDITIONS OF OBSERVATIONS
1/30/2020	1023	22ft	20ft	12ft	Watermeter (During AECOM water sampling)

PIEZOMETER__ MONITORING WELL__ INSTALLED no
SKETCH SHOWN ON NO

PAY QUANTITIES
2" DIA. SAMPLE BORING **LIN. FT.** 35ft
NO. OF 3" UNDISTURBED SAMPLES N/A
CORE DRILLING IN ROCK **LIN. FT.** 10 ft
OTHER N/A
BORING CONTRACTOR Craig Geotechnical Boring Co.
DRILLER Nick Bheeler **HELPER(S):** Steven
OEI OBSERVER Janitha Batagoda **DATE:** 1/30/2020
CLASSIFICATION CHECK Burmister Soil Classification System

BORING LOG

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT	South Battery Park Resiliency	**BORING NO.**	B-9
PROJECT NO.	17-NY165-01	**SHEET**	2 OF 5
LOCATION	South Battery Park Resiliency	**GROUND ELEVATION**	10±ft
		OEI OBSERVER	JB

DAILY PROGRESS	SYMBOL	SAMPLE NO.	DEPTH (ft)	BLOWS/6"	REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
01/30/20 8:30 JB			1			Vaccum cleared up to 8ft		1			①
			2			Brown, grey brown SAND, little Silt, w/gravel and brick fragments		2			
			3					3			
			4					4			
			5					5			
			6					6			
			7					7			② ③
			8					8			
		S-1	9	10 - 6	5	Brown, red brown m-f SAND, little (-) Silt w/brick and rock fragments, rock on tip (Class 6)		9	M		
			10	3 - 15				10			
		S-2	11	86 - 50/2"	3	Red brown, m-f SAND, little (+) Silt w/brick and rock fragments, rock on tip (Class 6)	FILL	11	M		RC
			12					12			RC
			13					13			③
			14					14			
			15					15			
		S-3	16	6 - 17	3	Grey, grey black m-f SAND, little (+) Silt w/rock fragments, rock on tip (Class 6)		16	W		
			17	19 - 21				17			
			18					18			LC ④
			19			Cored recovered 3 inch and 8 inch in length boulder pieces		19			RC
			20					20			⑤ RC
		S-4	21	6 - 14	0	No recovery		21			⑥
			22	7 - 8				22			⑦

BORING LOG

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Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency
BORING NO. B-9
SHEET 3 OF 5
GROUND ELEVATION 10±ft
OEI OBSERVER JB

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
											RC
			23					23			RC
			24					24			⑧
			25					25			RC
		S-5	26	16 - 5	18	Grey brown, grey m-f SAND, some Silt w/rounded pebbles and rock fragments (Class 6)	Fill	26	M		⑨
			27	8 - 16		Brown, grey brown m-f SAND some (+) Silt, trace Clay trace gravel (Class 6)		**27**			
			28					28			RC
			29					29			RC
			30					30			⑩
		S-6	31	60 - 90	16	Brown, m-f SAND some (+) Silt, some (-) Clay w/rock and brick fragments (Class 6)	Fill	31	M		
			32	50/1"				**32**			
			33					33			
			34					34			RC
			35					35			RC
		S-7	36	19 - 50/1"	4	Brown, m-f SAND, some (-) Silt, trace Clay w/rock fragments same as S-6 (Class 6)	Fill	36	M		⑪
			37					**37**			
			38					38			
			39			Approximate top of bedrock		39			
			40					40			⑫
		C-1	41	4 min 12 sec				41			
			42	2 min 14 sec				**42**			

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

BORING LOG

PROJECT	South Battery Park Resiliency	BORING NO.	B-9
PROJECT NO.	17-NY165-01	SHEET	4 OF 5
LOCATION	South Battery Park Resiliency	GROUND ELEVATION	10±ft
		OEI OBSERVER	JB

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
		C-1	43	2min 42sec		Grey, light grey hard, moderately fractured, slightly weathered manhattan schist REC = (56/60)x100% = 93.33% RQD = (31.5/60)x100% = 52.5%	Rock	43			
			44	1 min 54sec				44			
			45	missed				45			
		C-2	46	3 min 12sec		Grey, light grey hard, slightly fractured, slightly weathered manhattan schist REC = (60/60)x100% = 100% RQD = (44.5/60)x100% = 74.17%	Rock	46			
			47	2 min 57sec				47			
			48	3 min 27sec				48			
			49	3 min 31sec				49			
			50	4 min 10sec				50			
			51			End of Boring 50ft		51			
			52					52			
			53					53			
			54					54			
			55					55			
			56					56			
			57					57			
			58					58			
			59					59			
			60					60			
			61					61			
			62					62			

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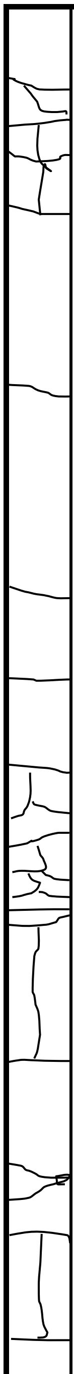
REV 1 3/2015

OWEIS ENGINEERING INC.

ROCK CORE SKETCH

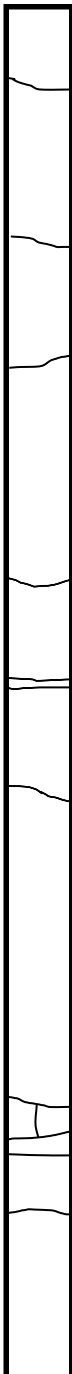
PROJECT	South Battery Park Resiliency	**BORING NO.**	B-9
PROJECT NO.	17-NY165-01	**SHEET NO**	5 OF 5
LOCATION	Battery Park City, NY	**SURFACE NO.**	10±ft
		OEI REP.	JB

Run #	Start Depth	End Depth	Rec	RQD
C-1	40ft	45ft	93%	52.5%
C-2	45ft	50ft	100%	74.17%



Grey, light grey, hard, moderately fractured , slightly weathered, manhattan schist
REC = (56/60)x100 = 93.33%
RQD = (31.5/60)x100 = 52.5%

1.0 2.0 3.0 4.0



Grey, light grey, hard, slightly fractured , slightly weathered, manhattan schist.
REC = (60/60)x100 = 100%
RQD = (44.5/60)x100 = 74.17%

1.0 2.0 3.0 4.0

1.0 2.0 3.0 4.0

LEGEND

DISCONTINUITY (DISCONT.)
F - Fault or Shear
J - Joint
Fo - Foliation
V - Vein
B - Bedding
MB - Mechanical Break

SURFACE SHAPE OF DISCONT.
Wa - Wavy
Pl - Planar
St - Stepped
Ir - Irregular

ROUGHNESS OF DISCONT.
Slk - Slickensided
S - Smooth
Sr - Slightly Rough
R - Rough
VR - Very Rough

INFILLING OR WEATHERED DISCONT.
w - Weathered discont.
fe - Iron stained discont.
min - Mineral coated discont. or mineral infilling
cl - Clay coated discont.

SKETCH SYMBOLS
Discontinuity
Healed Joint
Broken
Part of Core Not Recovered or Noticable Drop During Drilling
Vesicles, Vugs, or Amygdules
Clay
Sand
Empty Space

OWEIS ENGINEERING INC.

PROJECT South Battery Park Resiliency
LOCATION Battery Park City, NY
CLIENT AECOM
BORING LOCATION see plan
EASTING **NORTHING**

BORING NO. B-11
SHEET NO. 1 OF 3
PROJECT NO. 17-NY165-01
SURFACE ELEV. 10.5+/-
VER. DATUM NAVD 88
HOR. DATUM

EQUIPMENT AND METHODS OF STABILIZING BOREHOLE

DRILLING RIG Track Rig CME 55
CASING
4 in. dia. 12 ft
dia.
ADVANCEMENT METHOD Clear Water Rotary
DRILL RODS NWJ
ROTARY BIT DIAMETER, IN. 3-7/8 in. Tricone
DRILLING MUD USED N/A
AUGER N/A
SAMPLERS
HAMMER TYPE Safety Hammer
WEIGHT 140 lb **DROP** 30'' **RATE** Auto
D-SAMPLER 2'' split spoon
U-SAMPLER N/A/
OTHER N/A
ROCK CORING
CORING FEED N/A
CORE BARREL N/A
CORE BIT N/A

REMARKS
1. Advance 5' casing into ground.
2. Add 2' casing.
3. Add 5' casing.

LEGEND
TV = Torvane Shear Strength, TSF
CT = Coring Time, minutes/foot
CB = Casing Blows Per Foot
OLT = Other Lab Testing Performed
PP = Pocket Penetrometer
Unconfined Compressive Strength, TSF

REMARK TYPES
LC = Lost Circulation
HD = Hard Drilling
RC = Rig Chatter
CBJ = Core Barrel Jam
PO = Petroleum Odor
CW = Change in Wash
SS = Slickensided
EOB = End Of Boring
ML = Mudline

WATER LEVEL OBSERVATIONS IN BOREHOLE

DATE	TIME	DEPTH OF HOLE	DEPTH OF CASING	DEPTH TO WATER	CONDITIONS OF OBSERVATIONS

PIEZOMETER__ MONITORING WELL__ INSTALLED no
SKETCH SHOWN ON NO

PAY QUANTITIES
2" DIA. SAMPLE BORING **LIN. FT.** 32 ft
CORE DRILLING IN ROCK **LIN. FT.** N/A
NO. OF 3" UNDISTURBED SAMPLES N/A
OTHER N/A
BORING CONTRACTOR Craig Test Boring Co.
DRILLER Mike Tarter **HELPER(S):** Jimmy
OEI OBSERVER Jinfu Xiao **DATE:** 5/21/2019
CLASSIFICATION CHECK Burmister Soil Classcification System

BORING LOG

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Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency

BORING NO. B-11

GROUND ELEVATION 10.5+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	DEPTH (ft)	BLOWS/6"	REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
5/21/19 9:00 JX		S-1	1	2-4	27.0	Dark brown mf SAND, traces Silt, trace Gravel (Class 7)		1	M		
			2	4-3				2			
Perm. Test		S-2	3	8-10	15.0	Light brown f SAND, trace Silt (Class 7)		3			
			4	14-16				4			①
Perm. Test		S-3	5	5-9	12.0	Same (Class 7)		**5**			
			6	10-10				6	W		②
		S-4	7	6-7	12.0	Light brown f SAND, trace Silt, trace Gravel (Class 7)		7			
			8	8-8				8			
Perm. Test		S-5	9	8-8	14.0	Light brown f SAND, trace Silt (Class 7)	FILL	9			
			10	8-7				**10**			③
		S-6	11	13-7	8.0	Same (Class 7)		11			
			12	5-5				12			
			13					13			
			14					14			
			15					**15**			
		S-7	16	7-9	14.0	Same (Class 7)		16			
			17	11-12				17			
			18					18			
			19					19			
			20					**20**			
		S-5	21	7-7	10.0	Same (Class 7)		21			
			22	10-5				22			④

BORING LOG

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

PROJECT South Battery Park Resiliency
PROJECT NO. 17-NY165-01
LOCATION South Battery Park Resiliency
BORING NO. B-11
SHEET 3 OF 3
GROUND ELEVATION 10.5+/-
OEI OBSERVER JX

DAILY PROGRESS	SYMBOL	SAMPLE NO.	SAMPLE DEPTH (ft)	SAMPLE BLOWS/6"	SAMPLE REC (in)	SAMPLE DESCRIPTION	USCS	DEPTH (ft)	MOISTURE CONDITION	FIELD TESTS	REMARKS (TYPE)
			23					23			
			24					24			RC
			25					25			
		S-9	26	9-8	12.0	Same, cm Gravel at spoon tip (Class 7)	FILL	26			
			27	7-7				**27**			
			28					28			
			29			- - - - - - - - - - - - - - - -		29			
			30					30			
5/12/19		S-10	31	7-7	14.0	12'' Gray mf SAND, little Silt	SM	31			
11:40				10-10		(Class 3b)					
JX			32					**32**			
			33			End of boring at 32 ft bgs.		33			
			34					34			
			35					35			
			36					36			
			37					**37**			
			38					38			
			39					39			
			40					40			
			41					41			
			42					**42**			

APPENDIX B

FIELD WATER LEVEL READINGS

APPENDIX B: FIELD OBSERVATION OF GROUNDWATER LEVELS

Groundwater was measured in temporary wells at B-2 and B-5 (2” diameter PVC well casing with 10ft screen) during the subsurface investigation. The groundwater elevations were determined based on the field-measured depth to water from current grade and the elevation of existing ground surface at each well location approximated by field engineers. The results of the observation are summarized as follows.

Monitoring Wells	**Date-*Time***	**Depth of Water**	**Elevation of Water Level**
B-2	5/20/2019-*0819AM*	9.60	0.40
	5/21/2019-*0755AM*	10.40	-0.40
B-5	5/13/2019-*1130AM*	10.30	0.70
	5/16/2019-*0745AM*	9.85	1.15
	5/17/2019-*0730AM*	9.90	1.10
	5/20/2019-*0825AM*	10.40	0.60
	5/21/2019-*0800AM*	10.70	0.30

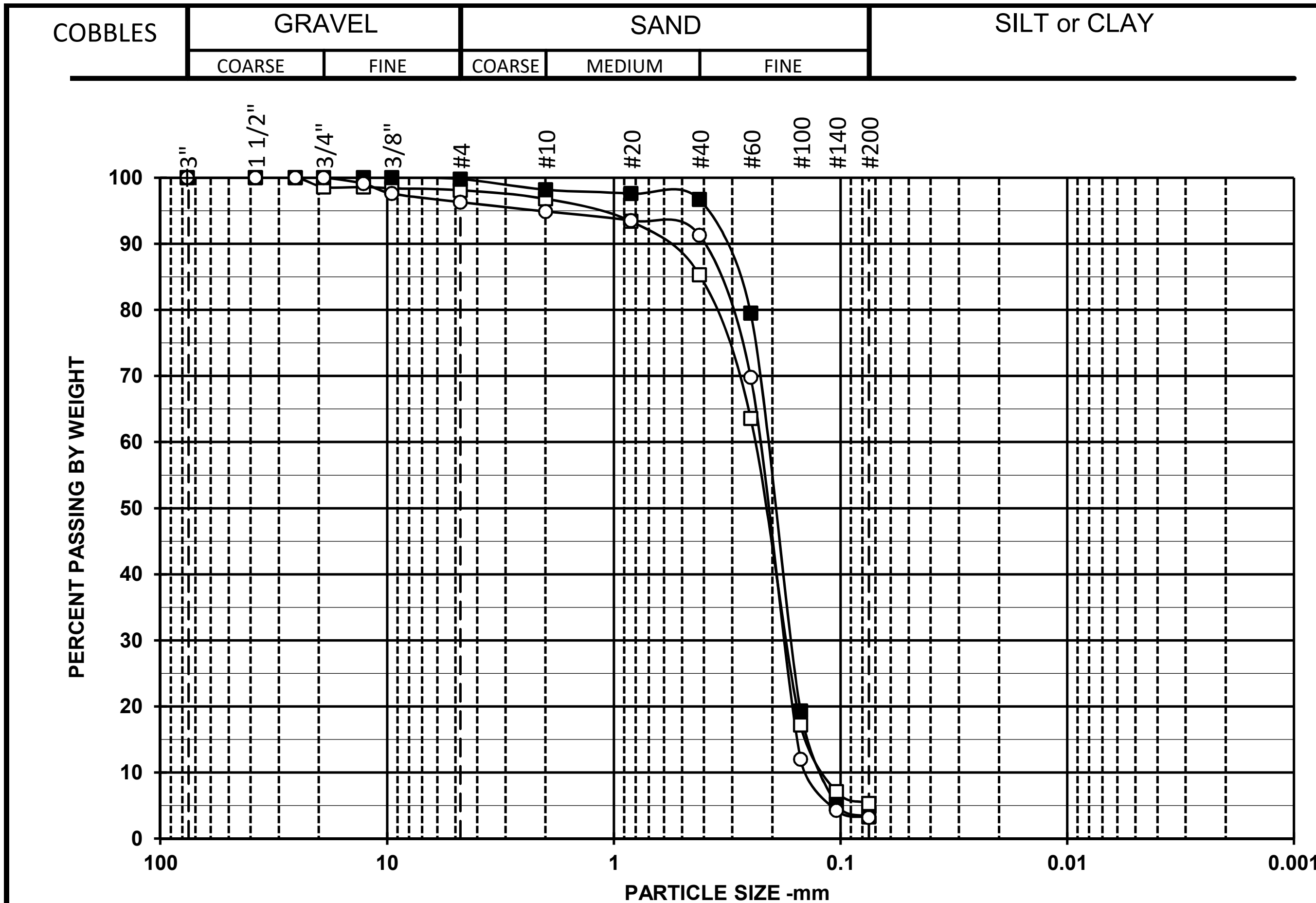
APPENDIX C

LABORATORY TEST RESULTS

Oweis Engineering, Inc. #17-NY165
South Battery Park Resiliency
LABORATORY TESTING DATA SUMMARY

BORING NO.	SAMPLE NO.	DEPTH (ft)	IDENTIFICATION TESTS						REMARKS
			WATER CONTENT (%)	LIQUID LIMIT (-)	PLASTIC LIMIT (-)	PLAS. INDEX (-)	USCS SYMB. (1)	SIEVE MINUS NO. 200 (%)	
B-1	S-3	10-12	21.7				SP-SM	5.3	
B-1	S-4	15-17	25.8				SP	3.3	
B-1	S-5	20-22	25.5				SP	3.2	
B-1	S-8	35-37	25.2				SC	24.3	
B-1	S-10	45-47	14.7				SP-SM	5.5	
B-2	S-2	5-6	6.3				SP	4.1	
B-2	S-6	25-27	27.1				SP	1.4	
B-2	S-9	40-42	22.2				SM	17.7	
B-2	S-10	45-47	18.0				SP-SM	6.8	
B-2	S-11A	50-52	14.8				SP	2.4	
B-3	S-1	1-3	2.2				SP-SM	5.0	
B-3	S-5	20-22	25.0				SP	2.2	
B-3	S-7	30-32	20.8				SP	2.1	
B-3	S-10	50-52	54.6	98	33	65	CH		
B-4	S-3	10-12	55.7				SP	3.1	
B-4	S-4	15-17	23.3				SP	4.1	
B-4	S-5	20-22	25.5				SP	1.8	
B-4	S-7	30-32	26.5				SP	1.6	
B-4	S-8	35-37	26.0				SP	2.2	
B-5	S-2	5-7	8.8				SP-SM	7.6	
B-5	S-5	20-22	26.4				SP	2.0	
B-5	S-6	25-27	26.2				SP	2.9	
B-5	S-7	30-32	25.6				SP	3.7	
B-6	S-5	20-22	26.1				SP	1.7	
B-6	S-7	30-32	23.7				SP	3.1	
B-6	S-9	40-42	46.1	91	36	55	CH		
B-7	S-1	1-3	14.1				SP-SM	7.5	
B-7	S-4	15-17	28.2				SM	21.6	
B-8	S-5	20-22	12.6				GP-GM	10.9	
B-8	S-6	25-27	29.5				SC	12.6	
B-8	S-7	30-32	28.1				SP-SC	10.6	
B-8	S-9	40-42	59.7	92	34	58	CH		
B-11	S-1	0-2	7.9				SP-SM	6.1	
B-11	S-2	2-4	3.3				SP-SM	8.2	
B-11	S-3	4-6	18.5				SP-SM	7.4	
B-11	S-4	6-8	21.6				SP	3.6	
B-11	S-5	8-10	20.1				SP-SM	5.2	
B-11	S-6	10-12	19.3				SP-SM	6.6	

Note: (1) USCS symbol based on visual observation and Sieve and Atterberg limits reported.



SYMBOL	w (%)	LL	PL	PI	USCS	AASHTO	USCS DESCRIPTION AND REMARKS	DATE
□	21.7				SP-SM		Brown, Poorly graded sand with silt	07/10/19
■	25.8				SP		Brown, Poorly graded sand	07/10/19
○	25.5				SP		Grayish brown, Poorly graded sand	07/10/19

Symbol	□	■	○
Boring	B-1	B-1	B-1
Sample	S-3	S-4	S-5
Depth	10-12	15-17	20-22
% +3"	0.0	0.0	0.0
% Gravel	1.9	0.2	3.7
% SAND	92.8	96.5	93.1
%C SAND	1.3	1.6	1.4
%M SAND	11.5	1.5	3.6
%F SAND	80.0	93.4	88.1
% FINES	5.3	3.3	3.2
D_{100} (mm)	25.400	9.530	19.050
D_{60} (mm)	0.239	0.211	0.228
D_{30} (mm)	0.172	0.164	0.176
D_{10} (mm)	0.116	0.118	0.136
Cc	1.100	1.100	1.000
Cu	2.1	1.8	1.7

Sieve Size/ID #	Percent Finer Data		
6"	100.0	100.0	100.0
4"	100.0	100.0	100.0
3"	100.0	100.0	100.0
1 1/2"	100.0	100.0	100.0
1"	100.0	100.0	100.0
3/4"	98.6	100.0	100.0
1/2"	98.6	100.0	99.1
3/8"	98.4	100.0	97.6
#4	98.1	99.8	96.3
#10	96.8	98.2	94.9
#20	93.4	97.6	93.5
#40	85.3	96.7	91.3
#60	63.6	79.5	69.8
#100	17.2	19.3	12.0
#140	7.1	5.2	4.3
#200	5.3	3.3	3.2
5μ m			
2μ m			
1μ m			

Oweis Engineering, Inc. #17-NY165

TerraSense, LLC #7844-19008

South Battery Park Resiliency

PARTICLE SIZE DISTRIBUTION

TerraSense Analysis File: GrainSizeV5Rev1 (5/19)

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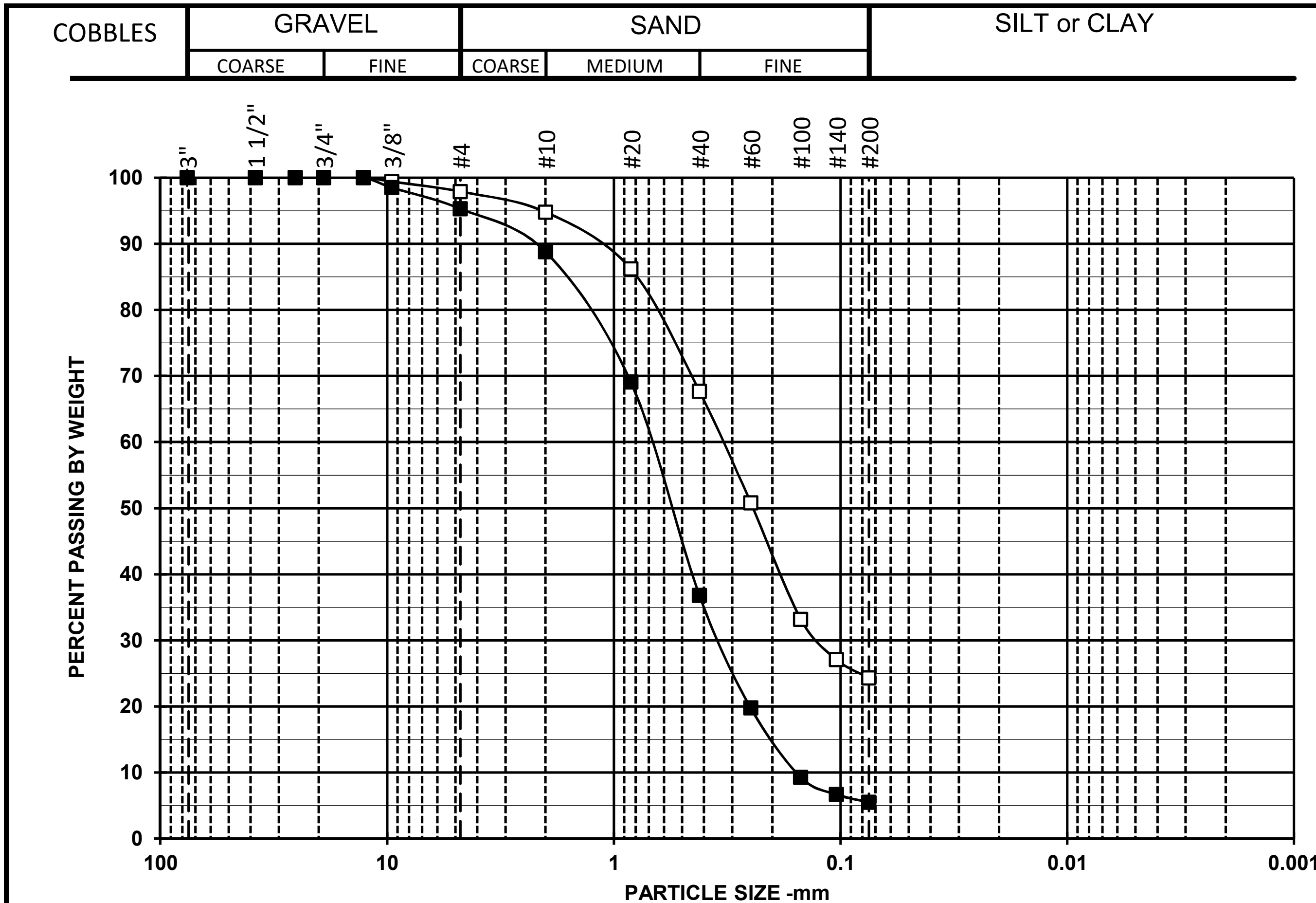

Symbol	□	■	○
Boring	B-1	B-1	
Sample	S-8	S-10	
Depth	35-37	45-47	
% +3"	0.0	0.0	
% Gravel	2.1	4.7	
% SAND	73.6	89.8	
%C SAND	3.1	6.5	
%M SAND	27.1	52.0	
%F SAND	43.4	31.3	
% FINES	24.3	5.5	
D_{100} (mm)	12.700	12.700	
D_{60} (mm)	0.331	0.691	
D_{30} (mm)	0.124	0.340	
D_{10} (mm)		0.155	
Cc		1.100	
Cu		4.5	

Sieve Size/ID #	Percent Finer Data		
6"	100.0	100.0	
4"	100.0	100.0	
3"	100.0	100.0	
1 1/2"	100.0	100.0	
1"	100.0	100.0	
3/4"	100.0	100.0	
1/2"	100.0	100.0	
3/8"	99.4	98.5	
#4	97.9	95.3	
#10	94.8	88.8	
#20	86.2	69.1	
#40	67.7	36.8	
#60	50.8	19.8	
#100	33.2	9.3	
#140	27.1	6.7	
#200	24.3	5.5	
5μ m			
2μ m			
1μ m			

SYMBOL	w (%)	LL	PL	PI	USCS	AASHTO	USCS DESCRIPTION AND REMARKS	DATE
□	25.2				SC		Reddish brown, Clayey sand	07/10/19
■	14.7				SP-SM		Reddish brown, Poorly graded sand with silt	07/10/19
○								

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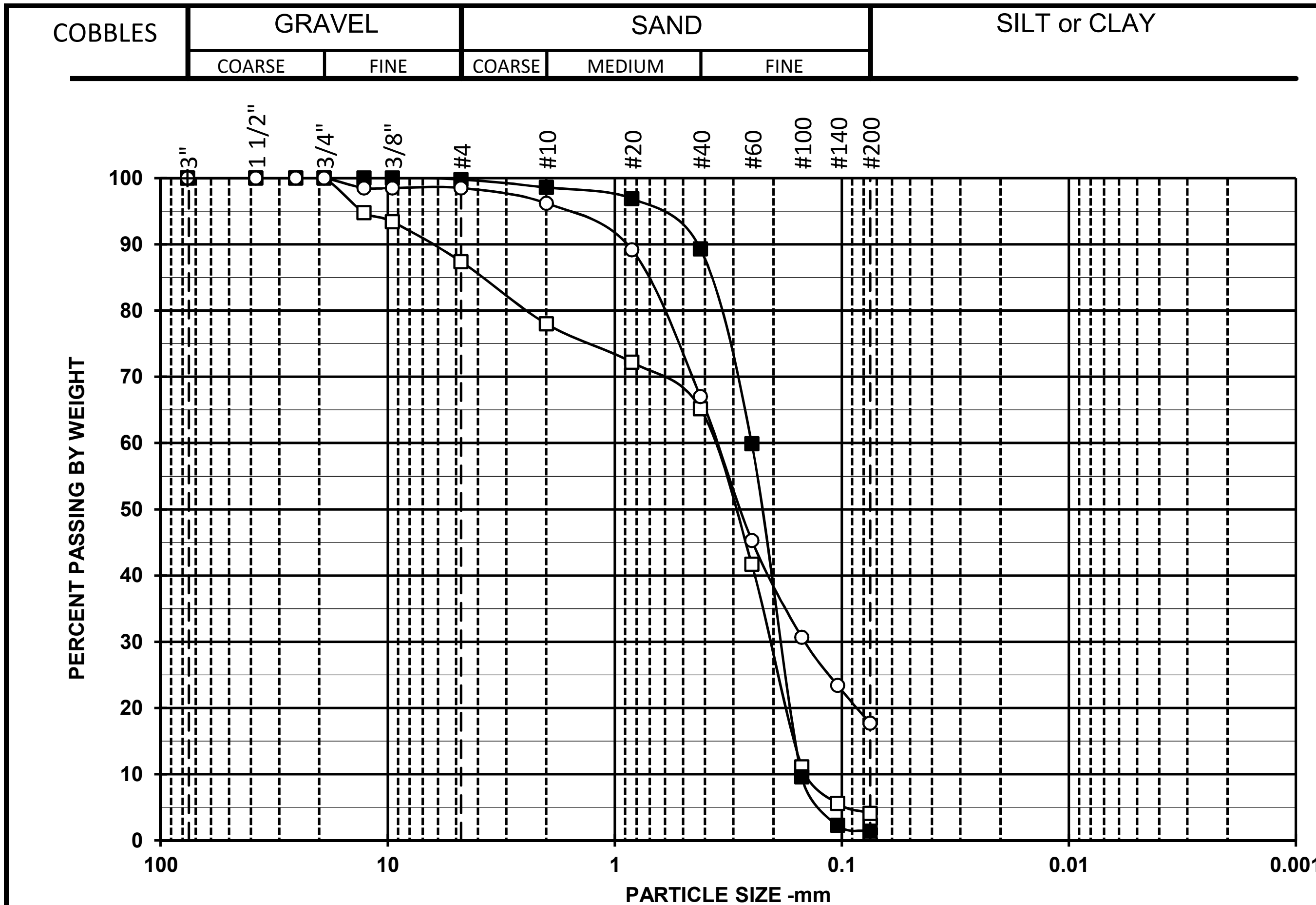

Symbol	□	■	○
Boring	B-2	B-2	B-2
Sample	S-2	S-6	S-9
Depth	5-6	25-27	40-42
% +3"	0.0	0.0	0.0
% Gravel	12.6	0.2	1.5
% SAND	83.3	98.4	80.8
%C SAND	9.4	1.2	2.3
%M SAND	12.8	9.3	29.2
%F SAND	61.1	87.9	49.3
% FINES	4.1	1.4	17.7
D_{100} (mm)	19.050	9.530	19.050
D_{60} (mm)	0.373	0.249	0.354
D_{30} (mm)	0.205	0.184	0.145
D_{10} (mm)	0.139	0.150	
Cc	0.800	0.900	
Cu	2.7	1.7	

Sieve Size/ID #	Percent Finer Data		
6"	100.0	100.0	100.0
4"	100.0	100.0	100.0
3"	100.0	100.0	100.0
1 1/2"	100.0	100.0	100.0
1"	100.0	100.0	100.0
3/4"	100.0	100.0	100.0
1/2"	94.8	100.0	98.5
3/8"	93.4	100.0	98.5
#4	87.4	99.8	98.5
#10	78.0	98.6	96.2
#20	72.2	96.9	89.2
#40	65.2	89.3	67.0
#60	41.7	59.9	45.3
#100	11.1	9.6	30.7
#140	5.6	2.3	23.4
#200	4.1	1.4	17.7
5μ m			
2μ m			
1μ m			

SYMBOL	w (%)	LL	PL	PI	USCS	AASHTO	USCS DESCRIPTION AND REMARKS	DATE
□	6.3				SP		Light brown, Poorly graded sand	07/10/19
■	27.1				SP		Grayish brown, Poorly graded sand	07/10/19
○	22.2				SM		Brown, Silty sand	07/10/19

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South Battery Park Resiliency

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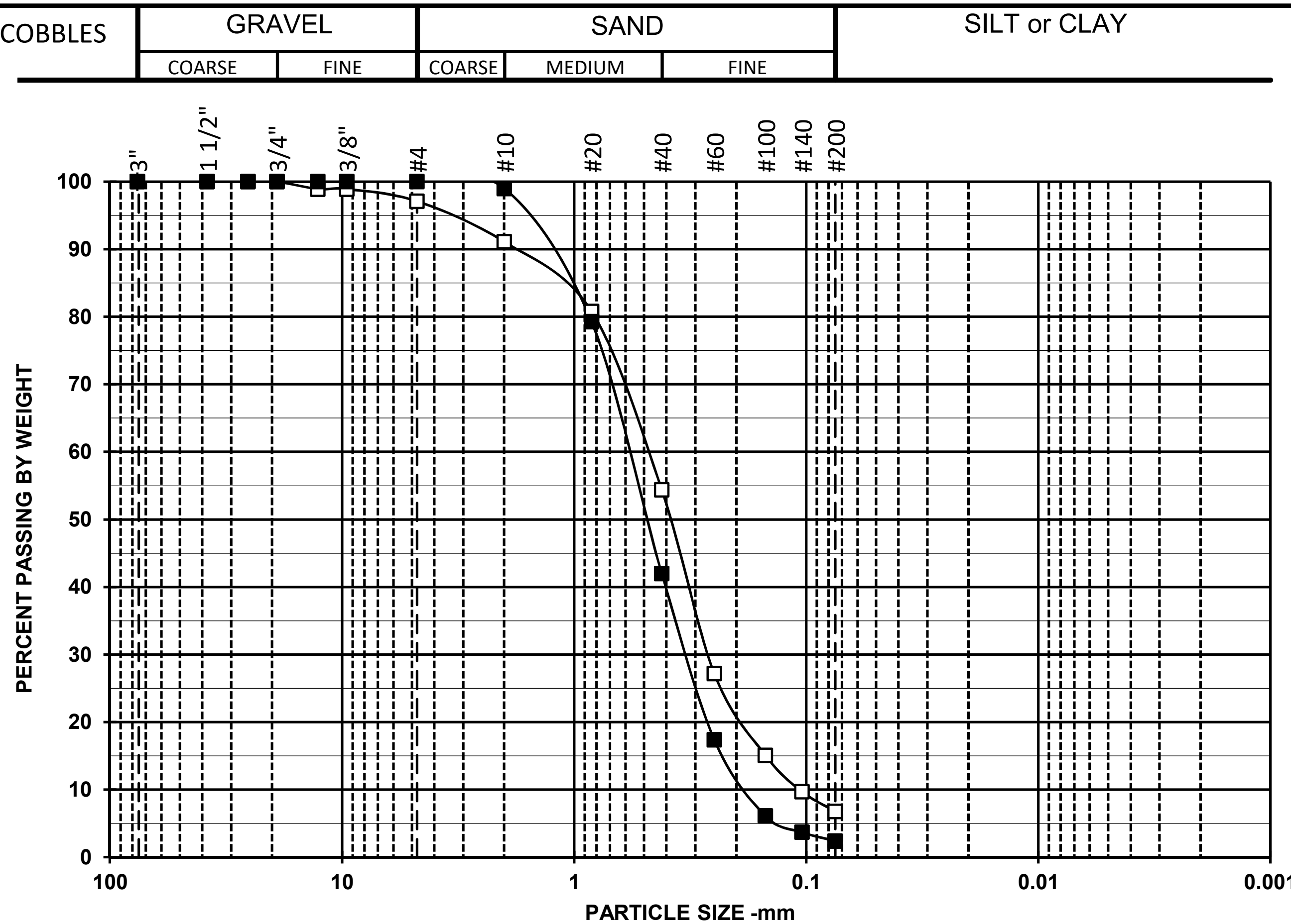

Symbol	□	■	○
Boring	B-2	B-2	
Sample	S-10	S-11A	
Depth	45-47	50-52	
% +3"	0.0	0.0	
% Gravel	2.9	0.0	
% SAND	90.3	97.6	
%C SAND	6.0	1.0	
%M SAND	36.7	57.0	
%F SAND	47.6	39.6	
% FINES	6.8	2.4	
D_{100} (mm)	19.050	4.750	
D_{60} (mm)	0.486	0.586	
D_{30} (mm)	0.263	0.325	
D_{10} (mm)	0.106	0.179	
Cc	1.300	1.000	
Cu	4.6	3.3	

Sieve Size/ID #	Percent Finer Data		
6"	100.0	100.0	
4"	100.0	100.0	
3"	100.0	100.0	
1 1/2"	100.0	100.0	
1"	100.0	100.0	
3/4"	100.0	100.0	
1/2"	98.9	100.0	
3/8"	98.9	100.0	
#4	97.1	100.0	
#10	91.1	99.0	
#20	80.8	79.3	
#40	54.4	42.0	
#60	27.2	17.4	
#100	15.1	6.1	
#140	9.7	3.7	
#200	6.8	2.4	
5μ m			
2μ m			
1μ m			

SYMBOL	w (%)	LL	PL	PI	USCS	AASHTO	USCS DESCRIPTION AND REMARKS	DATE
□	18.0				SP-SM		Reddish brown, Poorly graded sand with silt	07/10/19
■	14.8				SP		Brown, Poorly graded sand	07/10/19
○								

Oweis Engineering, Inc.	#17-NY165	South Battery Park Resiliency	**PARTICLE SIZE DISTRIBUTION**
TerraSense, LLC	#7844-19008		

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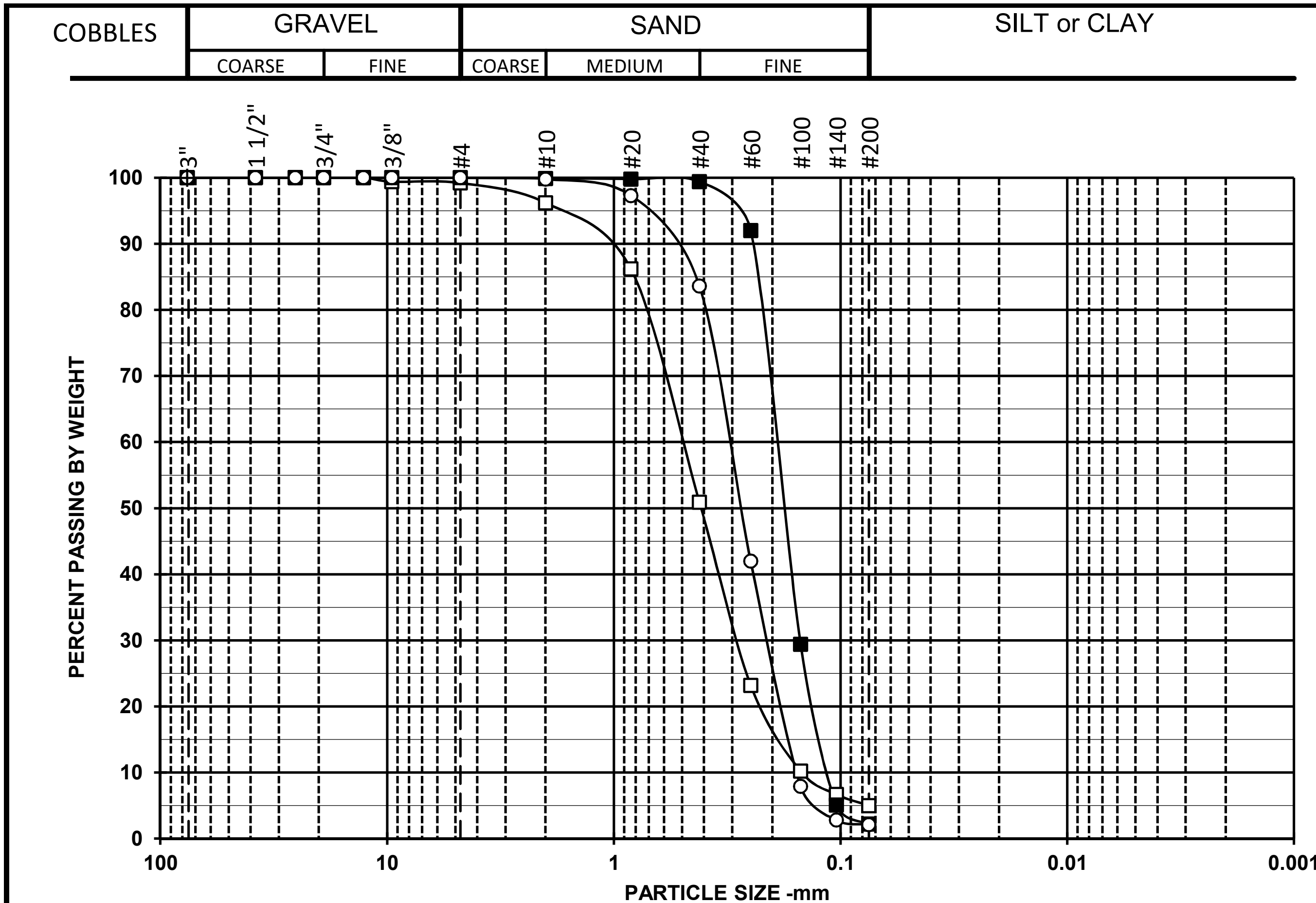

Symbol	□	■	○
Boring	B-3	B-3	B-3
Sample	S-1	S-5	S-7
Depth	1-3	20-22	30-32
% +3"	0.0	0.0	0.0
% Gravel	0.8	0.0	0.0
% SAND	94.2	97.8	97.9
%C SAND	3.0	0.1	0.2
%M SAND	45.3	0.5	16.2
%F SAND	45.9	97.2	81.5
% FINES	5.0	2.2	2.1
D_{100} (mm)	12.700	4.750	4.750
D_{60} (mm)	0.501	0.192	0.312
D_{30} (mm)	0.283	0.151	0.208
D_{10} (mm)	0.147	0.112	0.155
Cc	1.100	1.100	0.900
Cu	3.4	1.7	2.0

Sieve Size/ID #	Percent Finer Data		
6"	100.0	100.0	100.0
4"	100.0	100.0	100.0
3"	100.0	100.0	100.0
1 1/2"	100.0	100.0	100.0
1"	100.0	100.0	100.0
3/4"	100.0	100.0	100.0
1/2"	100.0	100.0	100.0
3/8"	99.4	100.0	100.0
#4	99.2	100.0	100.0
#10	96.2	99.9	99.8
#20	86.2	99.8	97.3
#40	50.9	99.4	83.6
#60	23.2	92.0	42.0
#100	10.2	29.4	7.9
#140	6.7	5.1	2.8
#200	5.0	2.2	2.1
5μ m			
2μ m			
1μ m			

SYMBOL	w (%)	LL	PL	PI	USCS	AASHTO	USCS DESCRIPTION AND REMARKS	DATE
□	2.2				SP-SM		Light brown, Poorly graded sand with silt	07/10/19
■	25.0				SP		Grayish brown, Poorly graded sand	07/10/19
○	20.8				SP		Grayish brown, Poorly graded sand	07/10/19

Oweis Engineering, Inc. #17-NY165

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South Battery Park Resiliency

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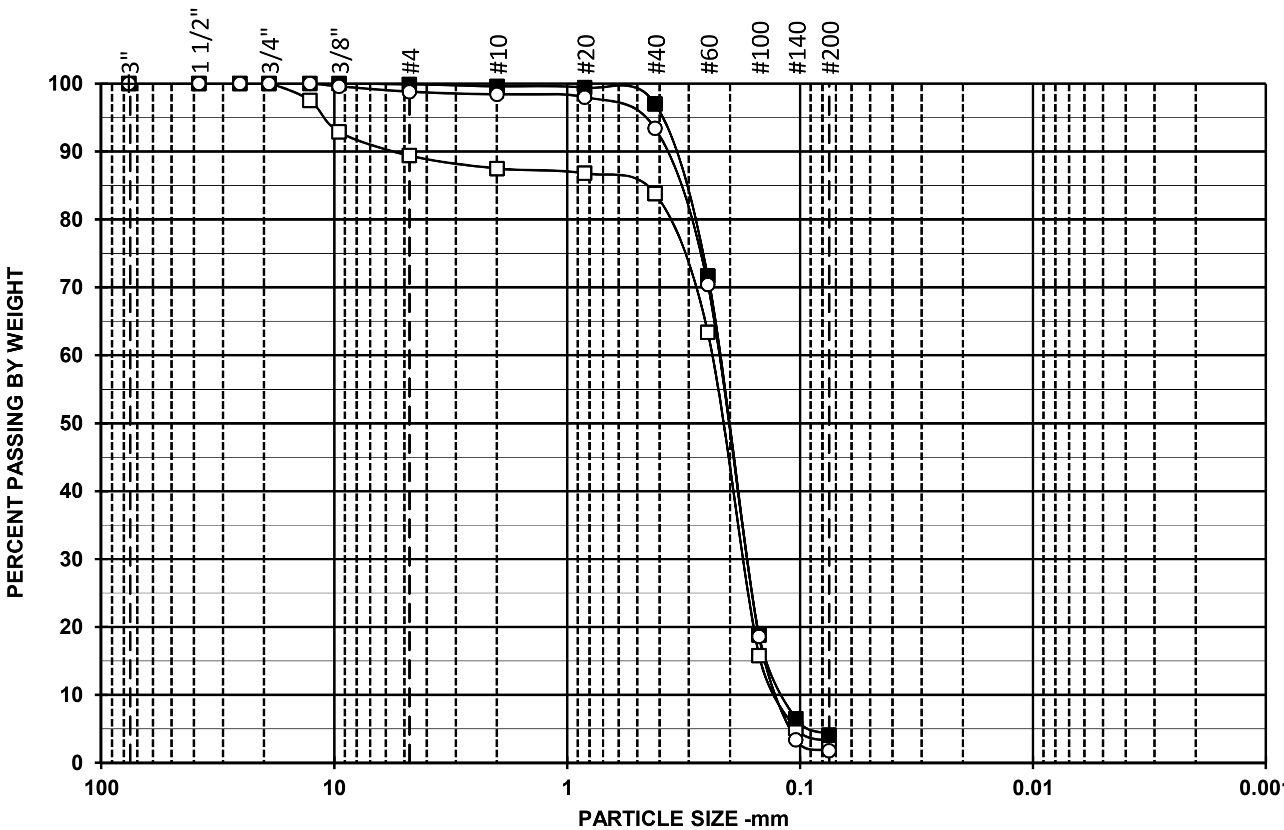
COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



Symbol	□	■	○
Boring	B-4	B-4	B-4
Sample	S-3	S-4	S-5
Depth	10-12	15-17	20-22
% +3"	0.0	0.0	0.0
% Gravel	10.6	0.1	1.2
% SAND	86.3	95.8	97.0
%C SAND	1.9	0.3	0.4
%M SAND	3.7	2.6	5.0
%F SAND	80.7	92.9	91.6
% FINES	3.1	4.1	1.8
D_{100} (mm)	19.050	9.530	12.700
D_{60} (mm)	0.240	0.222	0.225
D_{30} (mm)	0.174	0.167	0.168
D_{10} (mm)	0.123	0.116	0.122
Cc	1.000	1.100	1.000
Cu	2.0	1.9	1.8

Sieve Size/ID #	Percent Finer Data		
6"	100.0	100.0	100.0
4"	100.0	100.0	100.0
3"	100.0	100.0	100.0
1 1/2"	100.0	100.0	100.0
1"	100.0	100.0	100.0
3/4"	100.0	100.0	100.0
1/2"	97.5	100.0	100.0
3/8"	92.9	100.0	99.6
#4	89.4	99.9	98.8
#10	87.5	99.6	98.4
#20	86.8	99.4	98.0
#40	83.8	97.0	93.4
#60	63.4	71.7	70.4
#100	15.8	18.8	18.6
#140	5.1	6.5	3.4
#200	3.1	4.1	1.8
5µ m			
2µ m			
1µ m			

SYMBOL	w (%)	LL	PL	PI	USCS	AASHTO	USCS DESCRIPTION AND REMARKS	DATE
□	55.7				SP		Brown, Poorly graded sand	07/10/19
■	23.3				SP		Brown, Poorly graded sand	07/10/19
○	25.5				SP		Grayish brown, Poorly graded sand	07/10/19

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TerraSense, LLC #7844-19008

South Battery Park Resiliency

PARTICLE SIZE DISTRIBUTION

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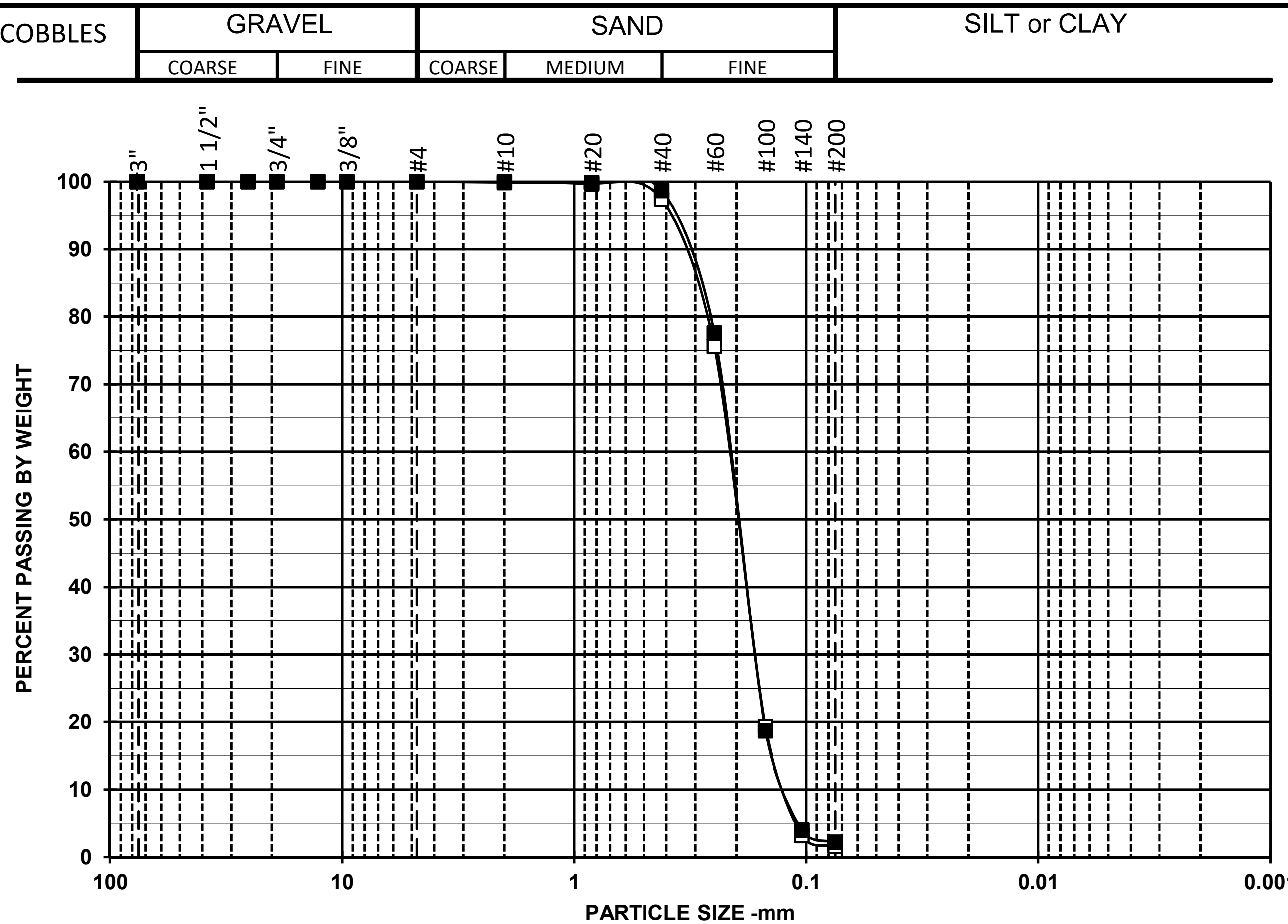

Symbol	□	■	○
Boring	B-4	B-4	
Sample	S-7	S-8	
Depth	30-32	35-37	
% +3"	0.0	0.0	
% Gravel	0.0	0.0	
% SAND	98.4	97.8	
%C SAND	0.0	0.1	
%M SAND	2.6	1.2	
%F SAND	95.8	96.5	
% FINES	1.6	2.2	
D_{100} (mm)	4.750	4.750	
D_{60} (mm)	0.216	0.214	
D_{30} (mm)	0.165	0.165	
D_{10} (mm)	0.121	0.121	
Cc	1.000	1.100	
Cu	1.8	1.8	

Sieve Size/ID #	Percent Finer Data		
6"	100.0	100.0	
4"	100.0	100.0	
3"	100.0	100.0	
1 1/2"	100.0	100.0	
1"	100.0	100.0	
3/4"	100.0	100.0	
1/2"	100.0	100.0	
3/8"	100.0	100.0	
#4	100.0	100.0	
#10	100.0	99.9	
#20	99.9	99.7	
#40	97.4	98.7	
#60	75.6	77.6	
#100	19.3	18.7	
#140	3.2	4.0	
#200	1.6	2.2	
5μ m			
2μ m			
1μ m			

SYMBOL	w (%)	LL	PL	PI	USCS	AASHTO	USCS DESCRIPTION AND REMARKS	DATE
□	26.5				SP		Grayish brown, Poorly graded sand	07/10/19
■	26.0				SP		Grayish brown, Poorly graded sand	07/10/19
○								

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TerraSense, LLC #7844-19008

South Battery Park Resiliency

PARTICLE SIZE DISTRIBUTION

TerraSense Analysis File: GrainSizeV5Rev1 (5/19)

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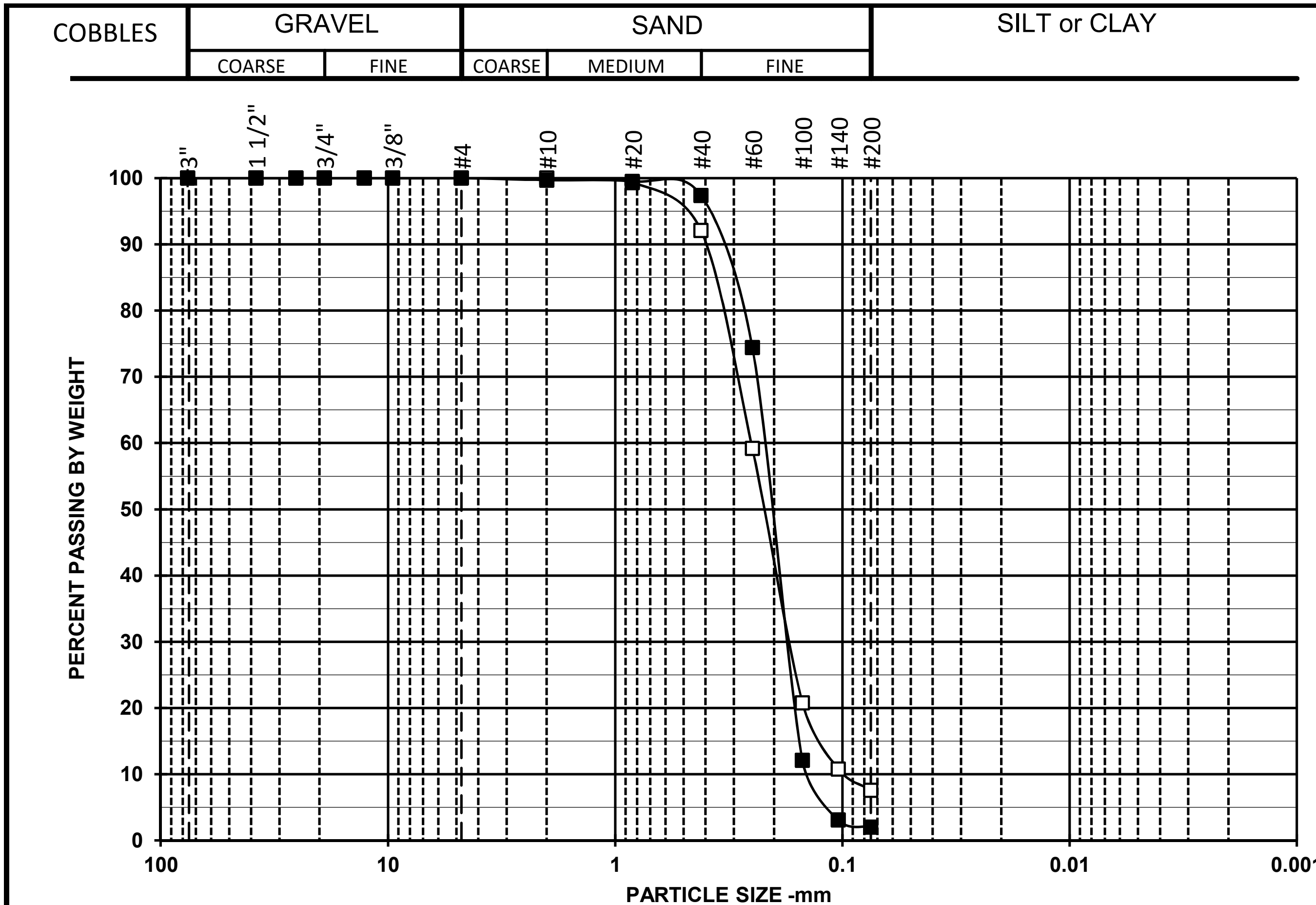

Symbol	□	■	○
Boring	B-5	B-5	
Sample	S-2	S-5	
Depth	5-7	20-22	
% +3"	0.0	0.0	
% Gravel	0.0	0.0	
% SAND	92.4	98.0	
%C SAND	0.0	0.3	
%M SAND	7.9	2.3	
%F SAND	84.5	95.4	
% FINES	7.6	2.0	
D_{100} (mm)	4.750	4.750	
D_{60} (mm)	0.252	0.221	
D_{30} (mm)	0.169	0.173	
D_{10} (mm)	0.096	0.138	
Cc	1.200	1.000	
Cu	2.6	1.6	

Sieve Size/ID #	Percent Finer Data		
6"	100.0	100.0	
4"	100.0	100.0	
3"	100.0	100.0	
1 1/2"	100.0	100.0	
1"	100.0	100.0	
3/4"	100.0	100.0	
1/2"	100.0	100.0	
3/8"	100.0	100.0	
#4	100.0	100.0	
#10	100.0	99.7	
#20	99.3	99.5	
#40	92.1	97.4	
#60	59.2	74.4	
#100	20.8	12.1	
#140	10.8	3.1	
#200	7.6	2.0	
5μ m			
2μ m			
1μ m			

SYMBOL	w (%)	LL	PL	PI	USCS	AASHTO	USCS DESCRIPTION AND REMARKS	DATE
□	8.8				SP-SM		Light brown, Poorly graded sand with silt	07/10/19
■	26.4				SP		Grayish brown, Poorly graded sand	07/10/19
○								

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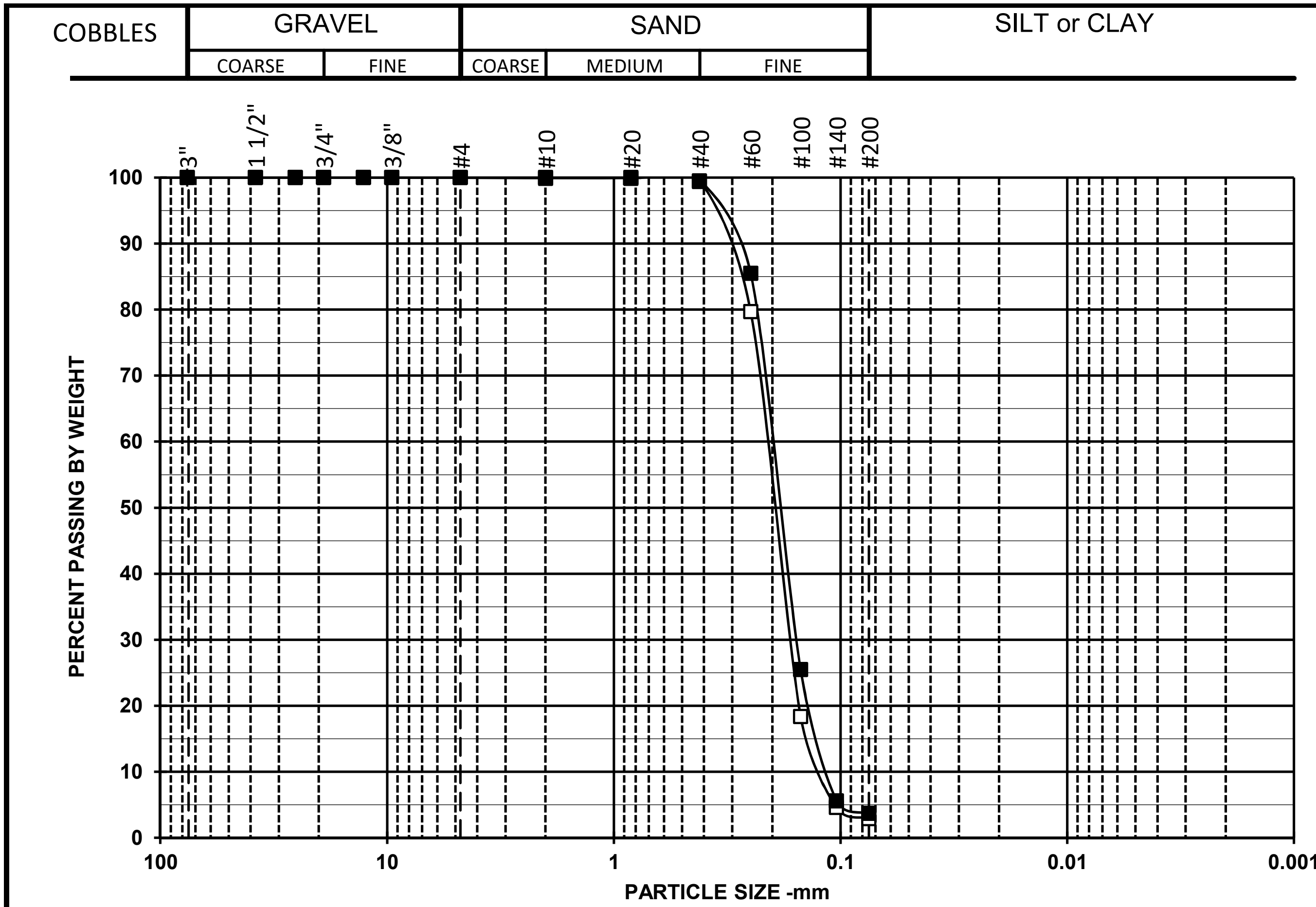

Symbol	□	■	○
Boring	B-5	B-5	
Sample	S-6	S-7	
Depth	25-27	30-32	
% +3"	0.0	0.0	
% Gravel	0.0	0.0	
% SAND	97.1	96.3	
%C SAND	0.0	0.1	
%M SAND	0.6	0.4	
%F SAND	96.5	95.8	
% FINES	2.9	3.7	
D_{100} (mm)	4.750	4.750	
D_{60} (mm)	0.211	0.201	
D_{30} (mm)	0.165	0.156	
D_{10} (mm)	0.120	0.113	
Cc	1.100	1.100	
Cu	1.8	1.8	

Sieve Size/ID #	Percent Finer Data		
6"	100.0	100.0	
4"	100.0	100.0	
3"	100.0	100.0	
1 1/2"	100.0	100.0	
1"	100.0	100.0	
3/4"	100.0	100.0	
1/2"	100.0	100.0	
3/8"	100.0	100.0	
#4	100.0	100.0	
#10	100.0	99.9	
#20	100.0	99.9	
#40	99.4	99.5	
#60	79.7	85.5	
#100	18.4	25.5	
#140	4.6	5.6	
#200	2.9	3.7	
5μ m			
2μ m			
1μ m			

SYMBOL	w (%)	LL	PL	PI	USCS	AASHTO	USCS DESCRIPTION AND REMARKS	DATE
□	26.2				SP		Brown, Poorly graded sand	07/10/19
■	25.6				SP		Grayish brown, Poorly graded sand	07/10/19
○								

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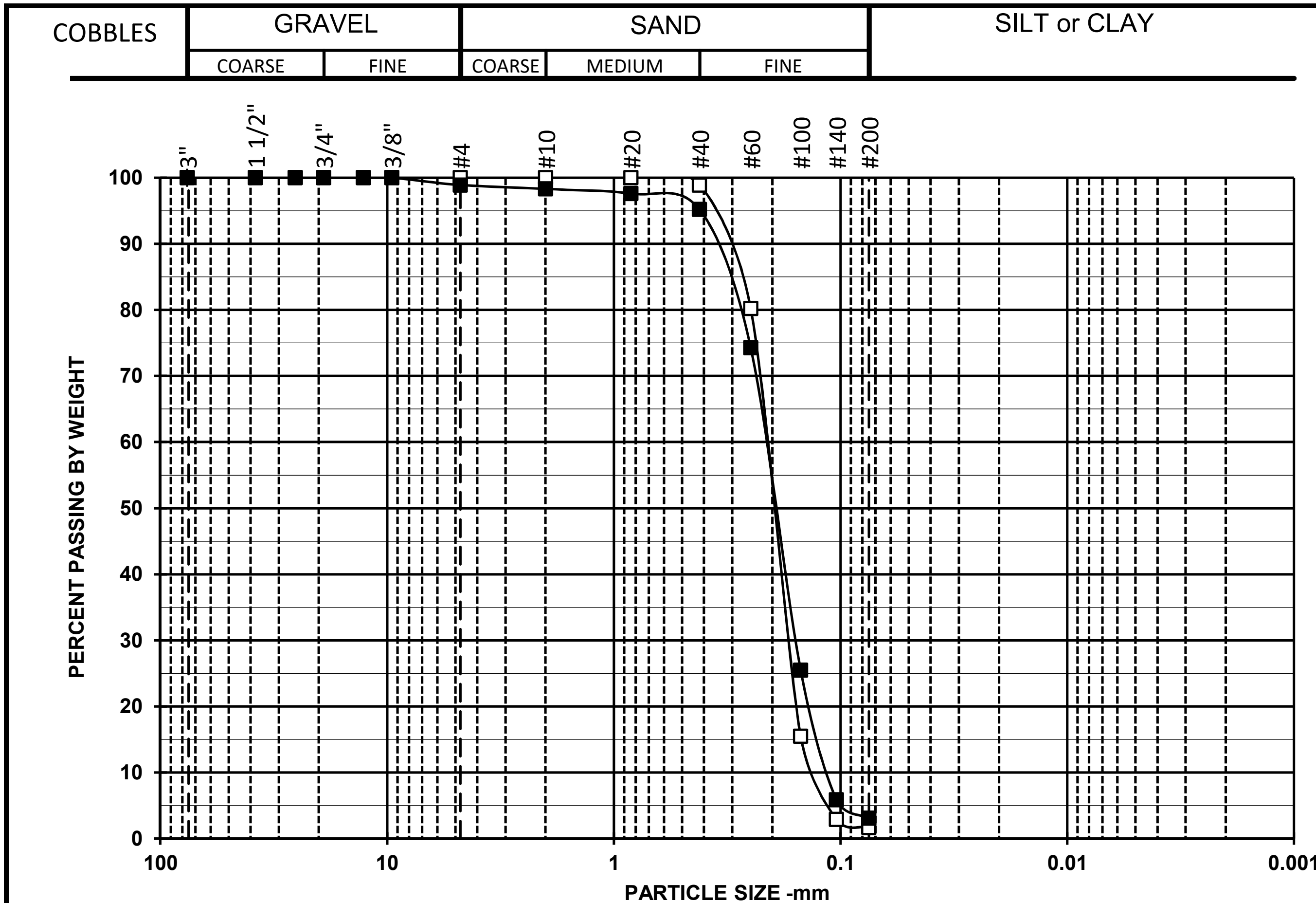

Symbol	□	■	○
Boring	B-6	B-6	
Sample	S-5	S-7	
Depth	20-22	30-32	
% +3"	0.0	0.0	
% Gravel	0.0	1.1	
% SAND	98.3	95.8	
%C SAND	0.0	0.6	
%M SAND	1.1	3.1	
%F SAND	97.2	92.1	
% FINES	1.7	3.1	
D_{100} (mm)	2.000	9.530	
D_{60} (mm)	0.212	0.215	
D_{30} (mm)	0.168	0.157	
D_{10} (mm)	0.128	0.112	
Cc	1.000	1.000	
Cu	1.7	1.9	

Sieve Size/ID #	Percent Finer Data		
6"	100.0	100.0	
4"	100.0	100.0	
3"	100.0	100.0	
1 1/2"	100.0	100.0	
1"	100.0	100.0	
3/4"	100.0	100.0	
1/2"	100.0	100.0	
3/8"	100.0	100.0	
#4	100.0	98.9	
#10	100.0	98.3	
#20	100.0	97.6	
#40	98.9	95.2	
#60	80.2	74.3	
#100	15.5	25.5	
#140	2.9	5.9	
#200	1.7	3.1	
5μ m			
2μ m			
1μ m			

SYMBOL	w (%)	LL	PL	PI	USCS	AASHTO	USCS DESCRIPTION AND REMARKS	DATE
□	26.1				SP		Grayish brown, Poorly graded sand	07/10/19
■	23.7				SP		Grayish brown, Poorly graded sand	07/10/19
○								

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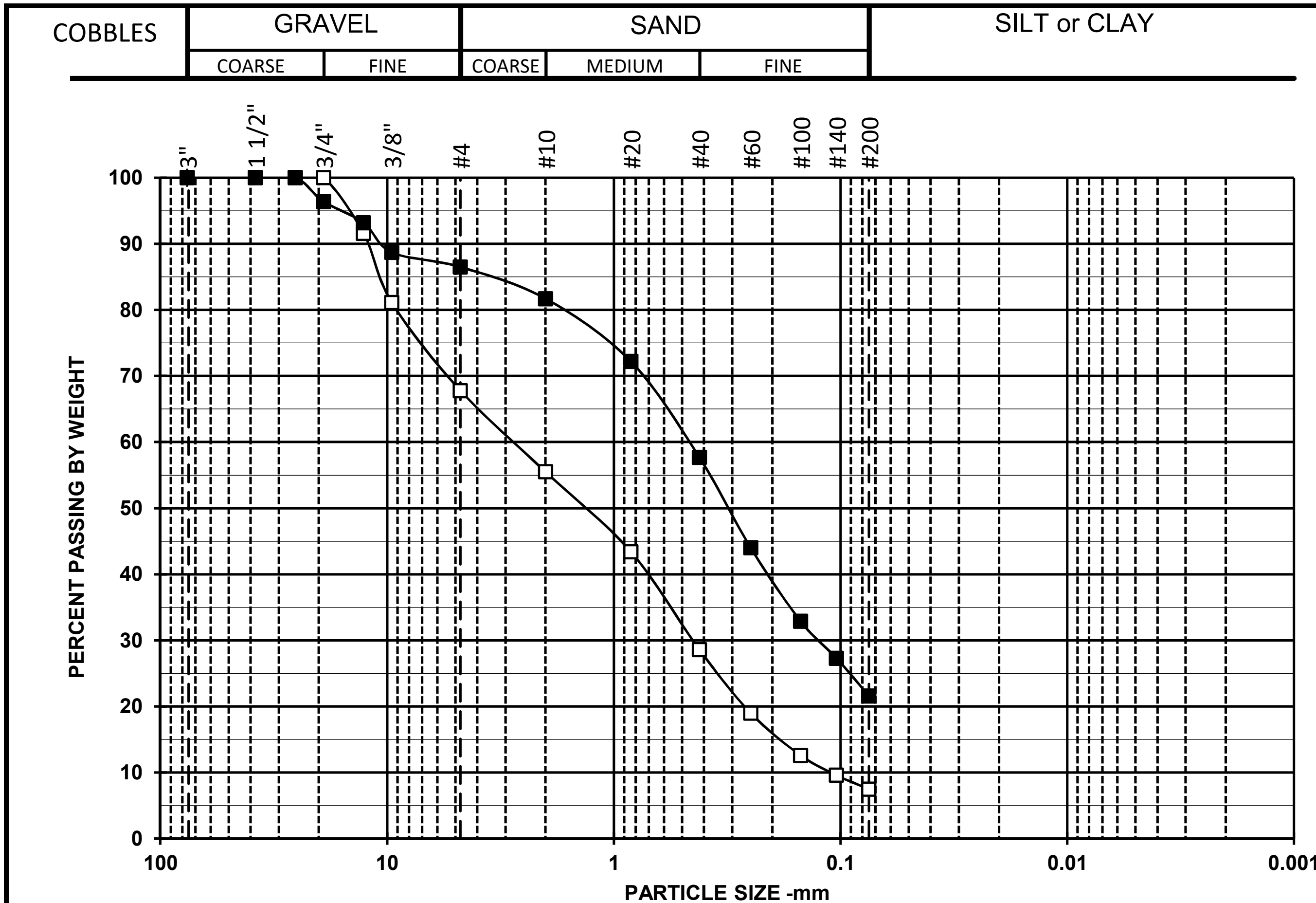

Symbol	□	■	○
Boring	B-7	B-7	
Sample	S-1	S-4	
Depth	1-3	15-17	
% +3"	0.0	0.0	
% Gravel	32.2	13.5	
% SAND	60.3	64.9	
%C SAND	12.3	4.8	
%M SAND	26.9	24.0	
%F SAND	21.1	36.1	
% FINES	7.5	21.6	
D_{100} (mm)	19.050	25.400	
D_{60} (mm)	2.744	0.468	
D_{30} (mm)	0.448	0.124	
D_{10} (mm)	0.109		
Cc	0.700		
Cu	25.1		

Sieve Size/ID #	Percent Finer Data		
6"	100.0	100.0	
4"	100.0	100.0	
3"	100.0	100.0	
1 1/2"	100.0	100.0	
1"	100.0	100.0	
3/4"	100.0	96.4	
1/2"	91.6	93.2	
3/8"	81.1	88.7	
#4	67.8	86.5	
#10	55.5	81.7	
#20	43.4	72.2	
#40	28.6	57.7	
#60	19.0	44.0	
#100	12.6	32.9	
#140	9.6	27.3	
#200	7.5	21.6	
5μ m			
2μ m			
1μ m			

SYMBOL	w (%)	LL	PL	PI	USCS	AASHTO	USCS DESCRIPTION AND REMARKS	DATE
□	14.1				SP-SM		Brown, Poorly graded sand with silt and gravel	07/10/19
■	28.2				SM		Grayish brown, Silty sand	07/10/19
○								

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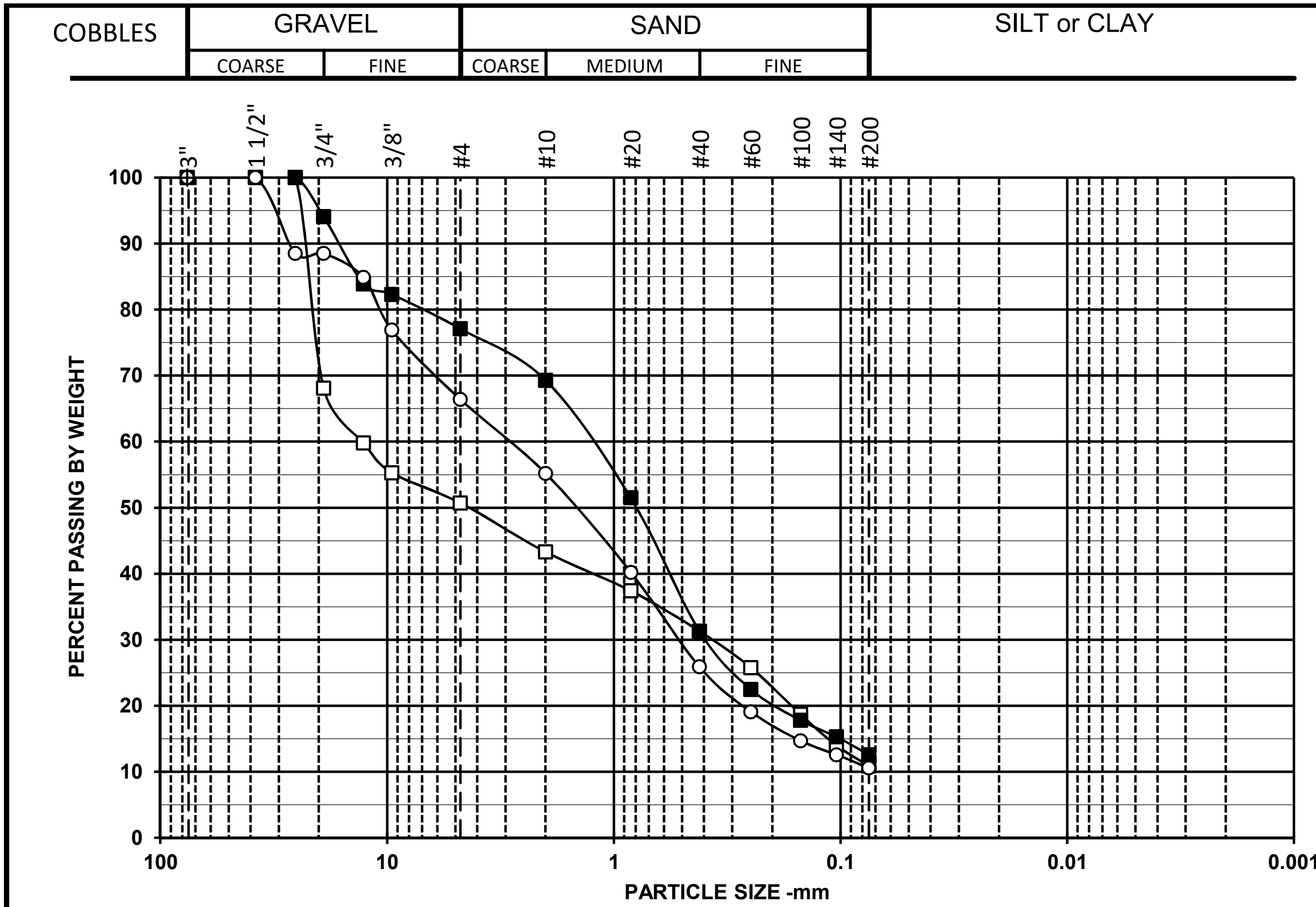

Symbol	□	■	○
Boring	B-8	B-8	B-8
Sample	S-5	S-6	S-7
Depth	20-22	25-27	30-32
% +3"	0.0	0.0	0.0
% Gravel	49.3	22.9	33.6
% SAND	39.8	64.5	55.8
%C SAND	7.4	7.8	11.2
%M SAND	12.0	38.0	29.3
%F SAND	20.4	18.7	15.3
% FINES	10.9	12.6	10.6
D_{100} (mm)	25.400	25.400	38.100
D_{60} (mm)	12.825	1.271	2.897
D_{30} (mm)	0.371	0.388	0.512
D_{10} (mm)			
Cc			
Cu			

Sieve Size/ID #	Percent Finer Data		
6"	100.0	100.0	100.0
4"	100.0	100.0	100.0
3"	100.0	100.0	100.0
1 1/2"	100.0	100.0	100.0
1"	100.0	100.0	88.5
3/4"	68.1	94.1	88.5
1/2"	59.8	83.9	84.9
3/8"	55.3	82.3	76.9
#4	50.7	77.1	66.4
#10	43.3	69.3	55.2
#20	37.4	51.5	40.2
#40	31.3	31.3	25.9
#60	25.8	22.5	19.1
#100	18.7	17.8	14.7
#140	14.0	15.3	12.6
#200	10.9	12.6	10.6
5μ m			
2μ m			
1μ m			

SYMBOL	w (%)	LL	PL	PI	USCS	AASHTO	USCS DESCRIPTION AND REMARKS	DATE
□	12.6				GP-GM		Brown, Poorly graded gravel with silt and sand shale noted	07/10/19
■	29.5				SC		Grayish brown, Clayey sand with gravel	07/10/19
○	28.1				SP-SC		Grayish brown, Poorly graded sand with clay and gravel shale noted	07/10/19

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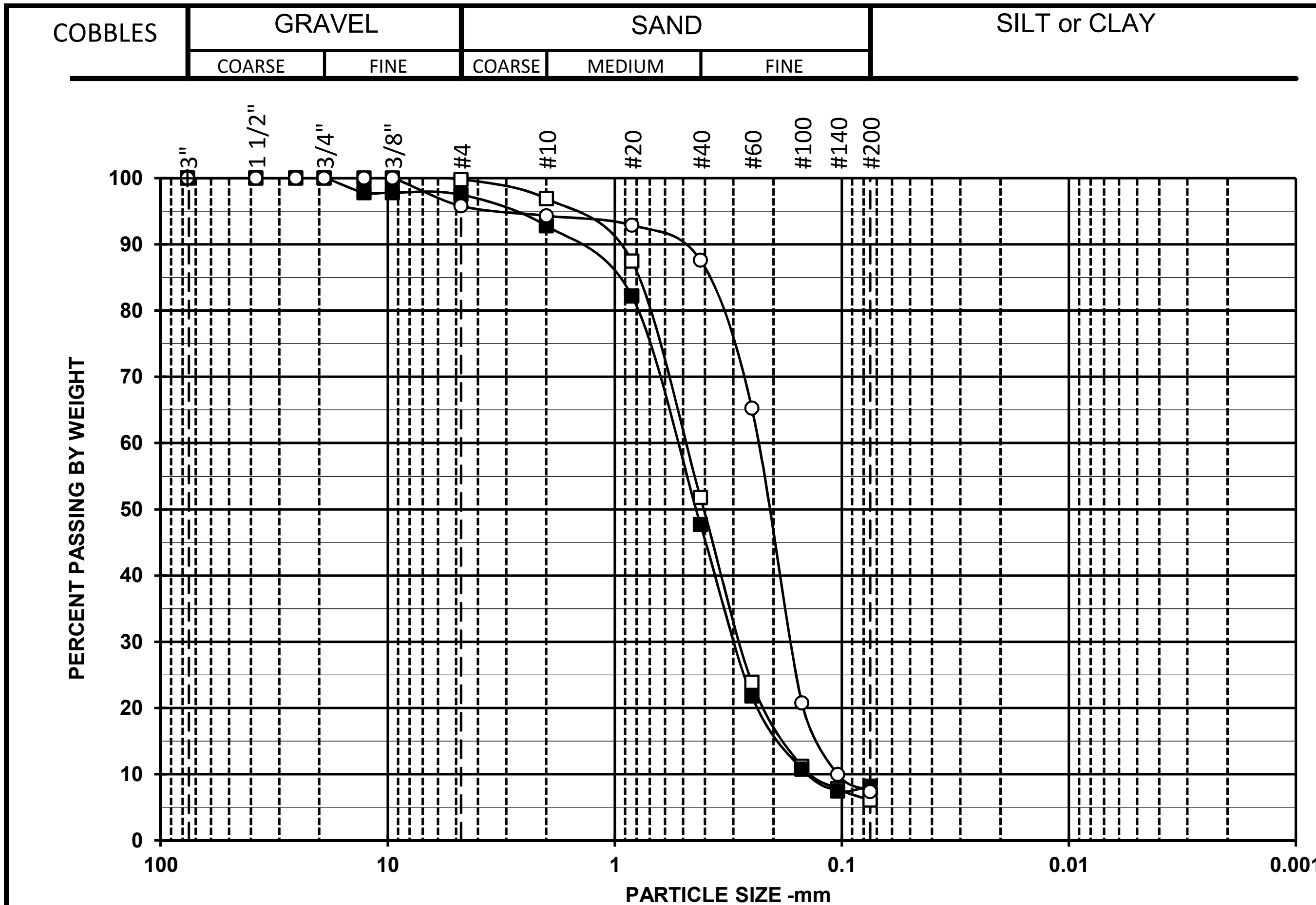

Symbol	□	■	○
Boring	B-11	B-11	B-11
Sample	S-1	S-2	S-3
Depth	0-2	2-4	4-6
% +3"	0.0	0.0	0.0
% Gravel	0.2	2.5	4.2
% SAND	93.7	89.3	88.4
%C SAND	2.9	4.7	1.5
%M SAND	45.1	45.1	6.7
%F SAND	45.7	39.5	80.2
% FINES	6.1	8.2	7.4
D_{100} (mm)	9.530	19.050	9.530
D_{60} (mm)	0.492	0.537	0.234
D_{30} (mm)	0.279	0.294	0.166
D_{10} (mm)	0.132	0.137	0.104
Cc	1.200	1.200	1.100
Cu	3.7	3.9	2.3

Sieve Size/ID #	Percent Finer Data		
6"	100.0	100.0	100.0
4"	100.0	100.0	100.0
3"	100.0	100.0	100.0
1 1/2"	100.0	100.0	100.0
1"	100.0	100.0	100.0
3/4"	100.0	100.0	100.0
1/2"	100.0	97.8	100.0
3/8"	100.0	97.8	100.0
#4	99.8	97.5	95.8
#10	96.9	92.8	94.3
#20	87.5	82.2	92.9
#40	51.8	47.7	87.6
#60	23.9	21.8	65.3
#100	11.2	10.8	20.8
#140	7.8	7.5	10.0
#200	6.1	8.2	7.4
5μ m			
2μ m			
1μ m			

SYMBOL	w (%)	LL	PL	PI	USCS	AASHTO	USCS DESCRIPTION AND REMARKS	DATE
□	7.9				SP-SM		Brown, Poorly graded sand with silt organic mat'l noted	07/10/19
■	3.3				SP-SM		Light brown, Poorly graded sand with silt	07/10/19
○	18.5				SP-SM		Brown, Poorly graded sand with silt	07/10/19

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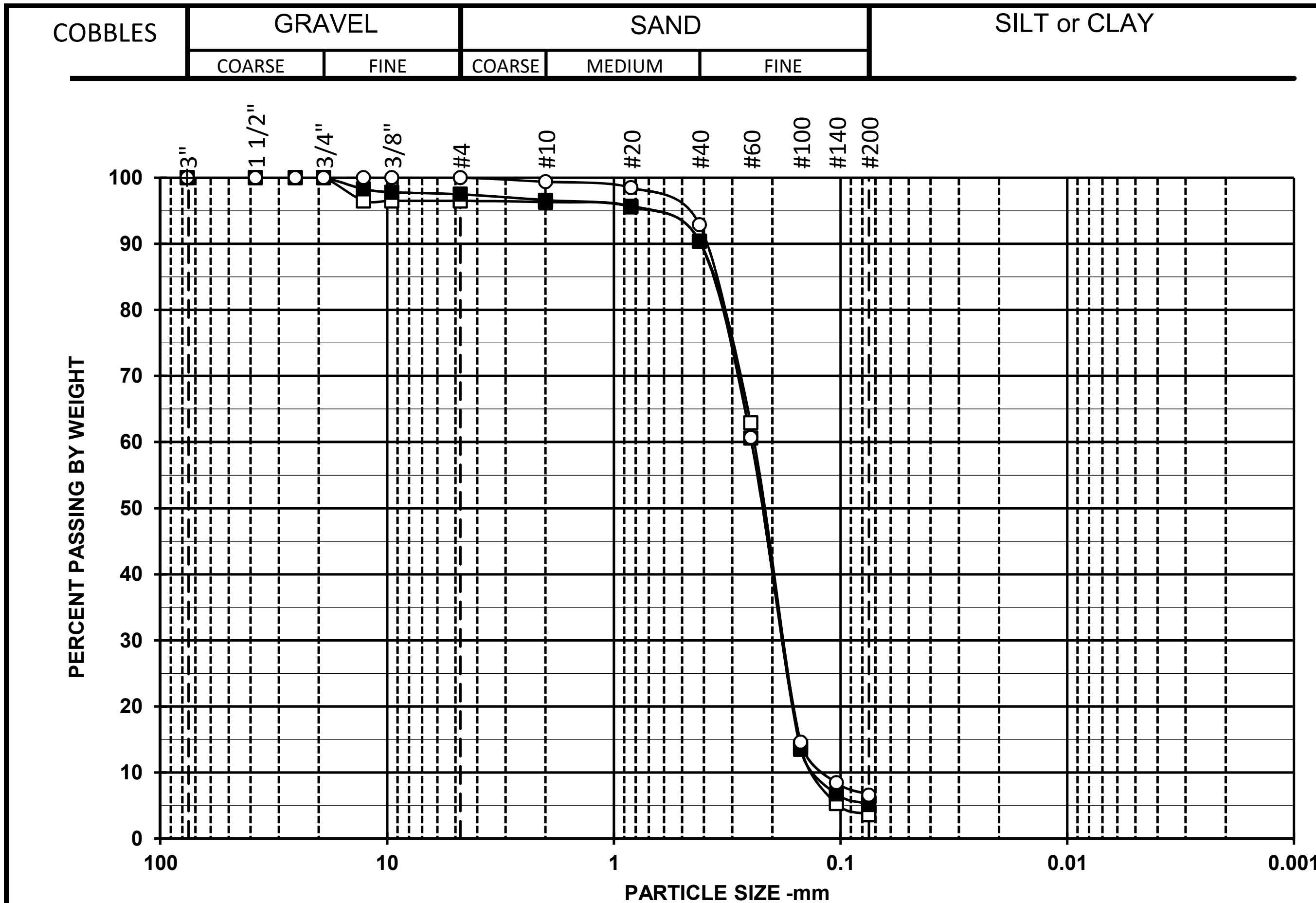

Symbol	□	■	○
Boring	B-11	B-11	B-11
Sample	S-4	S-5	S-6
Depth	6-8	8-10	10-12
% +3"	0.0	0.0	0.0
% Gravel	3.5	2.5	0.0
% SAND	92.9	92.3	93.4
%C SAND	0.2	0.9	0.6
%M SAND	5.9	6.2	6.5
%F SAND	86.8	85.2	86.3
% FINES	3.6	5.2	6.6
D_{100} (mm)	19.050	19.050	4.750
D_{60} (mm)	0.242	0.247	0.247
D_{30} (mm)	0.177	0.179	0.178
D_{10} (mm)	0.127	0.124	0.114
Cc	1.000	1.000	1.100
Cu	1.9	2.0	2.2

Sieve Size/ID #	Percent Finer Data		
6"	100.0	100.0	100.0
4"	100.0	100.0	100.0
3"	100.0	100.0	100.0
1 1/2"	100.0	100.0	100.0
1"	100.0	100.0	100.0
3/4"	100.0	100.0	100.0
1/2"	96.5	98.3	100.0
3/8"	96.5	97.8	100.0
#4	96.5	97.5	100.0
#10	96.3	96.6	99.4
#20	95.7	95.6	98.5
#40	90.4	90.4	92.9
#60	62.9	60.6	60.7
#100	13.9	13.5	14.6
#140	5.3	6.8	8.5
#200	3.6	5.2	6.6
5µ m			
2µ m			
1µ m			

SYMBOL	w (%)	LL	PL	PI	USCS	AASHTO	USCS DESCRIPTION AND REMARKS	DATE
□	21.6				SP		Brown, Poorly graded sand	07/10/19
■	20.1				SP-SM		Brown, Poorly graded sand with silt	07/10/19
○	19.3				SP-SM		Brown, Poorly graded sand with silt	07/10/19

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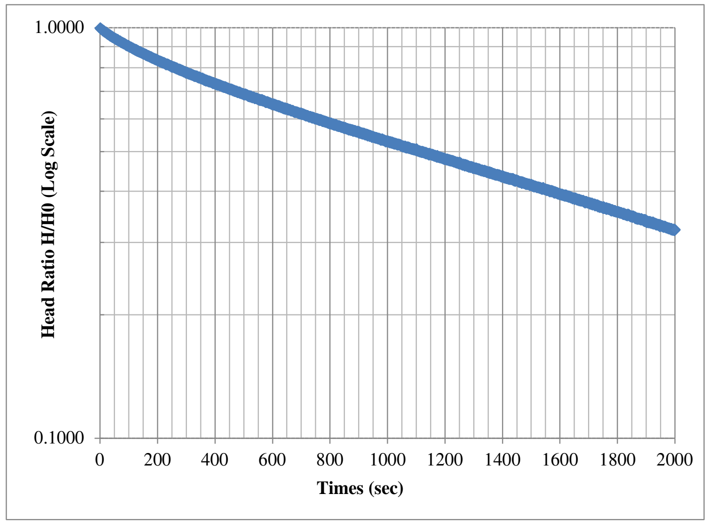
APPENDIX D

FIELD PERMEABILITY TEST DATA

CALCULATED BY: JB CHECKED BY:SG DATE:2/20/2020

B-1 Falling Head Test	Test Interval: 15'~17' bgs		
TIME (sec)	Head (ft)	Depth to Static Water Level (ft)	H/H_0
0.01	16.177	5.177	1.0000
1	16.161	5.161	0.9969
2	16.154	5.154	0.9956
3	16.146	5.146	0.9940
4	16.146	5.146	0.9940
5	16.134	5.134	0.9917
6	16.124	5.124	0.9898
7	16.121	5.121	0.9892
8	16.117	5.117	0.9884
9	16.113	5.113	0.9876
10	16.100	5.100	0.9851
11	16.094	5.094	0.9840
12	16.097	5.097	0.9845
13	16.090	5.090	0.9832
14	16.078	5.078	0.9809
15	16.065	5.065	0.9784
16	16.066	5.066	0.9786
17	16.068	5.068	0.9789
18	16.055	5.055	0.9764
19	16.046	5.046	0.9747
20	16.056	5.056	0.9766
21	16.034	5.034	0.9724
22	16.037	5.037	0.9730
23	16.028	5.028	0.9712
24	16.017	5.017	0.9691
25	16.011	5.011	0.9679
26	16.005	5.005	0.9668
27	16.006	5.006	0.9670
28	15.996	4.996	0.9650
29	15.999	4.999	0.9656
30	15.987	4.987	0.9633
31	15.982	4.982	0.9623
32	15.979	4.979	0.9618
33	15.971	4.971	0.9602
34	15.957	4.957	0.9575
35	15.970	4.970	0.9600
36	15.950	4.950	0.9562
37	15.947	4.947	0.9556
38	15.940	4.940	0.9542
39	15.942	4.942	0.9546
40	15.932	4.932	0.9527
41	15.937	4.937	0.9536
42	15.927	4.927	0.9517
43	15.914	4.914	0.9492
44	15.924	4.924	0.9511
45	15.911	4.911	0.9486
46	15.907	4.907	0.9478
47	15.904	4.904	0.9473
48	15.893	4.893	0.9451
49	15.888	4.888	0.9442
50	15.876	4.876	0.9419
51.017	15.881	4.881	0.9428
52	15.875	4.875	0.9417
53	15.874	4.874	0.9415
54	15.862	4.862	0.9392
55	15.869	4.869	0.9405
56	15.857	4.857	0.9382
57	15.853	4.853	0.9374
58	15.844	4.844	0.9357
59	15.845	4.845	0.9359
60	15.843	4.843	0.9355
61	15.846	4.846	0.9361
62	15.835	4.835	0.9339
63	15.827	4.827	0.9324
64	15.823	4.823	0.9316
65	15.813	4.813	0.9297
66	15.812	4.812	0.9295



Casing Radius	0.16666667	ft(2")
L	2	ft (10'~12')
H_0	16.177	
R	0.16666667	ft (2")
L/R	12	

Kave	Time (sec)	Head(ft)	
	50	4.876	1.131E+00 ft/day
	300.00	4.034	1.570E-04 inch/sec

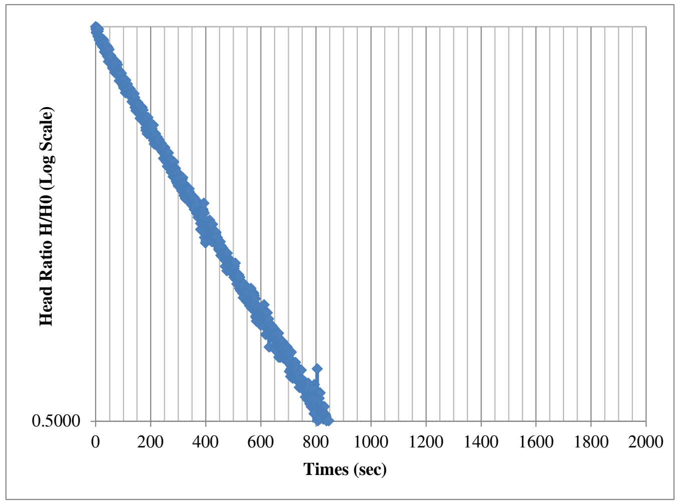
EQUATION (DM7 7.1-105 Table 15)-Variable Head Test

Condition C:

$$k = \frac{R^2}{2L(t_2 - t_1)} \ln(\frac{L}{R}) \ln(\frac{H_1}{H_2})$$

where: k=hydraulic conductivity, ft/min
R=radius of the casing, ft
L=length of test interval,ft
t: time interval between two water head readings,min
H=differential head of water at test, ft
1 For test above water table, H is the distance between the bottom of the test interval and the varying water level during the test;
2 For test beblow water table, H is the distance between the static water table and the varying water level during the test.

B-2 Falling Head Test	Test Interval: 45'~47' bgs		
TIME (sec)	Head (ft)	Depth to Static Water Level (ft)	H/H_0
0	24.795	0.795	1.0000
1	24.792	0.792	0.9962
2	24.787	0.787	0.9899
3	24.790	0.790	0.9937
4	24.786	0.786	0.9887
5	24.788	0.788	0.9912
6	24.794	0.794	0.9987
7	24.789	0.789	0.9925
8	24.782	0.782	0.9836
9	24.789	0.789	0.9925
10	24.792	0.792	0.9962
11	24.782	0.782	0.9836
12	24.781	0.781	0.9824
13	24.777	0.777	0.9774
14	24.779	0.779	0.9799
15	24.781	0.781	0.9824
16	24.779	0.779	0.9799
17	24.772	0.772	0.9711
18	24.775	0.775	0.9748
19	24.779	0.779	0.9799
20	24.776	0.776	0.9761
21	24.772	0.772	0.9711
22	24.773	0.773	0.9723
23	24.772	0.772	0.9711
24.011	24.776	0.776	0.9761
25	24.768	0.768	0.9660
26	24.771	0.771	0.9698
27	24.778	0.778	0.9786
28	24.768	0.768	0.9660
29.025	24.776	0.776	0.9761
30	24.773	0.773	0.9723
31	24.766	0.766	0.9635
32	24.761	0.761	0.9572
33	24.760	0.760	0.9560
34.032	24.765	0.765	0.9623
35	24.760	0.760	0.9560
36	24.764	0.764	0.9610
37	24.759	0.759	0.9547
38	24.765	0.765	0.9623
39.047	24.769	0.769	0.9673
40	24.761	0.761	0.9572
41	24.758	0.758	0.9535
42	24.76	0.760	0.9560
43	24.755	0.755	0.9497
44.049	24.767	0.767	0.9648
45	24.757	0.757	0.9522
46	24.748	0.748	0.9409
47	24.753	0.753	0.9472
48	24.754	0.754	0.9484
49.042	24.764	0.764	0.9610
50	24.752	0.752	0.9459
51	24.75	0.750	0.9434
52	24.749	0.749	0.9421
53	24.751	0.751	0.9447
54.049	24.756	0.756	0.9509
55	24.752	0.752	0.9459
56	24.752	0.752	0.9459
57	24.75	0.750	0.9434
58	24.749	0.749	0.9421
59.049	24.753	0.753	0.9472
60	24.747	0.747	0.9396
61	24.74	0.740	0.9308
62	24.743	0.743	0.9346
63	24.739	0.739	0.9296
64.045	24.747	0.747	0.9396
65	24.747	0.747	0.9396
66	24.745	0.745	0.9371



Casing Radius	0.166666667	ft(2")
L	2	ft (10'~12')
H_0	24.795	
R	0.166666667	ft (2")
L/R	12	

Kave	Time (sec)	Head(ft)	
	50	0.752	1.421E+00 ft/day
	100.00	0.717	5.408E-07 inch/sec

EQUATION (DM7 7.1-105 Table 15)-Variable Head Test

Condition C:

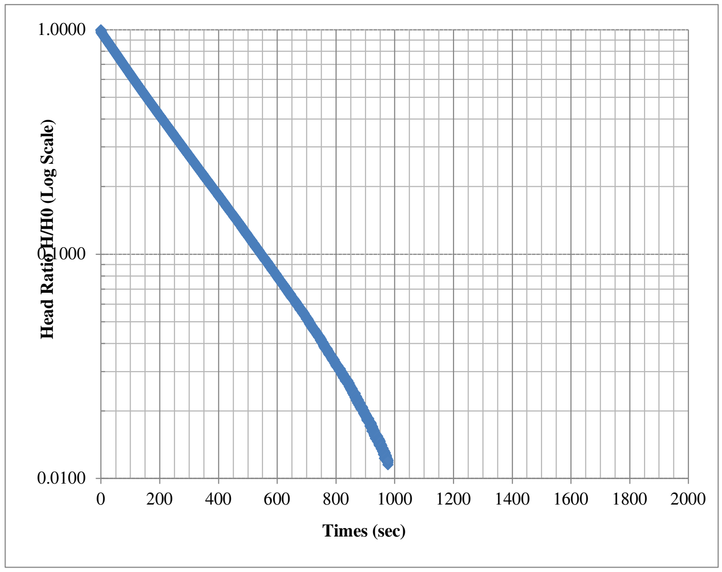
$$k = \frac{R^2}{2L(t_2 - t_1)} \ln(\frac{L}{R}) \ln(\frac{H_1}{H_2})$$

where: k=hydraulic conductivity, ft/min
R=radius of the casing, ft
L=length of test interval,ft
t: time interval between two water head readings,min
H=differential head of water at test, ft

1 For test above water table, H is the distance between the bottom of the test interval and the varying water level during the test;

2 For test beblow water table, H is the distance between the static water table and the varying water level during the test.

B-4 Falling Head Test	Test Interval: 15'~17' bgs		
TIME (sec)	Head (ft)	Depth to Static Water Level (ft)	H/H_0
0	17.126	14.126	1.0000
0.25	17.06	14.060	0.9953
0.5	17.01	14.010	0.9918
0.75	16.942	13.942	0.9870
1	16.692	13.692	0.9693
1.25	16.784	13.784	0.9758
1.5	16.816	13.816	0.9781
1.75	16.788	13.788	0.9761
2.248	16.701	13.701	0.9699
2.371	16.675	13.675	0.9681
2.5	16.67	13.670	0.9677
2.75	16.646	13.646	0.9660
3	16.631	13.631	0.9650
3.25	16.62	13.620	0.9642
3.5	16.599	13.599	0.9627
3.75	16.586	13.586	0.9618
4	16.574	13.574	0.9609
4.25	16.56	13.560	0.9599
4.5	16.54	13.540	0.9585
4.75	16.522	13.522	0.9572
5	16.515	13.515	0.9567
5.25	16.502	13.502	0.9558
5.5	16.483	13.483	0.9545
5.75	16.476	13.476	0.9540
6	16.451	13.451	0.9522
6.25	16.442	13.442	0.9516
6.5	16.424	13.424	0.9503
6.75	16.415	13.415	0.9497
7.264	16.386	13.386	0.9476
7.387	16.378	13.378	0.9470
7.51	16.374	13.374	0.9468
7.75	16.353	13.353	0.9453
8	16.335	13.335	0.9440
8.25	16.328	13.328	0.9435
8.5	16.307	13.307	0.9420
8.75	16.299	13.299	0.9415
9	16.282	13.282	0.9403
9.25	16.263	13.263	0.9389
9.5	16.254	13.254	0.9383
9.75	16.233	13.233	0.9368
10	16.221	13.221	0.9359
10.25	16.213	13.213	0.9354
10.5	16.196	13.196	0.9342
10.75	16.183	13.183	0.9332
11	16.171	13.171	0.9324
11.25	16.153	13.153	0.9311
11.5	16.135	13.135	0.9298
11.75	16.125	13.125	0.9291
12.281	16.094	13.094	0.9269
12.404	16.088	13.088	0.9265
12.527	16.078	13.078	0.9258
12.75	16.06	13.060	0.9245
13	16.056	13.056	0.9243
13.25	16.034	13.034	0.9227
13.5	16.023	13.023	0.9219
13.75	16.007	13.007	0.9208
14	15.999	12.999	0.9202
14.25	15.982	12.982	0.9190
14.5	15.971	12.971	0.9182
14.75	15.955	12.955	0.9171
15	15.933	12.933	0.9155
15.25	15.926	12.926	0.9151
15.5	15.908	12.908	0.9138
15.75	15.906	12.906	0.9136
16	15.884	12.884	0.9121
16.25	15.874	12.874	0.9114
16.5	15.856	12.856	0.9101



Casing Radius	0.166666667	ft(2")
L	2	ft (10'~12')
H_0	17.126	
R	0.166666667	ft (2")
L/R	12	

	Time (sec)	Head(ft)	
Kave	30	12.131	6.374E+00 ft/day
	200.00	5.865	2.425E-06 inch/sec

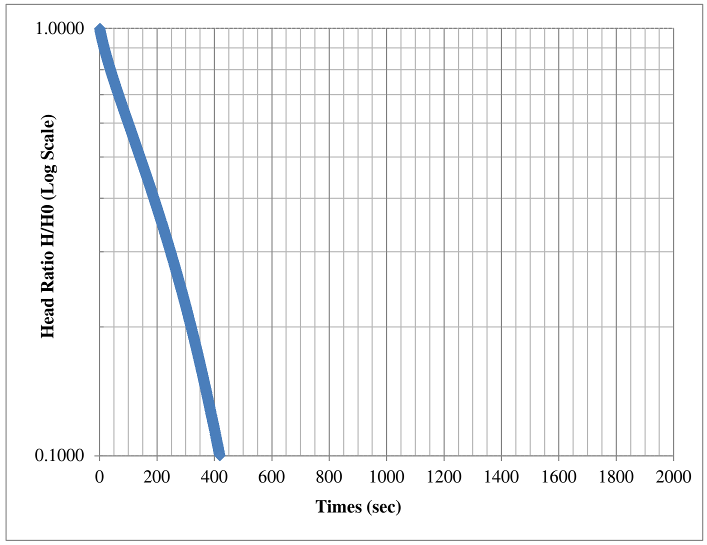
EQUATION (DM7 7.1-105 Table 15)-Variable Head Test

Condition C:

$$k = \frac{R^2}{2L(t_2 - t_1)} \ln(\frac{L}{R}) \ln(\frac{H_1}{H_2})$$

where: k=hydraulic conductivity, ft/min
R=radius of the casing, ft
L=length of test interval,ft
t: time interval between two water head readings,min
H=differential head of water at test, ft
1 For test above water table, H is the distance between the bottom of the test interval and the varying water level during the test;
2 For test beblow water table, H is the distance between the static water table and the varying water level during the test.

B-4 Falling Head Test	Test Interval: 30'~32' bgs		
TIME (sec)	Head (ft)	Depth to Static Water Level (ft)	H/H_0
0	25.245	16.245	1.0000
0.25	25.215	16.215	0.9982
0.5	25.217	16.217	0.9983
0.75	25.223	16.223	0.9986
1	25.104	16.104	0.9913
1.25	25.038	16.038	0.9873
1.5	25.002	16.002	0.9850
1.75	24.969	15.969	0.9830
2	24.947	15.947	0.9817
2.25	24.926	15.926	0.9804
2.5	24.892	15.892	0.9783
2.944	24.841	15.841	0.9751
3.067	24.823	15.823	0.9740
3.25	24.796	15.796	0.9724
3.5	24.77	15.770	0.9708
3.75	24.742	15.742	0.9690
4	24.705	15.705	0.9668
4.25	24.684	15.684	0.9655
4.5	24.651	15.651	0.9634
4.75	24.624	15.624	0.9618
5	24.605	15.605	0.9606
5.25	24.576	15.576	0.9588
5.5	24.539	15.539	0.9565
5.75	24.52	15.520	0.9554
6	24.492	15.492	0.9536
6.25	24.472	15.472	0.9524
6.5	24.439	15.439	0.9504
6.75	24.416	15.416	0.9490
7	24.392	15.392	0.9475
7.25	24.366	15.366	0.9459
7.5	24.338	15.338	0.9442
7.935	24.299	15.299	0.9418
8.059	24.284	15.284	0.9408
8.25	24.261	15.261	0.9394
8.5	24.24	15.240	0.9381
8.75	24.22	15.220	0.9369
9	24.187	15.187	0.9349
9.25	24.168	15.168	0.9337
9.5	24.138	15.138	0.9319
9.75	24.121	15.121	0.9308
10	24.092	15.092	0.9290
10.25	24.067	15.067	0.9275
10.5	24.045	15.045	0.9261
10.75	24.021	15.021	0.9247
11	24	15.000	0.9234
11.25	23.973	14.973	0.9217
11.5	23.948	14.948	0.9202
11.75	23.933	14.933	0.9192
12	23.9	14.900	0.9172
12.25	23.89	14.890	0.9166
12.5	23.863	14.863	0.9149
12.936	23.823	14.823	0.9125
13.06	23.817	14.817	0.9121
13.25	23.795	14.795	0.9107
13.5	23.779	14.779	0.9098
13.75	23.753	14.753	0.9082
14	23.731	14.731	0.9068
14.25	23.709	14.709	0.9054
14.5	23.691	14.691	0.9043
14.75	23.665	14.665	0.9027
15	23.646	14.646	0.9016
15.25	23.624	14.624	0.9002
15.5	23.583	14.583	0.8977
15.75	23.59	14.590	0.8981
16	23.554	14.554	0.8959
16.25	23.537	14.537	0.8949
16.5	23.518	14.518	0.8937



Casing Radius	0.166666667 ft(2")
L	2 ft (10'~12')
H_0	25.245
R	0.166666667 ft (2")
L/R	12

	Time (sec)	Head(ft)	
Kave	30	13.488	6.838E+00 ft/day
	155.00	7.603	2.602E-06 inch/sec

EQUATION (DM7 7.1-105 Table 15)-Variable Head Test

Condition C:

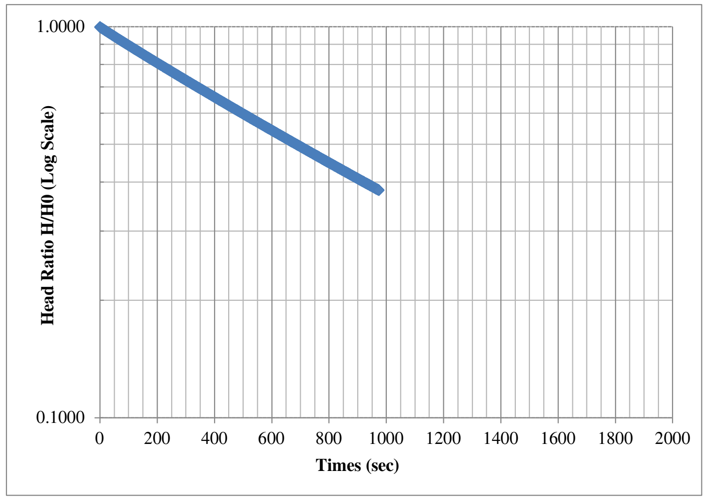
$$k = \frac{R^2}{2L(t_2 - t_1)} \ln(\frac{L}{R}) \ln(\frac{H_1}{H_2})$$

where: k=hydraulic conductivity, ft/min
R=radius of the casing, ft
L=length of test interval,ft
t: time interval between two water head readings,min
H=differential head of water at test, ft

1 For test above water table, H is the distance between the bottom of the test interval and the varying water level during the test;

2 For test beblow water table, H is the distance between the static water table and the varying water level during the test.

B-5 Falling Head Test	Test Interval: 25'~27' bgs		
TIME (sec)	Head (ft)	Depth to Static Water Level (ft)	H/H_0
0	25.913	12.913	1.0000
0.25	25.861	12.861	0.9960
0.5	25.869	12.869	0.9966
0.75	25.87	12.870	0.9967
1	25.865	12.865	0.9963
1.435	25.864	12.864	0.9962
1.558	25.864	12.864	0.9962
1.75	25.862	12.862	0.9961
2	25.853	12.853	0.9954
2.25	25.858	12.858	0.9957
2.5	25.848	12.848	0.9950
2.75	25.839	12.839	0.9943
3	25.841	12.841	0.9944
3.25	25.836	12.836	0.9940
3.5	25.832	12.832	0.9937
3.75	25.829	12.829	0.9935
4	25.825	12.825	0.9932
4.25	25.83	12.830	0.9936
4.5	25.814	12.814	0.9923
4.75	25.815	12.815	0.9924
5	25.814	12.814	0.9923
5.25	25.817	12.817	0.9926
5.5	25.802	12.802	0.9914
5.75	25.798	12.798	0.9911
6	25.802	12.802	0.9914
6.435	25.795	12.795	0.9909
6.558	25.793	12.793	0.9907
6.75	25.78	12.780	0.9897
7	25.783	12.783	0.9899
7.25	25.783	12.783	0.9899
7.5	25.778	12.778	0.9895
7.75	25.775	12.775	0.9893
8	25.776	12.776	0.9894
8.25	25.764	12.764	0.9885
8.5	25.766	12.766	0.9886
8.75	25.761	12.761	0.9882
9	25.753	12.753	0.9876
9.25	25.759	12.759	0.9881
9.5	25.755	12.755	0.9878
9.75	25.741	12.741	0.9867
10	25.742	12.742	0.9868
10.25	25.74	12.740	0.9866
10.5	25.739	12.739	0.9865
10.75	25.729	12.729	0.9858
11	25.734	12.734	0.9861
11.435	25.728	12.728	0.9857
11.558	25.723	12.723	0.9853
11.75	25.723	12.723	0.9853
12	25.72	12.720	0.9851
12.25	25.716	12.716	0.9847
12.5	25.709	12.709	0.9842
12.75	25.71	12.710	0.9843
13	25.702	12.702	0.9837
13.25	25.701	12.701	0.9836
13.5	25.701	12.701	0.9836
13.75	25.694	12.694	0.9830
14	25.693	12.693	0.9830
14.25	25.687	12.687	0.9825
14.5	25.685	12.685	0.9823
14.75	25.674	12.674	0.9815
15	25.678	12.678	0.9818
15.25	25.67	12.670	0.9812
15.5	25.67	12.670	0.9812
15.75	25.665	12.665	0.9808
16	25.664	12.664	0.9807
16.437	25.656	12.656	0.9801
16.56	25.65	12.650	0.9796
16.75	25.645	12.645	0.9792
17	25.648	12.648	0.9795
17.25	25.648	12.648	0.9795



Casing Radius	0.166666667	ft(2")
L	2	ft (10'~12')
H_0	25.913	
R	0.166666667	ft (2")
L/R	12	

Kave	Time (sec)	Head(ft)	
	30	12.468	1.558E+00 ft/day
	200.00	10.439	5.927E-07 inch/sec

EQUATION (DM7 7.1-105 Table 15)-Variable Head Test

Condition C:

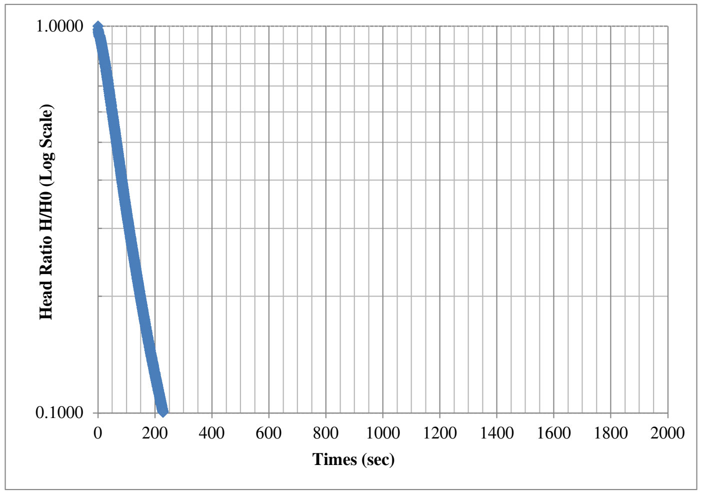
$$k = \frac{R^2}{2L(t_2 - t_1)} \ln(\frac{L}{R}) \ln(\frac{H_1}{H_2})$$

where:
k=hydraulic conductivity, ft/min
R=radius of the casing, ft
L=length of test interval,ft
t: time interval between two water head readings,min
H=differential head of water at test, ft

1 For test above water table, H is the distance between the bottom of the test interval and the varying water level during the test;

2 For test beblow water table, H is the distance between the static water table and the varying water level during the test.

B-8 Falling Head Test	Test Interval: 25'~27' bgs		
TIME (sec)	Head (ft)	Depth to Static Water Level (ft)	H/H_0
0	21.292	8.292	1.0000
0.25	21.129	8.129	0.9803
0.5	21.079	8.079	0.9743
0.75	21.004	8.004	0.9653
1	21.001	8.001	0.9649
1.25	21.005	8.005	0.9654
1.5	21.009	8.009	0.9659
1.75	20.983	7.983	0.9627
2	20.939	7.939	0.9574
2.25	20.929	7.929	0.9562
2.5	20.894	7.894	0.9520
2.75	20.856	7.856	0.9474
3	20.823	7.823	0.9434
3.25	20.822	7.822	0.9433
3.5	20.829	7.829	0.9442
3.75	20.788	7.788	0.9392
4	20.842	7.842	0.9457
4.25	20.855	7.855	0.9473
4.5	20.831	7.831	0.9444
4.75	20.847	7.847	0.9463
5	20.831	7.831	0.9444
5.25	20.849	7.849	0.9466
5.773	20.814	7.814	0.9424
5.895	20.812	7.812	0.9421
6.018	20.811	7.811	0.9420
6.25	20.793	7.793	0.9398
6.5	20.779	7.779	0.9381
6.75	20.761	7.761	0.9360
7	20.745	7.745	0.9340
7.25	20.735	7.735	0.9328
7.5	20.729	7.729	0.9321
7.75	20.708	7.708	0.9296
8	20.686	7.686	0.9269
8.25	20.675	7.675	0.9256
8.5	20.645	7.645	0.9220
8.75	20.62	7.620	0.9190
9	20.622	7.622	0.9192
9.25	20.596	7.596	0.9161
9.5	20.592	7.592	0.9156
9.75	20.578	7.578	0.9139
10	20.561	7.561	0.9118
10.25	20.538	7.538	0.9091
10.5	20.532	7.532	0.9083
10.75	20.505	7.505	0.9051
11	20.498	7.498	0.9042
11.25	20.473	7.473	0.9012
11.5	20.469	7.469	0.9007
11.75	20.429	7.429	0.8959
12	20.439	7.439	0.8971
12.25	20.41	7.410	0.8936
12.5	20.39	7.390	0.8912
12.75	20.371	7.371	0.8889
13.185	20.371	7.371	0.8889
13.313	20.357	7.357	0.8872
13.5	20.325	7.325	0.8834
13.75	20.305	7.305	0.8810
14	20.312	7.312	0.8818
14.25	20.283	7.283	0.8783
14.5	20.259	7.259	0.8754
14.75	20.246	7.246	0.8739
15	20.214	7.214	0.8700
15.25	20.222	7.222	0.8710
15.5	20.194	7.194	0.8676
15.75	20.183	7.183	0.8663
16	20.146	7.146	0.8618
16.25	20.16	7.160	0.8635
16.5	20.153	7.153	0.8626
16.75	20.104	7.104	0.8567
17	20.096	7.096	0.8558
17.25	20.077	7.077	0.8535
17.812	20.039	7.039	0.8489
17.934	20.032	7.032	0.8480



Casing Radius	0.166666667 ft(2")		
L	2 ft (10'~12')		
H_0	21.292		
R	0.166666667 ft (2")		
L/R	12		
Kave	Time (sec)	Head(ft)	
	30	6.255	1.765E+01 ft/day
	100.00	2.731	6.716E-06 inch/sec

EQUATION (DM7 7.1-105 Table 15)-Variable Head Test

Condition C:

$$k = \frac{R^2}{2L(t_2 - t_1)} \ln\left(\frac{L}{R}\right) \ln\left(\frac{H_1}{H_2}\right)$$

where:
k=hydraulic conductivity, ft/min
R=radius of the casing, ft
L=length of test interval,ft
t: time interval between two water head readings,min
H=differential head of water at test, ft

1 For test above water table, H is the distance between the bottom of the test interval and the varying water level during the test;

2 For test beblow water table, H is the distance between the static water table and the varying water level during the test.

Oweis ENGINEERING INC.

PT- 11 @ B-11

Sheet 1 of 3

Prepared for: AECOM	PROJECT: South Battery Park Resiliency LOCATION / BOROUGH : Manhattan NY
INSPECTOR: JINFU XIAO DRILLER: MIKE TARTER CONTRACTOR CRAIG GEOTECHNICAL DRILLING HELPER: JIMMY P.E./REP.: JIM MALAK	Start Date: 5/21/2019 Start Time: 9:26AM Weather: Sunny
Depth of PT: 4ft Rig Type: CME55 Drill Bit Type: Tricone Casing Internal Diameter: 4 in Casing Length: 72 in (24 in stickup)	Weight of Hammer for casing: 140 lbs Type of Hammer: Manual Safety Hammer

ASTM D-6391 – 11
PERMEABILITY COEFFICIENT (Km)
FORMULA:

General Formula:

$$K_m = \pi R_t \times \frac{\left[D\left\{\ln\left(\frac{h_1}{h_2}\right)\right\}\right]}{11\times(t_2 - t_1)}$$

Formula for 4" internal diameter casing (in/hr):

$$K_m = 1.142 R_t \times \frac{\left[\ln\left(\frac{h_1}{h_2}\right)\right]}{(t_2 - t_1)}$$

where: $$R_t = \frac{2.2902\left(0.9842^T\right)}{T^{0.1702}}$$

PT- 11 @ 4 ft

TEST 1

Water temperature (°C), T: 15.5   Rt= 1.122

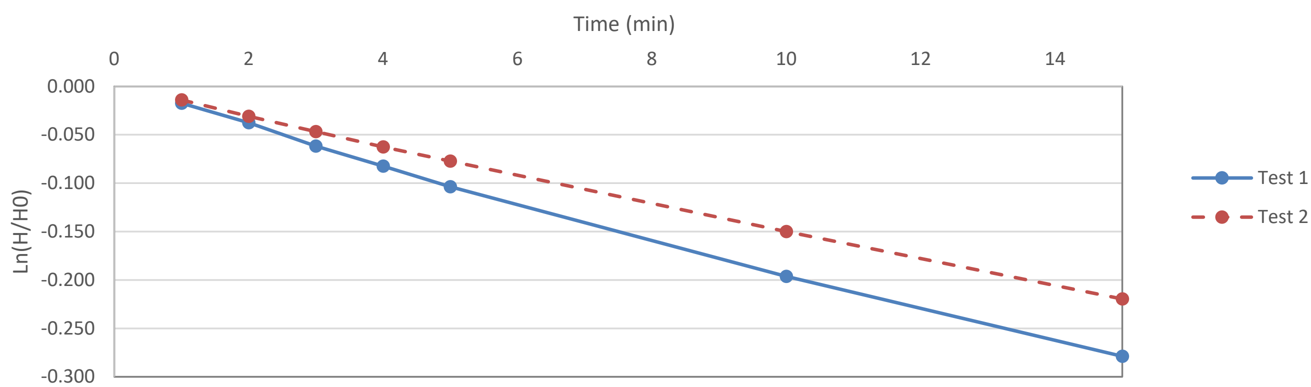
FIELD DATA		CALCULATED DATA				
Time (min)	Depth (in)	Height (in)	Ln(H/H0)	Ln (h1/h2)	(t2-t1)	*Km (in/hr)
1	1.236	70.764	-0.017	0.017	0.017	1.331
2	2.652	69.348	-0.038	0.020	0.017	1.554
3	4.296	67.704	-0.062	0.024	0.017	1.845
4	5.688	66.312	-0.082	0.021	0.017	1.597
5	7.080	64.920	-0.104	0.021	0.017	1.631
10	12.828	59.172	-0.196	0.093	0.083	1.426
15	17.520	54.480	-0.279	0.083	0.083	1.271

TEST 2

Water temperature (°C), T: 15.5   Rt= 1.122

FIELD DATA		CALCULATED DATA				
Time (min)	Depth (in)	Height (in)	Ln(H/H0)	Ln (h1/h2)	(t2-t1)	*Km (in/hr)
1	0.996	71.004	-0.014	0.014	0.017	1.071
2	2.184	69.816	-0.031	0.017	0.017	1.297
3	3.288	68.712	-0.047	0.016	0.017	1.226
4	4.356	67.644	-0.062	0.016	0.017	1.205
5	5.340	66.660	-0.077	0.015	0.017	1.127
10	10.020	61.980	-0.150	0.073	0.083	1.119
15	14.196	57.804	-0.220	0.070	0.083	1.073

PT-11 @ 4 ft



TEST 1 FINAL RESULTS

Time Weighted Average Permeability Coefficient **Km=** 1.522 in/hr

TEST 2 FINAL RESULTS

Time Weighted Average Permeability Coefficient **Km=** 1.160 in/hr

AVERAGE PT- 11 @ 4 ft

Time Weighted Average Permeability Coefficient Km = 1.341 in/hr

DEFINITION OF VARIABLES

*Km= Mean permeability
T = Temperature of permeant (water), in °C
Ln = Natural Logarithmic
t1 = Time at the start of the test in the same units selected for Km
t2= Time at the end of the test in the units selected for Km
h1= Height of the water above the bottom of the casing at the start of the test in the same units selected for Km
h2= Height of the water above the bottom of the casing at the end of the test in the same units selected for Km

May 2019

Oweis ENGINEERING INC.

Prepared for: NYC DDC	PROJECT: South Battery Park Resiliency
	LOCATION / BOROUGH : Manhattan NY
INSPECTOR: JINFU XIAO	DRILLER: MIKE TARTER
CONTRACTOR CRAIG GEOTECHNICAL DRILLING	HELPER: JIMMY
P.E./REP.: JIM MALAK	
Start Date: 5/21/2019	Weather: Sunny
Start Time: 10:21AM	
Depth of PT: 6ft	Drill Bit Type: Tricone
Rig Type: CME55	Casing Internal Diameter: 4 in
	Casing Length: 96 in (24 in stickup)
Weight of Hammer for casing: 140 lbs	Type of Hammer: Manual Safety Hammer

ASTM D-6391 – 11
PERMEABILITY COEFFICIENT (Km)
FORMULA:

General Formula:

$$K_m = \pi R_t \times \frac{\left[D\left\{\ln\left(\frac{h_1}{h_2}\right)\right\}\right]}{11\times(t_2 - t_1)}$$

Formula for 4" internal diameter casing (in/hr):

$$K_m = 1.142 R_t \times \frac{\left[\ln\left(\frac{h_1}{h_2}\right)\right]}{(t_2 - t_1)}$$

where: $R_t = 2.2902\left(0.9842^T\right) / T^{0.1702}$

PT- 11 @ 6 ft

TEST 1

Water temperature (°C), T: 18.3 Rt= 1.043

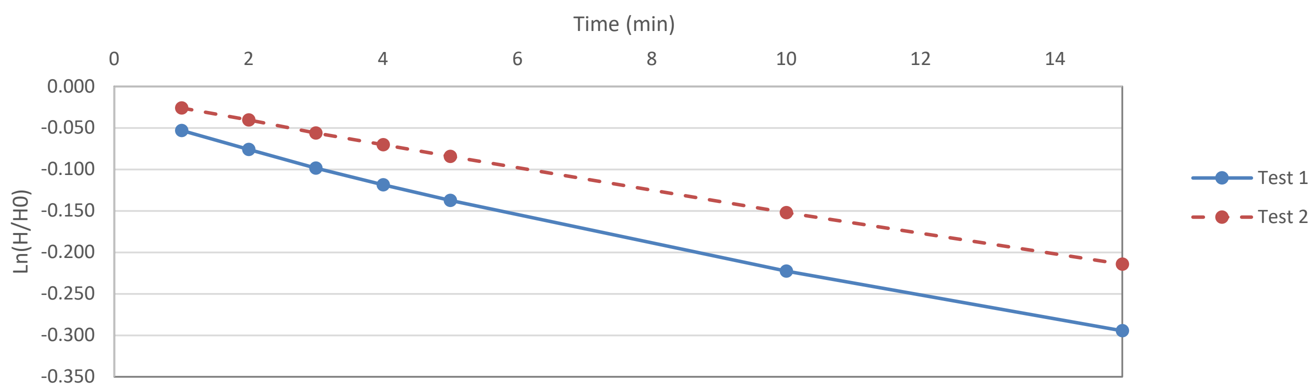
FIELD DATA		CALCULATED DATA				
Time (min)	Depth (in)	Height (in)	Ln(H/H0)	Ln (h1/h2)	(t2-t1)	*Km (in/hr)
1	4.956	91.044	-0.053	0.053	0.017	3.789
2	7.008	88.992	-0.076	0.023	0.017	1.630
3	9.012	86.988	-0.099	0.023	0.017	1.628
4	10.728	85.272	-0.119	0.020	0.017	1.424
5	12.312	83.688	-0.137	0.019	0.017	1.340
10	19.164	76.836	-0.223	0.085	0.083	1.221
15	24.492	71.508	-0.295	0.072	0.083	1.028

TEST 2

Water temperature (°C), T: 18.3 Rt= 1.043

FIELD DATA		CALCULATED DATA				
Time (min)	Depth (in)	Height (in)	Ln(H/H0)	Ln (h1/h2)	(t2-t1)	*Km (in/hr)
1	2.460	93.540	-0.026	0.026	0.017	1.856
2	3.792	92.208	-0.040	0.014	0.017	1.025
3	5.256	90.744	-0.056	0.016	0.017	1.144
4	6.504	89.496	-0.070	0.014	0.017	0.990
5	7.752	88.248	-0.084	0.014	0.017	1.004
10	13.536	82.464	-0.152	0.068	0.083	0.969
15	18.516	77.484	-0.214	0.062	0.083	0.891

PT-11 @ 6 ft



TEST 1 FINAL RESULTS

Time Weighted Average Permeability Coefficient **Km=** 1.723 in/hr

TEST 2 FINAL RESULTS

Time Weighted Average Permeability Coefficient **Km=** 1.126 in/hr

AVERAGE PT- 11 @ 6 ft

Time Weighted Average Permeability Coefficient Km = 1.424 in/hr

DEFINITION OF VARIABLES

*Km= Mean permeability
T = Temperature of permeant (water), in °C
Ln = Natural Logarithmic
t1 = Time at the start of the test in the same units selected for Km
t2= Time at the end of the test in the units selected for Km
h1= Height of the water above the bottom of the casing at the start of the test in the same units selected for Km
h2= Height of the water above the bottom of the casing at the end of the test in the same units selected for Km

PT- 11 @ B-11

Sheet 3 of 3

Oweis ENGINEERING INC.

Prepared for: NYC DDC	PROJECT: South Battery Park Resiliency LOCATION / BOROUGH : Manhattan NY
INSPECTOR: JINFU XIAO CONTRACTOR CRAIG GEOTECHNICAL DRILLING P.E./REP.: JIM MALAK DRILLER: MIKE TARTER HELPER: JIMMY	Start Date: 5/21/2019 Start Time: 11:16AM Weather: Sunny
Depth of PT: 10ft Rig Type: CME55 Drill Bit Type: Tricone Casing Internal Diameter: 4 in Casing Length: 144 in (24 in stickup)	Weight of Hammer for casing: 140 lbs Type of Hammer: Manual Safety Hammer

ASTM D-6391 – 11
PERMEABILITY COEFFICIENT (Km)
FORMULA:

General Formula:

$$K_m = \pi R_t \times \frac{\left[D\left\{\ln\left(\frac{h_1}{h_2}\right)\right\}\right]}{11\times(t_2 - t_1)}$$

Formula for 4" internal diameter casing (in/hr):

$$K_m = 1.142 R_t \times \frac{\left[\ln\left(\frac{h_1}{h_2}\right)\right]}{(t_2 - t_1)}$$

where: $R_t = 2.2902\left(0.9842^T\right) / T^{0.1702}$

PT- 11 @ 10 ft

TEST 1

Water temperature (°C), T: 22.8 Rt= 0.936

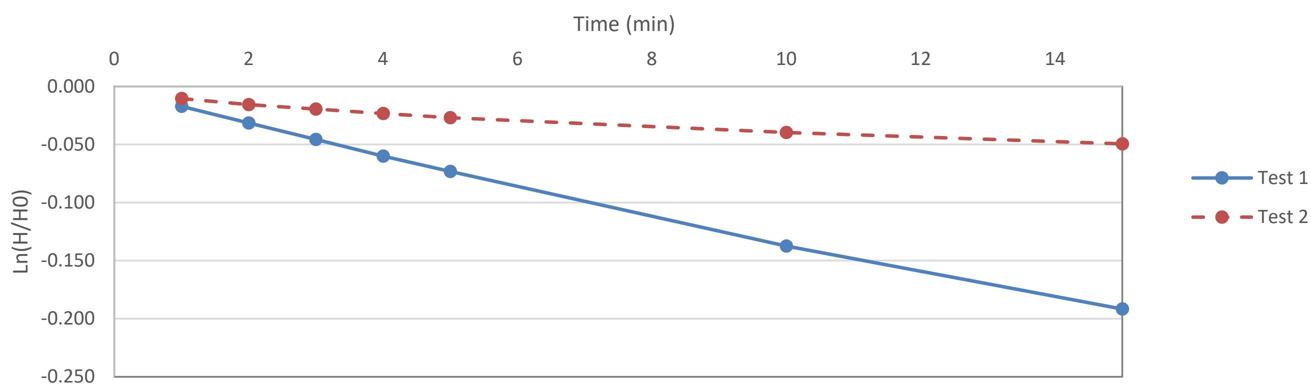
FIELD DATA		CALCULATED DATA				
Time (min)	Depth (in)	Height (in)	Ln(H/H0)	Ln (h1/h2)	(t2-t1)	*Km (in/hr)
1	2.448	141.552	-0.017	0.017	0.017	1.099
2	4.476	139.524	-0.032	0.014	0.017	0.925
3	6.408	137.592	-0.046	0.014	0.017	0.894
4	8.376	135.624	-0.060	0.014	0.017	0.923
5	10.164	133.836	-0.073	0.013	0.017	0.851
10	18.480	125.520	-0.137	0.064	0.083	0.822
15	25.116	118.884	-0.192	0.054	0.083	0.696

TEST 2

Water temperature (°C), T: 22.8 Rt= 0.936

FIELD DATA		CALCULATED DATA				
Time (min)	Depth (in)	Height (in)	Ln(H/H0)	Ln (h1/h2)	(t2-t1)	*Km (in/hr)
1	1.500	142.500	-0.010	0.010	0.017	0.671
2	2.244	141.756	-0.016	0.005	0.017	0.336
3	2.772	141.228	-0.019	0.004	0.017	0.239
4	3.336	140.664	-0.023	0.004	0.017	0.257
5	3.840	140.160	-0.027	0.004	0.017	0.230
10	5.580	138.420	-0.040	0.012	0.083	0.160
15	6.948	137.052	-0.049	0.010	0.083	0.127

PT-11 @ 10 ft



TEST 1 FINAL RESULTS

Time Weighted Average Permeability Coefficient **Km=** 0.887 in/hr

TEST 2 FINAL RESULTS

Time Weighted Average Permeability Coefficient **Km=** 0.289 in/hr

AVERAGE PT- 11 @ 10 ft

Time Weighted Average Permeability Coefficient Km = 0.588 in/hr

DEFINITION OF VARIABLES

*Km= Mean permeability
T = Temperature of permeant (water), in °C
Ln = Natural Logarithmic
t1 = Time at the start of the test in the same units selected for Km
t2= Time at the end of the test in the units selected for Km
h1= Height of the water above the bottom of the casing at the start of the test in the same units selected for Km
h2= Height of the water above the bottom of the casing at the end of the test in the same units selected for Km

May 2019

APPENDIX E

SITE CLASSIFICATION DETERMINATION BASED ON SPT VALUES

Appendix E-Average N Value for Site Class Determination

Boring Number	Depth Range		N value as recorded	Layer Thickness d (ft)	Average N as recorded	d/N
	From	to				
B-1	0	13.5	27,32,12	13.5	23.7	0.57
	13.5	23.5	5,7	10	6	1.66
	23.5	43.5	31,12,8,12	20	15.75	1.27
	43.5	53.5	14,23	10	18.5	0.54
	53.5	100	100	46.5	100	0.465
	$\bar{N}$=100/4.505=22.2[1]				Sum(d/N)	4.505
B-3	0	18.5	21,10,27,24	18.5	20.5	0.90
	18.5	33.5	10,5,8	15	7.7	1.95
	33.5	53	21,17,4,44	20	21.5	0.93
	53	100	100	47	100	0.47
	$\bar{N}$=100/4.25=23.5[2]				Sum(d/N)	4.25
B-5	0	13.5	28,37,33	13.5	32.7	0.413
	13.5	28.5	11,7,13	15	10.3	1.45
	28.5	40	7,11	11.5	9	1.27
	40	100	100	60	100	0.6
	$\bar{N}$ 100/3.733=26.8[3]					3.733

Note: [1] Increasing the field SPT N by 33% to convert it N_{60}, $\bar{N}$=100/(4.04/1.33+0.465)=28.6;
[2] Increasing the field SPT N by 33% to convert it N_{60}, $\bar{N}$=100/(3.78/1.33+0.47)=30.2;
[3] Increasing the field SPT N by 33% to convert it N_{60}, $\bar{N}$=100/(3.133/1.33+0.6)=33.8.

APPENDIX F

LIQUEFACTION EVALUATION

APPENDIX F: SUMMARY OF LIQUEFACTION EVALUATION

- **REFERENCE 1: BY LIQUEFACTION ASSESSMENT DIAGRAM (NYC BUILDING CODE 1813.1)**
  - Reference: NYC Building Code 1813.1-Liquefaction Analysis;
  - Structural Occupancy Category: **II** for the **proposed pavilion**; **IV** for the **proposed floodwall** according to Table 1604.5 of NYC Building Code;
  - Parameters: Depth: less than 50 feet below the ground surface; STP-N_{60}: Standard Penetration Resistance normalized to an energy of 60 percent efficiency.

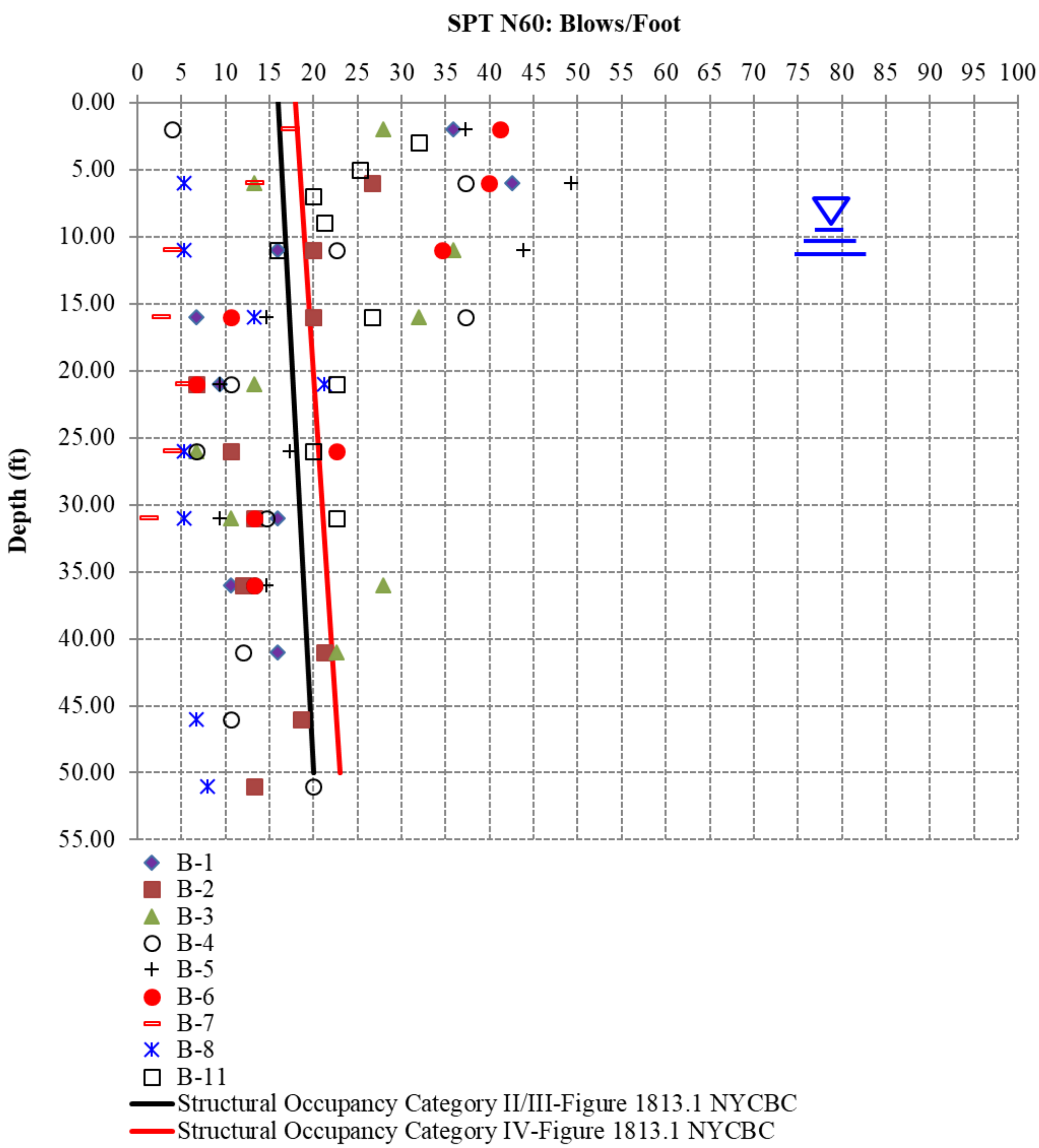


Figure 1: Liquefaction Evaluation by Liquefaction Assessment Diagram.

- **REFERECE 2-LIQUEFACTION ANALYSES ACCORDING TO NYC BUILDING CODE**

- Reference: NYC BUILDING CODE, and I.M. Idriss and R.W. Boulanger (2004): *Semi-empirical Procedures for Evaluating Liquefaction Potential During Earthquakes, 11th International Conferences on Soil Dynamics & Earthquake Engineering (ICSDEE)*.
- Parameters:
    1. Design Magnitude of Earthquake: **5.5** (*the maximum magnitude occurring during the past 300 years within a radius of 150 miles of the referenced site according to USGS Website:* https://earthquake.usgs.gov/earthquakes/search/);
    2. Peak Ground Acceleration: **0.24g** according to Table 1813.2.1 of NYC BUILDING CODE;
    3. Proposed Ground Elevation for the Proposed Pavilion: EL 15.0;
    4. Proposed Ground Elevation along the Flood Wall: 6 inch above the current grade.
- The Minimum Required Safety Factor: **FS=1.0** and **FS=1.2** according to NYC BUILDING CODE 1813.3 for Risk Category II and IV Structures.

THE RESULTS ARE PRESENTED IN THE FOLLWINGS FIGURES 2 AND 3:

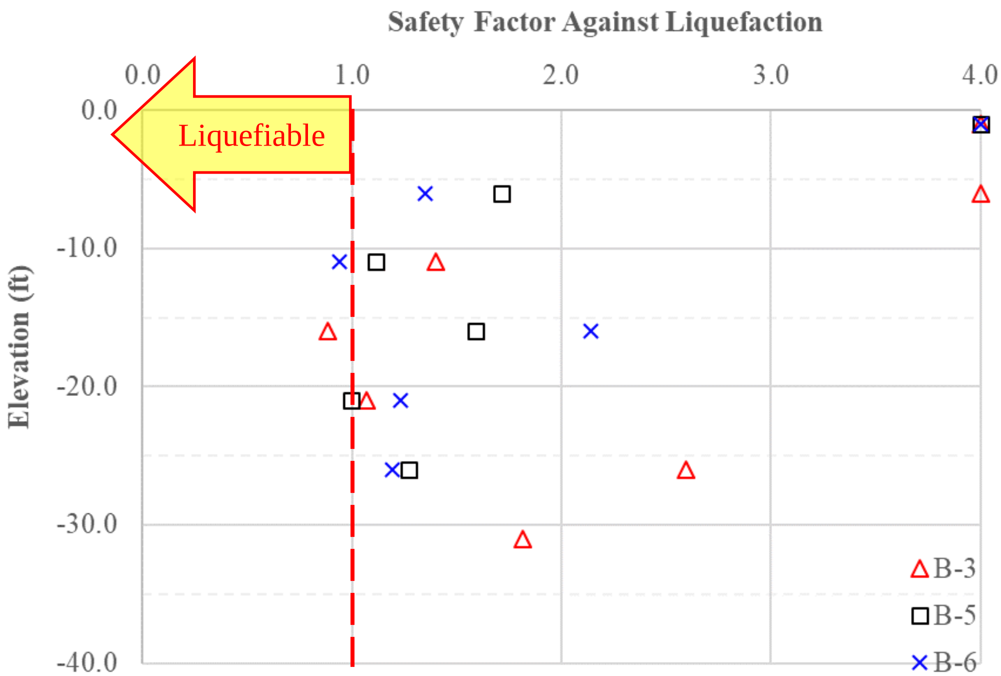


Figure 2: Factor of Safety against Liquefaction for the Proposed **Pavilion** (NYC Building Code).

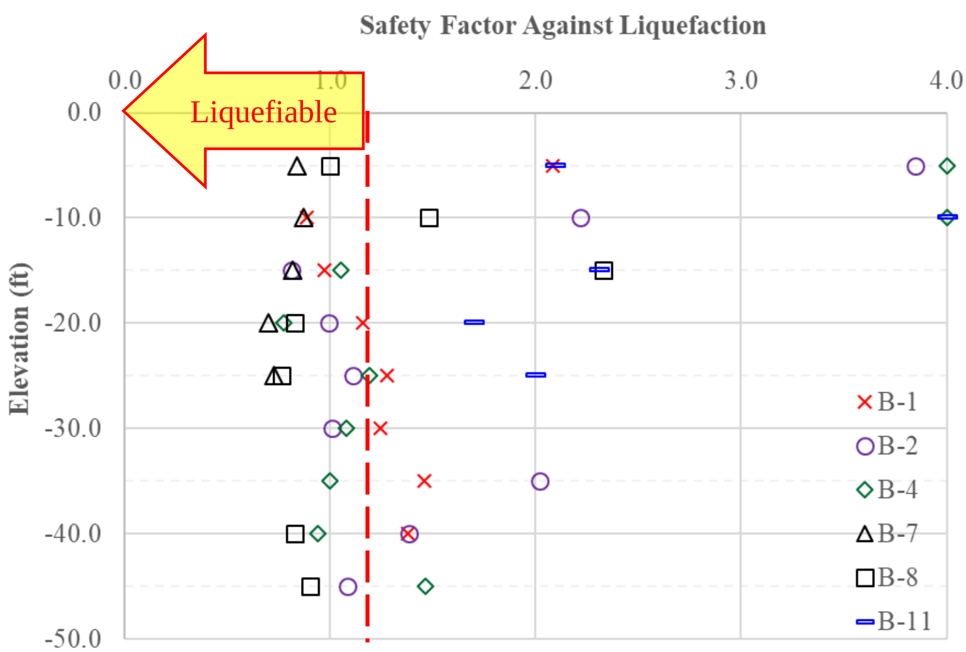


Figure 3: Safety Factor against Liquefaction Along the Proposed **Floodwall** (NYC Building Code).

- **REFERENCE 3-LIQUEFACTION ANALYSES FOR FLOODWALL ACCORDING TO NYCDOT-SDGBDR (SEISMIC DESIGN GUIDELINES FOR BRIDGES IN DOWNSTATE REGION)**

- Reference: NEW YORK CITY DEPARTMENT OF TRANSPORTATION-SEISMIC DESIGN GUIDELINES FOR BRIDGES IN DOWNSTATE REGION and I.M. Idriss and R.W. Boulanger (2004): *Semi-empirical Procedures for Evaluating Liquefaction Potential During Earthquakes, 11th International Conferences on Soil Dynamics & Earthquake Engineering (ICSDEE)*.
- Parameters:
    1. Design Magnitude of Earthquake: **6.0**;
    2. Peak Ground Acceleration: **0.184g** for 1000-Year Earthquake and **0.25g** for 1500-Year Earthquake according to Table 12 of NYCDOT-SDGBDR;
    3. Proposed Ground Elevation along the Flood Wall: 6 inch above the current grade.
- The Minimum Required Safety Factor: **FS=1.1** according to Geotechnical Design Procedure: Liquefaction Potential of Cohesionless Soils by New York State Department of Transportation EB15-025.

THE RESULTS ARE PRESENTED IN THE FOLLWINGS FIGURES 4 AND 5:

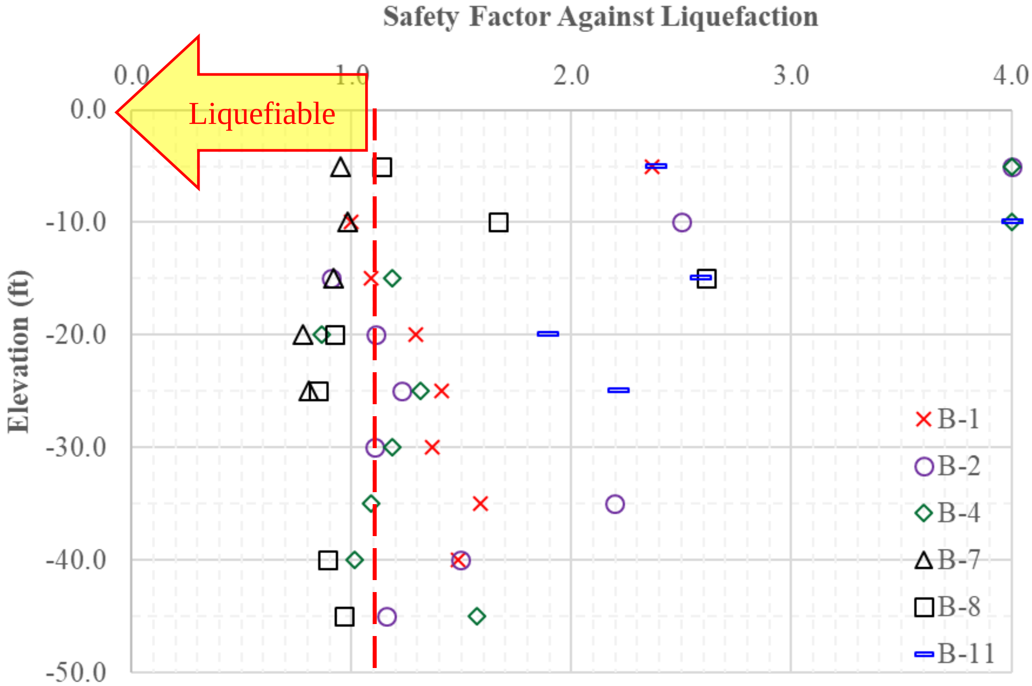


Figure 4: Safety Factor against Liquefaction Along the Proposed **Floodwall** with **1000-Year** Earthquake (NYCDOT-SDGBDR).

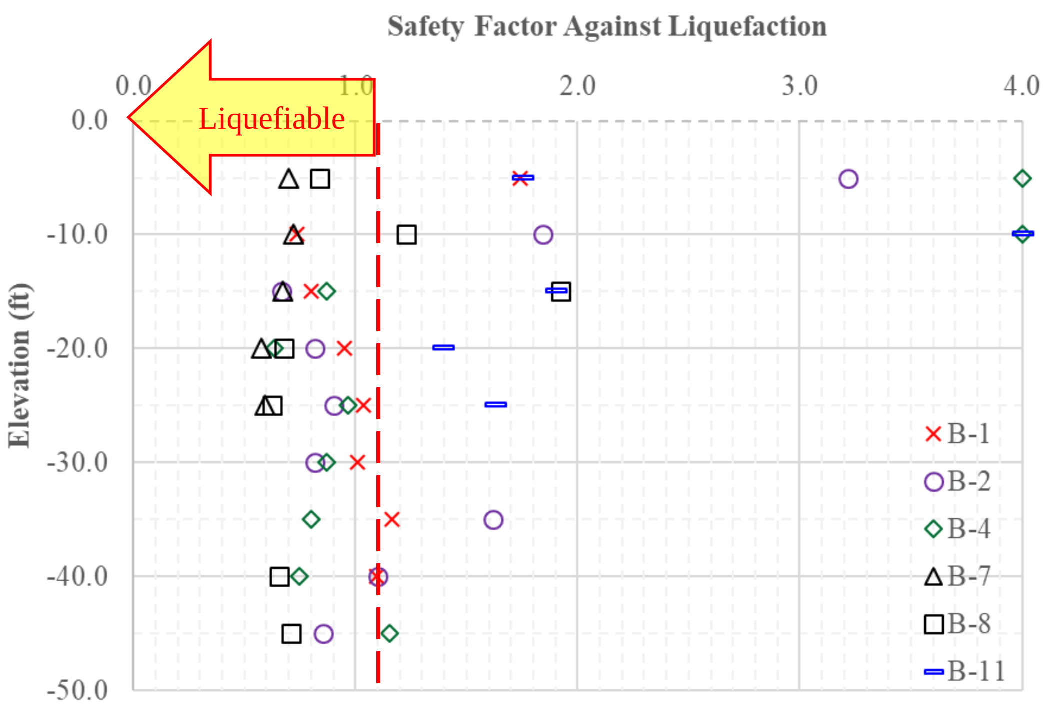


Figure 5: Safety Factor against Liquefaction Along the Proposed **Floodwall** with **1500-Year** Earthquake (NYCDOT-SDGBDR).

CALCULATED BY: SG CHECKED BY:JM DATE: 2/21/2020

Boring Number **B-3, B-5, B-6** Design EQ 5.50 **Proposed G.S. Elevation** 15
G.S. Elevation 10 MSF (<1.8) 1.69
G.W. Depth 10 PGA 0.240
G.W. Elevation 0
Hammer Type Auto (DH,SH,Auto)

Boring	Depth (ft)	Elevation (ft)	Layer[1]	N (bpf)	Idealized Sat. Unit Weight (pcf)	Total Overburden Stress (psf)	Pore Pressure (psf)	Effective Overburden Stress (psf)	Hammer Energy Correction Erm	N_{60} (bpf)	$(N_1)_{60}$ (bpf)	$(N_1)60$ (<46) (bpf)	Percent Fines (FC)	FC Corrected $(N_1)_{60cs}$	CRR (for blow>30, CRR=0.6) 7.5	Proposed Total Overburden Stress (psf)	Proposed Effective Overburden Stress (psf)	r_d (M) z(m) (z<20m)	alpha(z)	beta(z)	rd	Kσ Cσ	Kσ	CRR Corrected	CSR 6	F.S.
B-3	6.00	4.0	2	10	120	720	0	720.00	1.33	13	22	22	2.5	22	0.24	1345	1345	3.35	-0.16	0.02	0.94	0.15	1.00	0.24	0.09	**#N/A**
	11.00	-1.0	3	27	120	1320	62	1257.60	1.33	36	42	42	2.5	42	0.60	1945	1883	4.88	-0.26	0.03	0.91	0.30	1.00	0.60	0.09	**4.00**
	16.00	-6.0	3	24	120	1920	374	1545.60	1.33	32	35	35	2.5	35	0.60	2545	2171	6.40	-0.37	0.04	0.87	0.26	0.98	0.59	0.09	**4.00**
	21.00	-11.0	3	10	120	2520	686	1833.60	1.33	13	14	14	2.2	14	0.15	3145	2459	7.92	-0.50	0.06	0.83	0.11	0.98	0.14	0.10	**1.47**
	26.00	-16.0	3	5	120	3120	998	2121.60	1.33	7	6	6	2.5	6	0.09	3745	2747	9.45	-0.63	0.07	0.78	0.08	0.97	0.09	0.10	**0.93**
	31.00	-21.0	3	8	120	3720	1310	2409.60	1.33	11	10	10	2.1	10	0.12	4345	3035	10.97	-0.77	0.09	0.74	0.09	0.96	0.11	0.10	**1.13**
	36.00	-26.0	3	21	120	4320	1622	2697.60	1.33	28	25	25	2.1	25	0.29	4945	3323	12.50	-0.92	0.10	0.70	0.16	0.92	0.26	0.10	**2.74**
	41.00	-31.0	3	17	120	4920	1934	2985.60	1.33	23	19	19	2.5	19	0.20	5545	3611	14.02	-1.06	0.12	0.66	0.13	0.92	0.18	0.09	**1.92**
B-5	11.00	-1.0	3	33	120	1320	62	1257.60	1.33	44	50	46	2.5	46	0.60	1945	1883	4.88	-0.26	0.03	0.91	0.30	1.00	0.60	0.09	**4.00**
	16.00	-6.0	3	11	120	1920	374	1545.60	1.33	15	17	17	2.5	17	0.17	2545	2171	6.40	-0.37	0.04	0.87	0.12	0.99	0.17	0.09	**1.79**
	21.00	-11.0	3	7	120	2520	686	1833.60	1.33	9	10	10	2.0	10	0.12	3145	2459	7.92	-0.50	0.06	0.83	0.09	0.98	0.11	0.10	**1.17**
	26.00	-16.0	3	13	120	3120	998	2121.60	1.33	17	17	17	2.9	17	0.17	3745	2747	9.45	-0.63	0.07	0.78	0.12	0.96	0.17	0.10	**1.68**
	31.00	-21.0	3	7	120	3720	1310	2409.60	1.33	9	8	8	3.7	8	0.11	4345	3035	10.97	-0.77	0.09	0.74	0.09	0.96	0.10	0.10	**1.05**
	36.00	-26.0	3	11	120	4320	1622	2697.60	1.33	15	13	13	2.5	13	0.14	4945	3323	12.50	-0.92	0.10	0.70	0.10	0.95	0.13	0.10	**1.35**
B-6	11.00	-1.0	3	26	120	1320	62	1257.60	1.33	35	40	40	2.5	40	0.60	1945	1883	4.88	-0.26	0.03	0.91	0.30	1.00	0.60	0.09	**4.00**
	16.00	-6.0	3	8	120	1920	374	1545.60	1.33	11	12	12	2.5	12	0.13	2545	2171	6.40	-0.37	0.04	0.87	0.10	0.99	0.13	0.09	**1.41**
	21.00	-11.0	3	5	120	2520	686	1833.60	1.33	7	7	7	1.7	7	0.10	3145	2459	7.92	-0.50	0.06	0.83	0.08	0.98	0.10	0.10	**0.99**
	26.00	-16.0	3	17	120	3120	998	2121.60	1.33	23	22	22	2.5	22	0.23	3745	2747	9.45	-0.63	0.07	0.78	0.14	0.95	0.22	0.10	**2.26**
	31.00	-21.0	3	10	120	3720	1310	2409.60	1.33	13	12	12	3.1	12	0.13	4345	3035	10.97	-0.77	0.09	0.74	0.10	0.96	0.13	0.10	**1.30**
	36.00	-26.0	3	10	120	4320	1622	2697.60	1.33	13	11	11	2.5	11	0.13	4945	3323	12.50	-0.92	0.10	0.70	0.10	0.95	0.12	0.10	**1.26**

Ref: I.M. Idriss and R.W. Boulanger (2004) Semi-empirical Procedures for Evaluating Liquefaction Potential During Earthquakes, 11th International Conferences on Soil Dynamics&Earthquake Engineering (ICSDEE) and The 3rd International Conference on Earthquake Geotechnical Engineering (ICEGE).

[1]2 for Fill above water table 3 for granular soil below water table

Cells - better estimate can be obtained by trial and error according to Eq.21 in the reference

Boring Number | Design EQ 5.50 | **Proposed G.S. Elevation** 6.5

G.S. Elevation 6 | MSF (<1.8) 1.69

G.W. Depth 6 | PGA 0.240

G.W. Elevation 0

Hammer Type Auto (DH,SH,Auto)

Boring	Depth (ft)	Elevation (ft)	Layer[1]	N (bpf)	Idealized Sat. Unit Weight (pcf)	Total Overburden Stress (psf)	Pore Pressure (psf)	Effective Overburden Stress (psf)	Hammer Energy Correction Erm	N_{60} (bpf)	$(N_1)_{60}$ (bpf)	$(N_1)60$ (<46) (bpf)	Percent Fines (FC)	FC Corrected $(N_1)_{60cs}$	CRR (for blow>30, CRR=0.6) 7.5	Proposed Total Overburden Stress (psf)	Proposed Effective Overburden Stress (psf)	r_d (M) z(m) (z<20m)	alpha(z)	beta(z)	rd	Kσ Cσ	Kσ	CRR Corrected	CSR 6	F.S.
B-7	6.00	0.0	3	10	120	720	0	720.00	1.33	13	22	22	7.5	23	0.24	783	783	1.98	-0.08	0.01	0.97	0.15	1.00	0.24	0.09	#N/A
	11.00	-5.0	3	3	120	1320	312	1008.00	1.33	4	6	6	7.5	6	0.09	1383	1071	3.51	-0.17	0.02	0.94	0.08	1.00	0.09	0.11	0.84
	16.00	-10.0	3	2	120	1920	624	1296.00	1.33	3	4	4	21.6	8	0.11	1983	1359	5.03	-0.27	0.03	0.90	0.07	1.00	0.11	0.12	0.87
	21.00	-15.0	3	4	120	2520	936	1584.00	1.33	5	6	6	10.9	8	0.10	2583	1647	6.55	-0.38	0.04	0.86	0.08	1.00	0.10	0.13	0.82
	26.00	-20.0	3	3	120	3120	1248	1872.00	1.33	4	4	4	10.0	5	0.09	3183	1935	8.08	-0.51	0.06	0.82	0.07	1.00	0.09	0.13	0.70
	31.00	-25.0	3	1	120	3720	1560	2160.00	1.33	1	1	1	20.0	6	0.09	3783	2223	9.60	-0.65	0.07	0.78	0.06	0.99	0.09	0.12	0.73
B-1	11.00	-5.0	3	12	120	1320	312	1008.00	1.33	16	22	22	5.3	22	0.24	1383	1071	3.51	-0.17	0.02	0.94	0.14	1.00	0.24	0.11	2.09
	16.00	-10.0	3	5	120	1920	624	1296.00	1.33	7	9	9	3.3	9	0.11	1983	1359	5.03	-0.27	0.03	0.90	0.09	1.00	0.11	0.12	0.89
	21.00	-15.0	3	7	120	2520	936	1584.00	1.33	9	11	11	3.2	11	0.12	2583	1647	6.55	-0.38	0.04	0.86	0.09	1.00	0.12	0.13	0.97
	26.00	-20.0	3	10	120	3120	1248	1872.00	1.33	13	14	14	3.0	14	0.15	3183	1935	8.08	-0.51	0.06	0.82	0.11	1.00	0.15	0.13	1.17
	31.00	-25.0	3	12	120	3720	1560	2160.00	1.33	16	15	15	3.3	15	0.16	3783	2223	9.60	-0.65	0.07	0.78	0.11	0.99	0.16	0.12	1.28
	36.00	-30.0	3	8	120	4320	1872	2448.00	1.33	11	10	10	24.3	15	0.15	4383	2511	11.13	-0.79	0.09	0.74	0.09	0.98	0.15	0.12	1.25
	41.00	-35.0	3	12	120	4920	2184	2736.00	1.33	16	14	14	15.0	17	0.17	4983	2799	12.65	-0.93	0.10	0.70	0.11	0.96	0.17	0.11	1.46
	46.00	-40.0	3	14	120	5520	2496	3024.00	1.33	19	15	15	5.5	15	0.16	5583	3087	14.17	-1.08	0.12	0.66	0.11	0.95	0.15	0.11	1.38
B-11	11.00	-5.0	3	12	120	1320	312	1008.00	1.33	16	22	22	6.6	22	0.24	1383	1071	3.51	-0.17	0.02	0.94	0.14	1.00	0.24	0.11	2.10
	16.00	-10.0	3	20	120	1920	624	1296.00	1.33	27	31	31	6.6	32	0.60	1983	1359	5.03	-0.27	0.03	0.90	0.22	1.00	0.60	0.12	4.00
	21.00	-15.0	3	17	120	2520	936	1584.00	1.33	23	25	25	6.6	25	0.29	2583	1647	6.55	-0.38	0.04	0.86	0.16	1.00	0.29	0.13	2.32
	26.00	-20.0	3	15	120	3120	1248	1872.00	1.33	20	21	21	6.6	21	0.21	3183	1935	8.08	-0.51	0.06	0.82	0.14	1.00	0.21	0.13	1.71
	31.00	-25.0	3	17	120	3720	1560	2160.00	1.33	23	22	22	10.0	23	0.25	3783	2223	9.60	-0.65	0.07	0.78	0.14	0.98	0.25	0.12	2.01
B-4	11.00	-5.0	3	17	120	1320	312	1008.00	1.33	23	30	30	3.1	30	0.60	1383	1071	3.51	-0.17	0.02	0.94	0.20	1.00	0.60	0.11	4.00
	16.00	-10.0	3	28	120	1920	624	1296.00	1.33	37	43	43	4.1	43	0.60	1983	1359	5.03	-0.27	0.03	0.90	0.30	1.00	0.60	0.12	4.00
	21.00	-15.0	3	8	120	2520	936	1584.00	1.33	11	12	12	1.8	12	0.13	2583	1647	6.55	-0.38	0.04	0.86	0.10	1.00	0.13	0.13	1.06
	26.00	-20.0	3	5	120	3120	1248	1872.00	1.33	7	7	7	1.8	7	0.10	3183	1935	8.08	-0.51	0.06	0.82	0.08	1.00	0.10	0.13	0.78
	31.00	-25.0	3	11	120	3720	1560	2160.00	1.33	15	14	14	1.6	14	0.15	3783	2223	9.60	-0.65	0.07	0.78	0.11	0.99	0.15	0.12	1.20
	36.00	-30.0	3	10	120	4320	1872	2448.00	1.33	13	12	12	2.2	12	0.13	4383	2511	11.13	-0.79	0.09	0.74	0.10	0.98	0.13	0.12	1.09
	41.00	-35.0	3	9	120	4920	2184	2736.00	1.33	12	10	10	2.2	10	0.12	4983	2799	12.65	-0.93	0.10	0.70	0.09	0.97	0.12	0.11	1.01
	46.00	-40.0	3	8	120	5520	2496	3024.00	1.33	11	9	9	2.2	9	0.11	5583	3087	14.17	-1.08	0.12	0.66	0.09	0.96	0.10	0.11	0.95
	51.00	-45.0	3	15	120	6120	2808	3312.00	1.33	20	16	16	3.0	16	0.16	6183	3375	15.70	-1.22	0.14	0.62	0.11	0.94	0.15	0.11	1.47
B-2	11.00	-5.0	3	15	120	1320	312	1008.00	1.33	20	27	27	12.0	29	0.43	1383	1071	3.51	-0.17	0.02	0.94	0.18	1.00	0.43	0.11	3.86
	16.00	-10.0	3	15	120	1920	624	1296.00	1.33	20	24	24	1.4	24	0.27	1983	1359	5.03	-0.27	0.03	0.90	0.16	1.00	0.27	0.12	2.22
	21.00	-15.0	3	5	120	2520	936	1584.00	1.33	7	8	8	1.4	8	0.10	2583	1647	6.55	-0.38	0.04	0.86	0.08	1.00	0.10	0.13	0.81
	26.00	-20.0	3	8	120	3120	1248	1872.00	1.33	11	11	11	1.4	11	0.13	3183	1935	8.08	-0.51	0.06	0.82	0.10	1.00	0.13	0.13	1.00
	31.00	-25.0	3	10	120	3720	1560	2160.00	1.33	13	13	13	3.3	13	0.14	3783	2223	9.60	-0.65	0.07	0.78	0.10	0.99	0.14	0.12	1.11
	36.00	-30.0	3	9	120	4320	1872	2448.00	1.33	12	11	11	5.0	11	0.12	4383	2511	11.13	-0.79	0.09	0.74	0.09	0.98	0.12	0.12	1.01
	41.00	-35.0	3	16	120	4920	2184	2736.00	1.33	21	19	19	17.7	23	0.24	4983	2799	12.65	-0.93	0.10	0.70	0.13	0.96	0.23	0.11	2.03
	46.00	-40.0	3	14	120	5520	2496	3024.00	1.33	19	15	15	6.8	16	0.16	5583	3087	14.17	-1.08	0.12	0.66	0.11	0.95	0.15	0.11	1.39
	51.00	-45.0	3	10	120	6120	2808	3312.00	1.33	13	10	10	2.4	10	0.12	6183	3375	15.70	-1.22	0.14	0.62	0.09	0.95	0.11	0.11	1.09
B-8	6.00	0.0	3	4	120	720	0	720.00	1.33	5	10	10	5.0	10	0.12	783	783	1.98	-0.08	0.01	0.97	0.09	1.00	0.12	0.09	#N/A
	11.00	-5.0	3	4	120	1320	312	1008.00	1.33	5	8	8	10.0	9	0.11	1383	1071	3.51	-0.17	0.02	0.94	0.09	1.00	0.11	0.11	1.00
	16.00	-10.0	3	10	120	1920	624	1296.00	1.33	13	17	17	10.0	18	0.18	1983	1359	5.03	-0.27	0.03	0.90	0.12	1.00	0.18	0.12	1.48
	21.00	-15.0	3	16	120	2520	936	1584.00	1.33	21	24	24	10.9	25	0.29	2583	1647	6.55	-0.38	0.04	0.86	0.15	1.00	0.29	0.13	2.34
	26.00	-20.0	3	4	120	3120	1248	1872.00	1.33	5	6	6	12.6	8	0.10	3183	1935	8.08	-0.51	0.06	0.82	0.08	1.00	0.10	0.13	0.83
	31.00	-25.0	3	4	120	3720	1560	2160.00	1.33	5	5	5	10.6	7	0.10	3783	2223	9.60	-0.65	0.07	0.78	0.08	0.99	0.09	0.12	0.77
	46.00	-40.0	3	5	120	5520	2496	3024.00	1.33	7	5	5	10.0	6	0.09	5583	3087	14.17	-1.08	0.12	0.66	0.08	0.97	0.09	0.11	0.83
	51.00	-45.0	3	6	120	6120	2808	3312.00	1.33	8	6	6	10.0	7	0.10	6183	3375	15.70	-1.22	0.14	0.62	0.08	0.96	0.10	0.11	0.91

Ref: I.M. Idriss and R.W. Boulanger (2004) Semi-empirical Procedures for Evaluating Liquefaction Potential During Earthquakes, 11th International Conferences on Soil Dynamics&Earthquake Engineering (ICSDEE) and The 3rd International Conference on Earthquake Geotechnical Engineering (ICEGE).

[1] 2 for Fill above water table 3 for granular soil below water table

(grey) Cells - better estimate can be obtained by trial and error according to Eq.21 in the reference

Boring Number | Design EQ 6.00 | **Proposed G.S. Elevation** 6.5

G.S. Elevation 6 | MSF (<1.8) 1.48

G.W. Depth 6 | PGA 0.184

G.W. Elevation 0

Hammer Type Auto (DH,SH,Auto)

Boring	Depth	Elevation	Layer[1]	N	Idealized Sat. Unit Weight	Total Overburden Stress	Pore Pressure	Effective Overburden Stress	Hammer Energy Correction Erm	N_{60}	$(N_1)_{60}$	$(N_1)60$ (<46)	Percent Fines (FC)	FC Corrected $(N_1)_{60cs}$	CRR (for blow>30, CRR=0.6)	Proposed Total Overburden Stress	Proposed Effective Overburden Stress	r_d (M) z(m)				Kσ		CRR	CSR	F.S.
Boring	(ft)	(ft)		(bpf)	(pcf)	(psf)	(psf)	(psf)		(bpf)	(bpf)	(bpf)			7.5	(psf)	(psf)	(z<20m)	alpha(z)	beta(z)	rd	Cσ	Kσ	Corrected	6	
B-7	6.00	0.0	3	10	120	720	0	720.00	1.33	13	22	22	7.5	23	0.24	783	783	1.98	-0.08	0.01	0.98	0.15	1.00	0.24	0.08	#N/A
	11.00	-5.0	3	3	120	1320	312	1008.00	1.33	4	6	6	7.5	6	0.09	1383	1071	3.51	-0.17	0.02	0.95	0.08	1.00	0.09	0.10	0.95
	16.00	-10.0	3	2	120	1920	624	1296.00	1.33	3	4	4	21.6	8	0.11	1983	1359	5.03	-0.27	0.03	0.92	0.07	1.00	0.11	0.11	0.98
	21.00	-15.0	3	4	120	2520	936	1584.00	1.33	5	6	6	10.9	8	0.10	2583	1647	6.55	-0.38	0.04	0.88	0.08	1.00	0.10	0.11	0.92
	26.00	-20.0	3	3	120	3120	1248	1872.00	1.33	4	4	4	10.0	5	0.09	3183	1935	8.08	-0.51	0.06	0.85	0.07	1.00	0.09	0.11	0.78
	31.00	-25.0	3	1	120	3720	1560	2160.00	1.33	1	1	1	20.0	6	0.09	3783	2223	9.60	-0.65	0.07	0.81	0.06	0.99	0.09	0.11	0.81
B-1	11.00	-5.0	3	12	120	1320	312	1008.00	1.33	16	22	22	5.3	22	0.24	1383	1071	3.51	-0.17	0.02	0.95	0.14	1.00	0.24	0.10	2.38
	16.00	-10.0	3	5	120	1920	624	1296.00	1.33	7	9	9	3.3	9	0.11	1983	1359	5.03	-0.27	0.03	0.92	0.09	1.00	0.11	0.11	1.00
	21.00	-15.0	3	7	120	2520	936	1584.00	1.33	9	11	11	3.2	11	0.12	2583	1647	6.55	-0.38	0.04	0.88	0.09	1.00	0.12	0.11	1.09
	26.00	-20.0	3	10	120	3120	1248	1872.00	1.33	13	14	14	3.0	14	0.15	3183	1935	8.08	-0.51	0.06	0.85	0.11	1.00	0.15	0.11	1.30
	31.00	-25.0	3	12	120	3720	1560	2160.00	1.33	16	15	15	3.3	15	0.16	3783	2223	9.60	-0.65	0.07	0.81	0.11	0.99	0.16	0.11	1.42
	36.00	-30.0	3	8	120	4320	1872	2448.00	1.33	11	10	10	24.3	15	0.15	4383	2511	11.13	-0.79	0.09	0.77	0.09	0.98	0.15	0.11	1.37
	41.00	-35.0	3	12	120	4920	2184	2736.00	1.33	16	14	14	15.0	17	0.17	4983	2799	12.65	-0.93	0.10	0.73	0.11	0.96	0.17	0.11	1.59
	46.00	-40.0	3	14	120	5520	2496	3024.00	1.33	19	15	15	5.5	15	0.16	5583	3087	14.17	-1.08	0.12	0.70	0.11	0.95	0.15	0.10	1.49
B-11	11.00	-5.0	3	12	120	1320	312	1008.00	1.33	16	22	22	6.6	22	0.24	1383	1071	3.51	-0.17	0.02	0.95	0.14	1.00	0.24	0.10	2.39
	16.00	-10.0	3	20	120	1920	624	1296.00	1.33	27	31	31	6.6	32	0.60	1983	1359	5.03	-0.27	0.03	0.92	0.22	1.00	0.60	0.11	4.00
	21.00	-15.0	3	17	120	2520	936	1584.00	1.33	23	25	25	6.6	25	0.29	2583	1647	6.55	-0.38	0.04	0.88	0.16	1.00	0.29	0.11	2.60
	26.00	-20.0	3	15	120	3120	1248	1872.00	1.33	20	21	21	6.6	21	0.21	3183	1935	8.08	-0.51	0.06	0.85	0.14	1.00	0.21	0.11	1.90
	31.00	-25.0	3	17	120	3720	1560	2160.00	1.33	23	22	22	10.0	23	0.25	3783	2223	9.60	-0.65	0.07	0.81	0.14	0.98	0.25	0.11	2.22
B-4	11.00	-5.0	3	17	120	1320	312	1008.00	1.33	23	30	30	3.1	30	0.60	1383	1071	3.51	-0.17	0.02	0.95	0.20	1.00	0.60	0.10	4.00
	16.00	-10.0	3	28	120	1920	624	1296.00	1.33	37	43	43	4.1	43	0.60	1983	1359	5.03	-0.27	0.03	0.92	0.30	1.00	0.60	0.11	4.00
	21.00	-15.0	3	8	120	2520	936	1584.00	1.33	11	12	12	1.8	12	0.13	2583	1647	6.55	-0.38	0.04	0.88	0.10	1.00	0.13	0.11	1.19
	26.00	-20.0	3	5	120	3120	1248	1872.00	1.33	7	7	7	1.8	7	0.10	3183	1935	8.08	-0.51	0.06	0.85	0.08	1.00	0.10	0.11	0.87
	31.00	-25.0	3	11	120	3720	1560	2160.00	1.33	15	14	14	1.6	14	0.15	3783	2223	9.60	-0.65	0.07	0.81	0.11	0.99	0.15	0.11	1.32
	36.00	-30.0	3	10	120	4320	1872	2448.00	1.33	13	12	12	2.2	12	0.13	4383	2511	11.13	-0.79	0.09	0.77	0.10	0.98	0.13	0.11	1.19
	41.00	-35.0	3	9	120	4920	2184	2736.00	1.33	12	10	10	2.2	10	0.12	4983	2799	12.65	-0.93	0.10	0.73	0.09	0.97	0.12	0.11	1.10
	46.00	-40.0	3	8	120	5520	2496	3024.00	1.33	11	9	9	2.2	9	0.11	5583	3087	14.17	-1.08	0.12	0.70	0.09	0.96	0.10	0.10	1.02
	51.00	-45.0	3	15	120	6120	2808	3312.00	1.33	20	16	16	3.0	16	0.16	6183	3375	15.70	-1.22	0.14	0.66	0.11	0.94	0.15	0.10	1.58
B-2	11.00	-5.0	3	15	120	1320	312	1008.00	1.33	20	27	27	12.0	29	0.43	1383	1071	3.51	-0.17	0.02	0.95	0.18	1.00	0.43	0.10	4.00
	16.00	-10.0	3	15	120	1920	624	1296.00	1.33	20	24	24	1.4	24	0.27	1983	1359	5.03	-0.27	0.03	0.92	0.16	1.00	0.27	0.11	2.51
	21.00	-15.0	3	5	120	2520	936	1584.00	1.33	7	8	8	1.4	8	0.10	2583	1647	6.55	-0.38	0.04	0.88	0.08	1.00	0.10	0.11	0.91
	26.00	-20.0	3	8	120	3120	1248	1872.00	1.33	11	11	11	1.4	11	0.13	3183	1935	8.08	-0.51	0.06	0.85	0.10	1.00	0.13	0.11	1.11
	31.00	-25.0	3	10	120	3720	1560	2160.00	1.33	13	13	13	3.3	13	0.14	3783	2223	9.60	-0.65	0.07	0.81	0.10	0.99	0.14	0.11	1.23
	36.00	-30.0	3	9	120	4320	1872	2448.00	1.33	12	11	11	5.0	11	0.12	4383	2511	11.13	-0.79	0.09	0.77	0.09	0.98	0.12	0.11	1.11
	41.00	-35.0	3	16	120	4920	2184	2736.00	1.33	21	19	19	17.7	23	0.24	4983	2799	12.65	-0.93	0.10	0.73	0.13	0.96	0.23	0.11	2.21
	46.00	-40.0	3	14	120	5520	2496	3024.00	1.33	19	15	15	6.8	16	0.16	5583	3087	14.17	-1.08	0.12	0.70	0.11	0.95	0.15	0.10	1.50
	51.00	-45.0	3	10	120	6120	2808	3312.00	1.33	13	10	10	2.4	10	0.12	6183	3375	15.70	-1.22	0.14	0.66	0.09	0.95	0.11	0.10	1.17
B-8	6.00	0.0	3	4	120	720	0	720.00	1.33	5	10	10	5.0	10	0.12	783	783	1.98	-0.08	0.01	0.98	0.09	1.00	0.12	0.08	#N/A
	11.00	-5.0	3	4	120	1320	312	1008.00	1.33	5	8	8	10.0	9	0.11	1383	1071	3.51	-0.17	0.02	0.95	0.09	1.00	0.11	0.10	1.14
	16.00	-10.0	3	10	120	1920	624	1296.00	1.33	13	17	17	10.0	18	0.18	1983	1359	5.03	-0.27	0.03	0.92	0.12	1.00	0.18	0.11	1.68
	21.00	-15.0	3	16	120	2520	936	1584.00	1.33	21	24	24	10.9	25	0.29	2583	1647	6.55	-0.38	0.04	0.88	0.15	1.00	0.29	0.11	2.62
	26.00	-20.0	3	4	120	3120	1248	1872.00	1.33	5	6	6	12.6	8	0.10	3183	1935	8.08	-0.51	0.06	0.85	0.08	1.00	0.10	0.11	0.93
	31.00	-25.0	3	4	120	3720	1560	2160.00	1.33	5	5	5	10.6	7	0.10	3783	2223	9.60	-0.65	0.07	0.81	0.08	0.99	0.09	0.11	0.85
	46.00	-40.0	3	5	120	5520	2496	3024.00	1.33	7	5	5	10.0	6	0.09	5583	3087	14.17	-1.08	0.12	0.70	0.08	0.97	0.09	0.10	0.90
	51.00	-45.0	3	6	120	6120	2808	3312.00	1.33	8	6	6	10.0	7	0.10	6183	3375	15.70	-1.22	0.14	0.66	0.08	0.96	0.10	0.10	0.97

Ref: I.M. Idriss and R.W. Boulanger (2004) Semi-empirical Procedures for Evaluating Liquefaction Potential During Earthquakes, 11th International Conferences on Soil Dynamics&Earthquake Engineering (ICSDEE) and The 3rd International Conference on Earthquake Geotechnical Engineering (ICEGE).

[1] 2 for Fill above water table 3 for granular soil below water table

(grey box) Cells - better estimate can be obtained by trial and error according to Eq.21 in the reference

Boring Number | Design EQ 6.00 | **Proposed G.S. Elevation** 6.5
G.S. Elevation 6 | MSF (<1.8) 1.48
G.W. Depth 6 | PGA 0.250
G.W. Elevation 0
Hammer Type Auto (DH,SH,Auto)

Boring	Depth (ft)	Elevation (ft)	Layer[1]	N (bpf)	Idealized Sat. Unit Weight (pcf)	Total Overburden Stress (psf)	Pore Pressure (psf)	Effective Overburden Stress (psf)	Hammer Energy Correction Erm	N_{60} (bpf)	$(N_1)_{60}$ (bpf)	$(N_1)60$ (<46) (bpf)	Percent Fines (FC)	FC Corrected $(N_1)_{60cs}$	CRR (for blow>30, CRR=0.6) 7.5	Proposed Total Overburden Stress (psf)	Proposed Effective Overburden Stress (psf)	r_d (M) z(m) (z<20m)	alpha(z)	beta(z)	rd	Kσ Cσ	Kσ	CRR Corrected	CSR 6	F.S.
B-7	6.00	0.0	3	10	120	720	0	720.00	1.33	13	22	22	7.5	23	0.24	783	783	1.98	-0.08	0.01	0.98	0.15	1.00	0.24	0.11	#N/A
	11.00	-5.0	3	3	120	1320	312	1008.00	1.33	4	6	6	7.5	6	0.09	1383	1071	3.51	-0.17	0.02	0.95	0.08	1.00	0.09	0.13	0.70
	16.00	-10.0	3	2	120	1920	624	1296.00	1.33	3	4	4	21.6	8	0.11	1983	1359	5.03	-0.27	0.03	0.92	0.07	1.00	0.11	0.15	0.72
	21.00	-15.0	3	4	120	2520	936	1584.00	1.33	5	6	6	10.9	8	0.10	2583	1647	6.55	-0.38	0.04	0.88	0.08	1.00	0.10	0.15	0.68
	26.00	-20.0	3	3	120	3120	1248	1872.00	1.33	4	4	4	10.0	5	0.09	3183	1935	8.08	-0.51	0.06	0.85	0.07	1.00	0.09	0.15	0.58
	31.00	-25.0	3	1	120	3720	1560	2160.00	1.33	1	1	1	20.0	6	0.09	3783	2223	9.60	-0.65	0.07	0.81	0.06	0.99	0.09	0.15	0.60
B-1	11.00	-5.0	3	12	120	1320	312	1008.00	1.33	16	22	22	5.3	22	0.24	1383	1071	3.51	-0.17	0.02	0.95	0.14	1.00	0.24	0.13	1.75
	16.00	-10.0	3	5	120	1920	624	1296.00	1.33	7	9	9	3.3	9	0.11	1983	1359	5.03	-0.27	0.03	0.92	0.09	1.00	0.11	0.15	0.74
	21.00	-15.0	3	7	120	2520	936	1584.00	1.33	9	11	11	3.2	11	0.12	2583	1647	6.55	-0.38	0.04	0.88	0.09	1.00	0.12	0.15	0.80
	26.00	-20.0	3	10	120	3120	1248	1872.00	1.33	13	14	14	3.0	14	0.15	3183	1935	8.08	-0.51	0.06	0.85	0.11	1.00	0.15	0.15	0.96
	31.00	-25.0	3	12	120	3720	1560	2160.00	1.33	16	15	15	3.3	15	0.16	3783	2223	9.60	-0.65	0.07	0.81	0.11	0.99	0.16	0.15	1.04
	36.00	-30.0	3	8	120	4320	1872	2448.00	1.33	11	10	10	24.3	15	0.15	4383	2511	11.13	-0.79	0.09	0.77	0.09	0.98	0.15	0.15	1.01
	41.00	-35.0	3	12	120	4920	2184	2736.00	1.33	16	14	14	15.0	17	0.17	4983	2799	12.65	-0.93	0.10	0.73	0.11	0.96	0.17	0.14	1.17
	46.00	-40.0	3	14	120	5520	2496	3024.00	1.33	19	15	15	5.5	15	0.16	5583	3087	14.17	-1.08	0.12	0.70	0.11	0.95	0.15	0.14	1.10
B-11	11.00	-5.0	3	12	120	1320	312	1008.00	1.33	16	22	22	6.6	22	0.24	1383	1071	3.51	-0.17	0.02	0.95	0.14	1.00	0.24	0.13	1.76
	16.00	-10.0	3	20	120	1920	624	1296.00	1.33	27	31	31	6.6	32	0.60	1983	1359	5.03	-0.27	0.03	0.92	0.22	1.00	0.60	0.15	4.00
	21.00	-15.0	3	17	120	2520	936	1584.00	1.33	23	25	25	6.6	25	0.29	2583	1647	6.55	-0.38	0.04	0.88	0.16	1.00	0.29	0.15	1.91
	26.00	-20.0	3	15	120	3120	1248	1872.00	1.33	20	21	21	6.6	21	0.21	3183	1935	8.08	-0.51	0.06	0.85	0.14	1.00	0.21	0.15	1.40
	31.00	-25.0	3	17	120	3720	1560	2160.00	1.33	23	22	22	10.0	23	0.25	3783	2223	9.60	-0.65	0.07	0.81	0.14	0.98	0.25	0.15	1.64
B-4	11.00	-5.0	3	17	120	1320	312	1008.00	1.33	23	30	30	3.1	30	0.60	1383	1071	3.51	-0.17	0.02	0.95	0.20	1.00	0.60	0.13	4.00
	16.00	-10.0	3	28	120	1920	624	1296.00	1.33	37	43	43	4.1	43	0.60	1983	1359	5.03	-0.27	0.03	0.92	0.30	1.00	0.60	0.15	4.00
	21.00	-15.0	3	8	120	2520	936	1584.00	1.33	11	12	12	1.8	12	0.13	2583	1647	6.55	-0.38	0.04	0.88	0.10	1.00	0.13	0.15	0.87
	26.00	-20.0	3	5	120	3120	1248	1872.00	1.33	7	7	7	1.8	7	0.10	3183	1935	8.08	-0.51	0.06	0.85	0.08	1.00	0.10	0.15	0.64
	31.00	-25.0	3	11	120	3720	1560	2160.00	1.33	15	14	14	1.6	14	0.15	3783	2223	9.60	-0.65	0.07	0.81	0.11	0.99	0.15	0.15	0.97
	36.00	-30.0	3	10	120	4320	1872	2448.00	1.33	13	12	12	2.2	12	0.13	4383	2511	11.13	-0.79	0.09	0.77	0.10	0.98	0.13	0.15	0.88
	41.00	-35.0	3	9	120	4920	2184	2736.00	1.33	12	10	10	2.2	10	0.12	4983	2799	12.65	-0.93	0.10	0.73	0.09	0.97	0.12	0.14	0.81
	46.00	-40.0	3	8	120	5520	2496	3024.00	1.33	11	9	9	2.2	9	0.11	5583	3087	14.17	-1.08	0.12	0.70	0.09	0.96	0.10	0.14	0.75
	51.00	-45.0	3	15	120	6120	2808	3312.00	1.33	20	16	16	3.0	16	0.16	6183	3375	15.70	-1.22	0.14	0.66	0.11	0.94	0.15	0.13	1.16
B-2	11.00	-5.0	3	15	120	1320	312	1008.00	1.33	20	27	27	12.0	29	0.43	1383	1071	3.51	-0.17	0.02	0.95	0.18	1.00	0.43	0.13	3.23
	16.00	-10.0	3	15	120	1920	624	1296.00	1.33	20	24	24	1.4	24	0.27	1983	1359	5.03	-0.27	0.03	0.92	0.16	1.00	0.27	0.15	1.85
	21.00	-15.0	3	5	120	2520	936	1584.00	1.33	7	8	8	1.4	8	0.10	2583	1647	6.55	-0.38	0.04	0.88	0.08	1.00	0.10	0.15	0.67
	26.00	-20.0	3	8	120	3120	1248	1872.00	1.33	11	11	11	1.4	11	0.13	3183	1935	8.08	-0.51	0.06	0.85	0.10	1.00	0.13	0.15	0.82
	31.00	-25.0	3	10	120	3720	1560	2160.00	1.33	13	13	13	3.3	13	0.14	3783	2223	9.60	-0.65	0.07	0.81	0.10	0.99	0.14	0.15	0.91
	36.00	-30.0	3	9	120	4320	1872	2448.00	1.33	12	11	11	5.0	11	0.12	4383	2511	11.13	-0.79	0.09	0.77	0.09	0.98	0.12	0.15	0.82
	41.00	-35.0	3	16	120	4920	2184	2736.00	1.33	21	19	19	17.7	23	0.24	4983	2799	12.65	-0.93	0.10	0.73	0.13	0.96	0.23	0.14	1.63
	46.00	-40.0	3	14	120	5520	2496	3024.00	1.33	19	15	15	6.8	16	0.16	5583	3087	14.17	-1.08	0.12	0.70	0.11	0.95	0.15	0.14	1.11
	51.00	-45.0	3	10	120	6120	2808	3312.00	1.33	13	10	10	2.4	10	0.12	6183	3375	15.70	-1.22	0.14	0.66	0.09	0.95	0.11	0.13	0.86
B-8	6.00	0.0	3	4	120	720	0	720.00	1.33	5	10	10	5.0	10	0.12	783	783	1.98	-0.08	0.01	0.98	0.09	1.00	0.12	0.11	#N/A
	11.00	-5.0	3	4	120	1320	312	1008.00	1.33	5	8	8	10.0	9	0.11	1383	1071	3.51	-0.17	0.02	0.95	0.09	1.00	0.11	0.13	0.84
	16.00	-10.0	3	10	120	1920	624	1296.00	1.33	13	17	17	10.0	18	0.18	1983	1359	5.03	-0.27	0.03	0.92	0.12	1.00	0.18	0.15	1.23
	21.00	-15.0	3	16	120	2520	936	1584.00	1.33	21	24	24	10.9	25	0.29	2583	1647	6.55	-0.38	0.04	0.88	0.15	1.00	0.29	0.15	1.93
	26.00	-20.0	3	4	120	3120	1248	1872.00	1.33	5	6	6	12.6	8	0.10	3183	1935	8.08	-0.51	0.06	0.85	0.08	1.00	0.10	0.15	0.68
	31.00	-25.0	3	4	120	3720	1560	2160.00	1.33	5	5	5	10.6	7	0.10	3783	2223	9.60	-0.65	0.07	0.81	0.08	0.99	0.09	0.15	0.63
	46.00	-40.0	3	5	120	5520	2496	3024.00	1.33	7	5	5	10.0	6	0.09	5583	3087	14.17	-1.08	0.12	0.70	0.08	0.97	0.09	0.14	0.66
	51.00	-45.0	3	6	120	6120	2808	3312.00	1.33	8	6	6	10.0	7	0.10	6183	3375	15.70	-1.22	0.14	0.66	0.08	0.96	0.10	0.13	0.72

Ref: I.M. Idriss and R.W. Boulanger (2004) Semi-empirical Procedures for Evaluating Liquefaction Potential During Earthquakes, 11th International Conferences on Soil Dynamics&Earthquake Engineering (ICSDEE) and The 3rd International Conference on Earthquake Geotechnical Engineering (ICEGE).

[1]2 for Fill above water table 3 for granular soil below water table

Cells - better estimate can be obtained by trial and error according to Eq.21 in the reference

APPENDIX G

SETTLEMENT ESTIMATION OF MAT FOUNDATION

APPENDIX G-MAT FOUNDATION FOR THE PROPOSED PAVILION

1. INTRODUCTION

The proposed pavilion is a two-story building with potential area of 6000 SF for restaurant, 1000 SF for restrooms, 2000 SF for Service Yard and 3600 SF for maintenance. According to the three borings (B-3, B-5 and B-6) performed by OEI adjacent to/within the footprint of the proposed pavilion, the subsurface condition includes 15 ft fill material consisting of brown medium to fine sand in generally medium dense condition overlying 25 ft possible fill material consisting of gray fine sand in generally loose to medium dense condition followed by a thin layer till (0ft~8ft) consisting of black medium to fine sand with organic silt to dark gray silty clay with fine gravel above the bedrock. According to NYC Building Code, the allowable soil bearing pressure on satisfactory uncontrolled fill material shall not exceed 2 tons per square foot. Hence, 1.5 tsf of allowable bearing pressure is recommended to be used in the proposed mat foundation design.

2. REQUIRED ADDITIONAL FIELD INVESTIGATION

According to NYC Building Code 1804.2.3, fills other than controlled fill may be considered as satisfactory bearing material but additional field investigation is required in addition to the typical field exploration using one standard boring for every 2500 square foot of building footprint area. As it is specified in the NYC Building Code that if mat foundation is used, one test pit or minimum 3-inch diameter sampler boring shall be provided for every 1,000 square feet of building footprint area.

3. ELASTIC SETTLEMENT OF MAT FOUNDATION

- *FOOTING DETAILS*

1) Footing Dimensions: 78ft by 78ft *(for the proposed restaurant with potential area of 6000SF)*

2) Proposed Ground Elevation: Average GL at EL+15.0

3) Thickness of Mat: 2.5ft

4) Allowable Bearing Pressure: 1.5tsf (*NYC Building Code 1804.2.3*)

- *ELASTIC SETTLEMENT COMPUTATIONS*

1) Methods: Fraser and Wardle (1976) (see attachment).

2) Soil Profile: based on the worse subsurface condition encountered at boring B-3.

- *CALCULATIONS AND REFERENCE*

OWEIS ENGINEERING COMPUTATIONS

PROJECT NAME: South Battery Park Pavilion
CALCULATED BY: SG
DATE: 2/28/20
PROJECT NUMBER: 17-NJ165-01
CHECKED BY: AM
DATE: 3/9/21
SHEET: 1 OF 2
SCALE:

Mat Foundation Settlement

Parameters:

Footing Size: 78ft X 78ft

proposed GL: EL +15.0

Thickness of Mat: 2.5ft

Allowable bearing at bottom of Mat: 1.5tsf

E of Mat: $E = 57000\sqrt{f'_c} = 57000\sqrt{3500} \times 144/2000 = 242{,}796$ tsf, $\nu = 0.2$

Soil based on boring at B-3 (the worst one), $\nu = 0.3$

depth from G.L.	N_{60}		E (tsf)	Z_{top}/b	Z_{bot}/b	$I_{top} - I_{bot}$
				I (Fraser and Wardle, 1976)		
0~5	20	$E = 7N_{60}$ For sand, Silty sand	140	0	0.03	0.0272
5~15	13		91	0.03	0.16	0.0909
15~25	31		217	0.16	0.288	0.1091
25~40	8	$E = 4N_{60}$ For Silt, Cohesive Silt sand mixtures	56	0.288	0.48	0.1636
40~50	22		154	0.48	0.61	0.0909
50~55	5		20	0.61	0.67	0.0364
55~60	30		120	0.67	0.74	0.0272

$$E_{eq} = \frac{0.5453}{\frac{0.0272}{140} + \frac{0.0909}{91} + \frac{0.1091}{217} + \frac{0.1636}{56} + \frac{0.0909}{154} + \frac{0.0364}{20} + \frac{0.0272}{120}}$$

$= 75.16$

$\doteq 75$ tsf

$$K = \frac{4}{3}\frac{E_r}{E_s}\frac{(1-\nu_s^2)t^3}{(1-\nu_r^2)b^3} = \frac{4}{3} \times \frac{242796}{75} \times \frac{(1-0.3^2)}{(1-0.2^2)} \times \frac{2.5^3}{78^3}$$

$= 0.135$

OWEIS ENGINEERING COMPUTATIONS

PROJECT NAME: South Battery Park | CALCULATED BY: SG | DATE: 2/28/20

PROJECT NUMBER: 17-NJ165-01 | CHECKED BY: Ar | DATE: 3/8/21

SHEET: 2 OF 2 | SCALE:

$$\frac{d}{b} = \frac{60-2.5}{78} = 0.737$$

For semi-infinite soil mass:

I_A (Fig 3 in Reference) = 1.0
(Center)

$$\rho_A = Pb\,\frac{(1-\nu_s^2)}{E_s}\,I_A$$

$$= \frac{1.5 \times 78 \times (1-0.3^2)}{75} \times 1.0$$

$$= 1.42 \text{ ft}$$

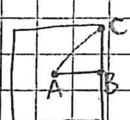
Settlement Correction S for $\frac{d}{b} = 0.737$, $K = 0.138$ (From Fig. 4 of the Reference)

$$S = 0.5$$

Settlemen at center: $\rho_A = 1.42 \times 0.5 = 0.71$ ft (8.5 inches)

Differential Settlement: $I_{AB} = 0.14 \Rightarrow \rho_{AB} = 0.199$ ft

$I_{AC} = 0.28 \Rightarrow \rho_{AC} = 0.398$ ft



Settlement Correction. $S_{AB} = 0.82$

$S_{AC} = 0.80$

$\Rightarrow$ Differential settlent: $\Delta_{AB} = 0.82 \times 0.199 \times 12 = 1.96''$

$\Delta_{AC} = 0.80 \times 0.398 \times 12 = 3.82''$

4. SETTLEMENT DUE TO PARTIAL LIQUEFACTION

The settlements due to partial liquefaction for the proposed pavilion are estimated at three locations (B-3, B-5 and B-6) according to the method proposed by Tokimatsu and Seed (1987) [Evaluation of Settlements in Sands due to Earthquake Shaking, *Journal of Geotechnical Engineering*, 1987, Vol.113, No. 8.]. Based on the calculation the partial liquefaction induced settlements for the proposed pavilion range from 0.27" to 0.68". The details of the calculations are presented as follows:

Table 1: Settlement Due to Partial Liquefaction at B-3 (After Tokimatsu and Seed, 1987)

Depth (ft)	Thickness (ft)	Normalized Stress Ratio[1]	$(N_1)_{60}$	Vol. Strain (%)[2]	Settlement (in)
18.5~23.5	5	0.68	14	0.025	0.02
23.5~28.5	5	1.07	6	1	0.60
28.5~33.5	5	0.88	10	0.15	0.06
				Total (inches)=	**0.68**

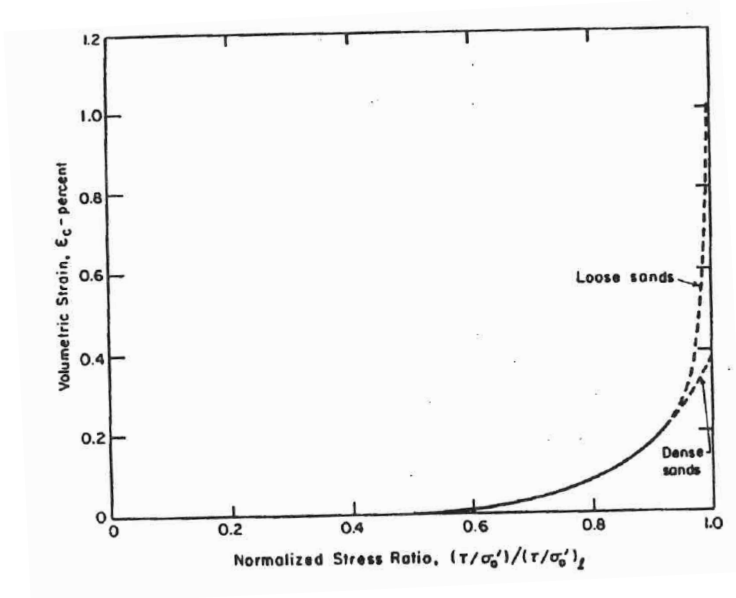
Table 2: Settlement Due to Partial Liquefaction at B-5 (After Tokimatsu and Seed, 1987)

Depth (ft)	Thickness (ft)	Normalized Stress Ratio[1]	$(N_1)_{60}$	Vol. Strain (%)[2]	Settlement (in)
18.5~23.5	5	0.85	10	0.12	0.07
28.5~33.5	5	0.95	8	0.28	0.17
33.5~38.5	5	0.74	13	0.05	0.03
				Total (inches)=	**0.27**

Table 3: Settlement Due to Partial Liquefaction at B-6 (After Tokimatsu and Seed, 1987)

Depth (ft)	Thickness (ft)	Normalized Stress Ratio[1]	$(N_1)_{60}$	Vol. Strain (%)[2]	Settlement (in)
13.5~18.5	5	0.71	12	0.03	0.02
18.5~23.5	5	1.01	7	1	0.60
28.5~33.5	5	0.77	12	0.07	0.04
				Total (inches)=	**0.66**

Notes: [1] Partial liquefaction assumed in stratum with FS<1.5.



[2] Relationship between Volumetric Strain and Normalized Stress Ratio for Saturated Clean Sands (Tokimatsu and Seed, 1987)

5. SUMMARY OF RESULTS

Considering the footing dimensions of 78ft.×78ft.×2.5ft. thick for the proposed area of 6, 000 s.f. and the average proposed grade at El. 15.0, the estimated maximum settlement occurring at center of the mat based on the most critical surface condition is approximate 8.5 inches. The proposed mat foundation would experience a differential settlement of approximately 2 inches and 4 inches between the center and mid-edge of mat and between center and corner of mat, respectively.

The estimated settlements due to partial liquefaction for the proposed pavilion, which were estimated at the three locations (B-3, B-5 and B-6) according to the method proposed by Tokimatsu and Seed (1987) *[Evaluation of Settlements in Sands due to Earthquake Shaking, Journal of Geotechnical Engineering, 1987, Vol.113, No. 8.]*, range from 0.3" to 0.7".

FRASER, R. A. & WARDLE, L. J. (1976). *Géotechnique* **26**, No. 4, 613–630.

Numerical analysis of rectangular rafts on layered foundations

R. A. FRASER* and L. J. WARDLE*

The behaviour of perfectly smooth, uniformly loaded rectangular rafts of any rigidity resting on a homogeneous elastic layer which is underlain by a rough rigid base is analysed. Graphical solutions are presented which enable the determination of vertical displacement at the centre, mid-edges and corner of the raft, and the maximum bending moment in the raft. The solutions have been obtained by the finite element method with the interaction between raft and finite soil layer being incorporated through the use of surface elements. A weighting method is presented which allows an approximate isotropic modulus to be derived for a multi-layered soil permitting the solutions to be applied to multi-layered foundations. Variations in raft rigidity and length/breadth ratio and soil layer depth and Poisson's ratio can markedly effect both displacements and bending moments in raft foundations.

On analyse le comportement de radiers rectangulaires parfaitement lisses, chargés uniformément, de n'importe quelle rigidité, reposant sur une couche élastique homogène située au-dessus d'une base rugueuse, rigide. Des solutions graphiques sont présentées qui permettent la détermination du déplacement vertical au centre, au milieu des bords et aux coins du radier, et du moment de flexion maximum dans le radier. Les solutions ont été obtenues par la méthode des éléments finis, l'interaction entre radier et la couche de sol d'épaisseur finie étant prise en compte en utilisant des éléments de surface. Une méthode de pesanteur est présentée, qui permet d'obtenir un module isotrope approximatif pour un sol à couches multiples permettant aux solutions d'être appliquées aux fondations sur couches multiples. Les variations de la rigidité des radiers, du rapport longueur/largeur, de la profondeur de la couche du sol et du coefficient de Poisson peuvent affecter d'une façon marquée aussi bien les déplacements que les moments de flexion dans les radiers.

The designer of rectangular raft foundations has very little information readily available for the estimation of both total and differential settlements and maximum bending moments in the preliminary design phase. Computer programs, e.g. FOCALS (Wardle and Fraser, 1975) are now available which will consider superstructure/raft/soil interaction, but these require the input of raft thickness from a preliminary design for the final detailed design.

A crude estimate of maximum differential settlement across a raft and total settlement of the raft can be made using available solutions for uniformly loaded rectangular areas on finite elastic layers.

At one extreme full flexibility can be assumed. In this case Ueshita and Meyerhof (1968) and Milovic and Tournier (1971) have presented information on the displacement at the corner of a uniform rectangular load on an elastic layer of finite thickness overlying a rough rigid base. Thus central and differential settlements can be conservatively estimated. At the other extreme of a rigid raft, Giroud (1972) proposed that the average settlement over a uniformly loaded rectangular area on an elastic layer represented the settlement of a rigid rectangular load, and presented appropriate tables of average settlements. However, this technique gives no information about raft thickness for detailed design of a raft of intermediate flexibility.

Discussion on this Paper closes 1 March, 1977. For further details see page 648.

* *CSIRO, Division of Applied Geomechanics, Melbourne, Australia.*

NOTATION

t	raft thickness
b	raft breadth
l	raft length ($l \geqslant b$)
K	raft stiffness factor
d	soil layer depth
ν_r	Poisson's ratio of raft
ν_s	Poisson's ratio of soil
E_r	modulus of elasticity of raft
E_s	modulus of elasticity of soil
E^*	$=E/(1-\nu^2)$
p	applied uniform load
ρ	settlement
I	settlement influence factor
S	settlement correction factor for finite layer thickness
m	bending moment per unit width
M	bending moment influence factor
R	bending moment correction factor for finite layer thickness
n	number of plate finite elements
$E_{h,\,v}$	cross-anisotropic elastic moduli (eqns 9)
$\nu_{hv,\,vh,\,h}$	cross-anisotropic Poisson's ratios (eqns 9)
f	cross-anisotropic shear modulus (eqns 9)
$\epsilon_{x,\,y,\,z}$	direct strain components
$\gamma_{xy,\,xz,\,yz}$	shear strain components
$\sigma_{x,\,y,\,z}$	direct stress components
$\tau_{xy,\,xz,\,yz}$	shear stress components
$a_{11,\,33,\,13}$	cross-anisotropic elastic constants (eqns 12)
α	cross-anisotropic elastic constant (eqns 12)

For rigid raft foundations on a semi-infinite elastic soil layer there are solutions available for contact stress, bending moment and shear force. Gorbunov-Possadov and Serebrjanyi (1961) have presented solutions for contact pressure and bending moment for a square slab subject to a central concentrated load. Butterfield and Banerjee (1971) have given solutions for settlement and contact pressure for rigid rectangular rafts. Brown (1972) obtained solutions for contact pressure and bending moment in rigid, square and rectangular rafts subject to various combinations of concentrated loads. Chan and Cheung (1974) have given values of contact pressure for rectangular and circular rigid footings due to concentric and eccentric loading. These solutions enable an estimate to be made of the bending moment in a rigid footing.

In this Paper, numerical solutions are presented for the displacements and maximum bending moments for uniformly loaded raft foundations of arbitrary flexibility on a homogeneous isotropic elastic layer of finite thickness overlying a rough rigid base. The Appendix shows how the results for the isotropic semi-infinite medium can be applied to a cross-anisotropic semi-infinite medium.

Details of how the graphical solutions presented can provide approximate solutions for multi-layered media are also given.

METHOD

The first satisfactory solutions for square rafts of arbitrary flexibility were obtained by Cheung and Zienkiewicz (1965). The stiffness of the soil was derived from the Boussinesq equation and combined with plate bending finite elements to form a stiffness matrix for the whole system. The displacements were solved using the finite element method. Cheung and Nag (1968) used a similar technique to allow for horizontal contact pressures beneath the raft, and for uplift between the plate and soil. Svec and Gladwell (1973) improved the method of Cheung and Zienkiewicz by assuming a continuous contact pressure distribution, described by a third degree polynomial, under each plate finite element. They also developed a 10-node triangular plate bending element specifically for contact problems.

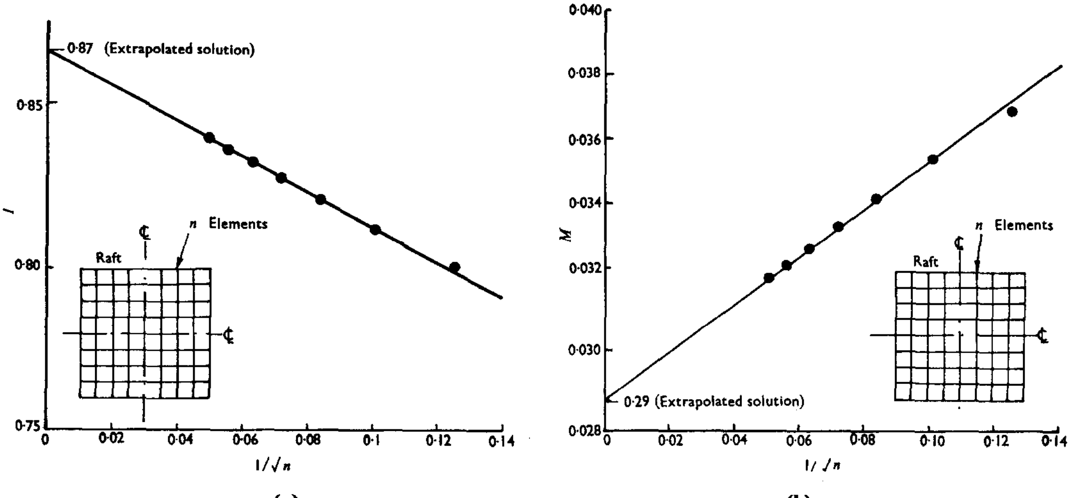


Fig. 1. Convergence of solutions for rigid square raft: (a) settlement; (b) maximum bending moment

Wardle and Fraser (1974) extended the approach of Cheung and Zienkiewicz to a multi-layered soil system, investigating the effects of a finite homogeneous soil layer and a soil modulus that increased linearly with depth. The results presented in this Paper have been derived using the computer program FOCALS (Wardle and Fraser, 1975). The computer program performs a static elastic analysis of rafts of arbitrary rigidity and variable thickness resting on a layered soil mass. The response of the loaded area of the soil system is modelled using surface elements (Wardle and Fraser, 1975). The surface element stiffness matrix is derived from the surface settlements due to uniformly loaded rectangular areas, obtained using integral transform techniques (Gerrard and Harrison, 1971). The layered soil mass consists of any number of horizontal layers of uniform thickness, with infinite lateral extent. The bottom layer may rest on a rigid base or extend to infinite depth.

The surface element approach offers many advantages over conventional three-dimensional finite elements. Only the portion of the surface of the soil mass that is loaded needs to be discretized; for conventional finite elements the whole volume of soil needs to be discretized, leading to many degrees of freedom and the imposition of artificial boundary conditions. A comparison between both methods applied to a square raft on a finite layer indicated that the degrees of freedom and band width modelled using surface elements were much smaller than for brick elements and the total solution time was smaller by a factor of 20 (Wardle and Fraser, 1974).

The raft (and any superstructure) is modelled using conventional finite elements. The computer program can also consider rafts that are not rectangular in plan or which contain cut-outs. In addition, cross-anisotropic soil properties can be used. Consideration of anisotropy is particularly important for overconsolidated soils where the deformation moduli in the vertical and horizontal directions are different and the independent shear modulus is lower than expected from isotropic theory (Gerrard *et al.*, 1972).

For simplicity of analysis the contact between the raft and the soil is assumed to be frictionless. Hooper (1974) indicated that the presence of an adhesive interface between the raft and the soil can significantly reduce differential raft displacements. For a uniformly loaded

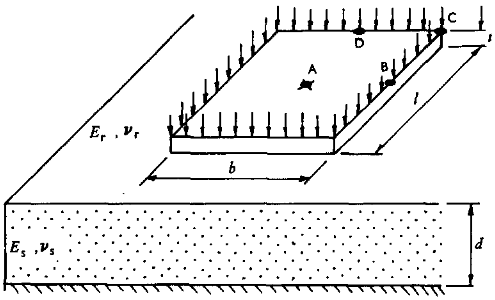


Fig. 2. Rectangular raft on homogeneous layer

fully flexible circular raft resting on a semi-infinite soil mass with Poisson's ratio, ν_s, equal to 0, central settlement is reduced by 16% and differential settlement by 44% when full adhesion is considered. For a completely rigid circular raft full adhesion leads to a 9% reduction in settlement for $\nu_s=0$. When $\nu_s=0{\cdot}5$, no lateral surface displacements occur under the raft and the adhesive and frictionless cases give identical results. Hooper (1975) demonstrated similar behaviour for a cross-anisotropic half-space. In practice, interfacial slip will limit the extent of these reductions.

ACCURACY OF ANALYSIS

The accuracy of the solutions was found to depend markedly on the degree of discretization used. The effect which varying the number of plate elements has on the convergence of the displacements and bending moments is illustrated in Fig. 1, for a rigid square raft on a semi-infinite soil mass. The results for a range of meshes are plotted against $n^{-1/2}$, where n is the number of plate elements for the whole raft. (Only one quarter of the raft was used in the computer analysis.) For $n > 36$, the results fall on a straight line. The correct solution is assumed to be given by extrapolation of the straight line to the limit $n^{-1/2}=0$. All of the problems examined in this Paper exhibited similar behaviour. To maximize the accuracy of the solutions, this extrapolation technique has been used throughout.

Confirmation of the likely accuracy of the extrapolated solutions is given by comparison with other published solutions for the settlement of a uniformly loaded square rigid raft on a semi-infinite soil mass. The extrapolated solution obtained from Fig. 1 is $I=0{\cdot}87$. By comparison, Gorbunov-Possadov and Serebrjanyi (1961) give $I=0{\cdot}88$ and Absi (1970) gives $I=0{\cdot}87$.

INFLUENCE CHARTS

Graphical solutions for the settlements and bending moments in a uniformly loaded rectangular raft are presented in this section. The supporting soil system consists of a homogeneous isotropic layer of thickness d resting on a rigid base (Fig. 2).

The stiffness factor for the system is defined by:

$$K=\frac{4}{3}\frac{E_r(1-\nu_s^2)}{E_s(1-\nu_r^2)}\frac{t^3}{b^3} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where E_r is the modulus of elasticity of the raft, ν_r is the raft Poisson's ratio, E_s is the modulus of elasticity of the soil, ν_s is the soil Poisson's ratio, t is the raft thickness and b is the raft width.

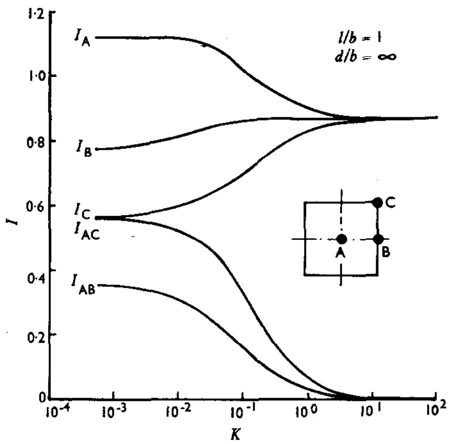


Fig. 3. Settlement influence factor I for $d/b=\infty$, ($l/b=1$)

The settlements are given by:

$$\rho = pb\frac{(1-\nu_s^2)}{E_s}I \qquad (2)$$

where p is the applied uniform pressure and I is the influence factor for the settlement of the raft

ρ and I can have the following typical subscripts: A, associated with central settlement (point A, Fig. 2) and AB, associated with differential settlement between centre (point A) and mid-edge (point B) (Fig. 2).

The maximum bending moment per unit width is given by

$$m = plbM \qquad (3)$$

where l is the raft length ($l > b$) and M is the influence factor for the maximum bending moment in a raft. M has the following typical subscript: AB, denoting bending about axis AB.

Because of the concave shape of the displacement profile, caused by the assumption of uniform loading, the maximum bending moments are always positive, i.e. tension at the base of the raft. In general the maximum bending moment occurs at the centre of the raft, but as the raft stiffness approaches fully flexible, the maximum bending moment moves towards the edge of the raft.

Displacement, differential displacement and bending moment influence factor values for a semi-infinite layer may be read directly from the charts and used in eqns (2) and (3).

For raft foundations with l/b ratios of 1 and 2 correction factors are also provided to correct for the effect of a finite layer depth.

In this case the displacement is given by:

$$\rho = S\rho^{si} \qquad (4)$$

where ρ^{si} is the displacement for a semi-infinite soil mass and S is a correction factor for the effect of the finite layer depth d. (For a semi-infinite soil mass S equals unity.)

Similarly the maximum bending moment is given by:

$$m = Rm^{si} \qquad (5)$$

where m^{si} is the maximum bending moment for a semi-infinite soil mass and R is a correction factor for the effect of the finite layer depth d.

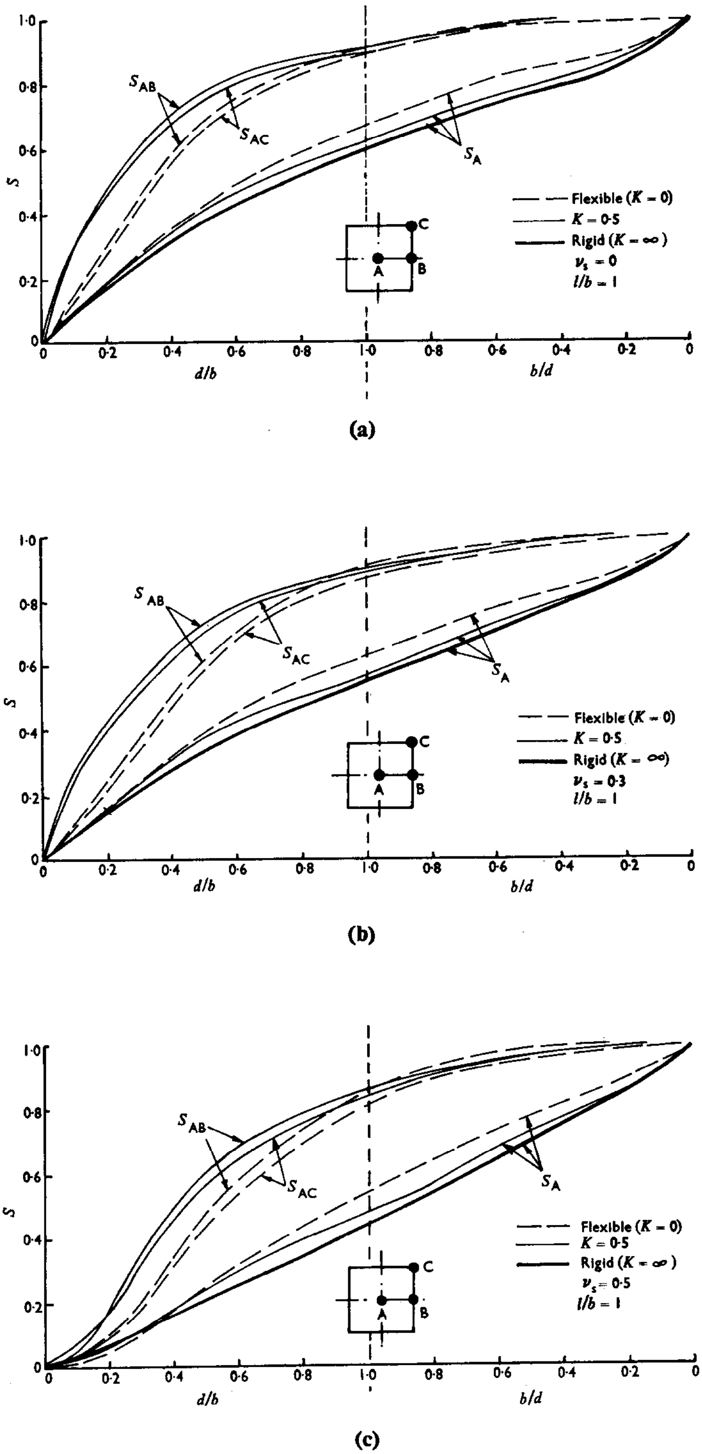


Fig. 4. Settlement correction factor $S(l/b=1)$: (a) $\nu_s=0$; (b) $\nu_s=0{\cdot}3$; (c) $\nu_s=0{\cdot}5$

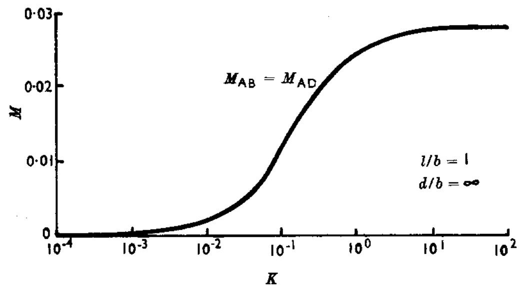


Fig. 5. Bending moment influence factor M for $d/b=\infty$, ($l/b=1$)

Charts for $l/b=1$

Values of settlement influence factor I are given in Fig. 3 and correction factors, S, for finite layer depth in Fig. 4. The corresponding bending moment influence factor M and correction factors, R, are given in Figs 5 and 6.

The effects on the finite layer depth are clearly demonstrated by Figs 4 and 6. For a layer thickness equal to the raft width, predictions of total settlement differ by as much as 55%, differential settlement by 18% and maximum bending moment by 15% when compared with a semi-infinite soil mass. In general, the effect of finite layer depth becomes greater as Poisson's ratio approaches 0·5. The relative stiffness factor K of the raft–soil system is a major factor in determining its performance. Note that from eqn (1), with other factors kept constant, K is proportional to the ratio of the raft modulus to the soil modulus. Therefore while a raft founded on rock may behave flexibly, the same raft founded on soft clay would behave rigidly.

From Figs 3 and 5 it can be seen that the most rapid change in performance is the range $0{\cdot}05<K<0{\cdot}5$.

A system with K less than 0·01 can be considered fully flexible. That is, decreasing the raft thickness below the value associated with K equal to 0·01 produces only a very small difference in the overall performance of the system. Similarly, a system with K greater than unity can be considered fully rigid, and increasing raft thickness will have little effect on performance.

Charts for $l/b=2$

The influence charts for $l/b=2$ (Figs 7–10) are similar to those for $l/b=1$ (Figs 3–6). Again the most rapid change in performance is in the range $0{\cdot}05<K<0{\cdot}5$, and the effect of finite layer depth becomes greatest as Poisson's ratio approaches 0·5.

The effect of finite layer thickness is greater than for the case $l/b=1$. Considering the effect of a finite layer of thickness b beneath such a raft, it is found that central settlement can be decreased by 63%, differential displacement by 50% and bending moment by 20% in the short direction and by 45% in the long direction from the values for a semi-infinite soil mass.

Charts for $3<l/b<5$

In situations where the l/b value exceeds 2 and consequently falls outside the range of the influence charts in Figs 3 to 10, the charts in Figs 11–16 can be used to provide an estimate of settlement, differential settlement and bending moment.

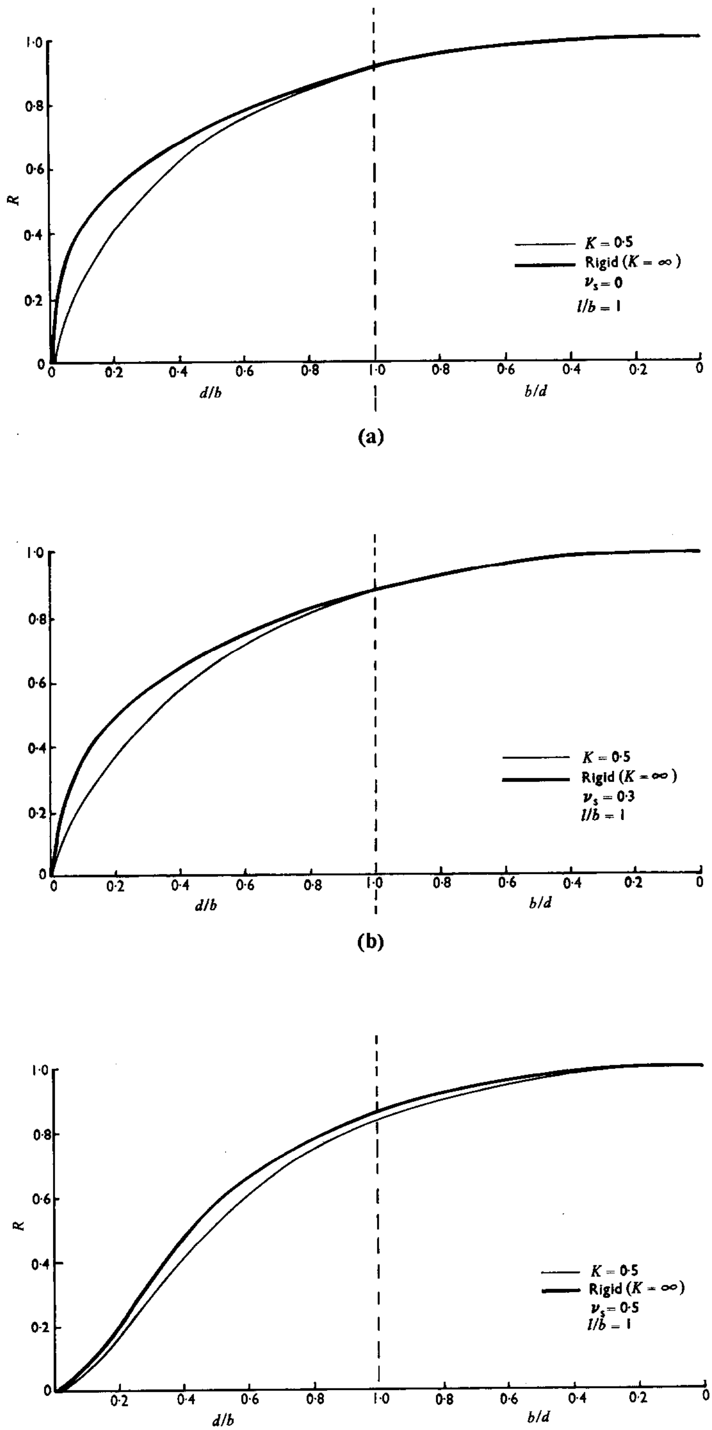


Fig. 6. Bending moment correction factor $R(l/b=1)$: (a) $\nu_s=0$; (b) $\nu_s=0{\cdot}3$; (c) $\nu_s=0{\cdot}5$

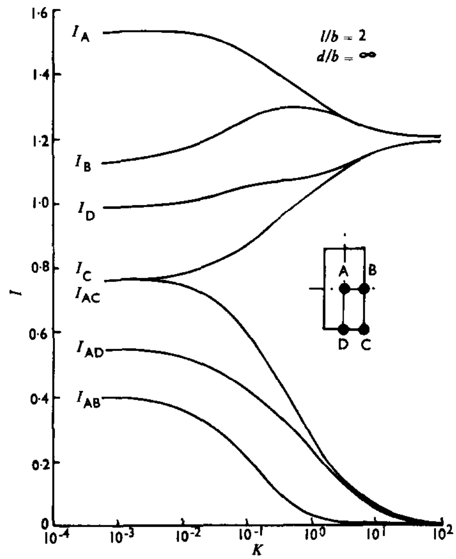


Fig. 7. Settlement influence factor I for $d/b = \infty$, ($l/b = 2$)

Figure 11 gives influence coefficients for central displacement for l/b values in the range 1 to 5 for a semi-infinite medium ($d/b = \infty$) and Fig. 12 gives similar curves for $d/b = 1$. Although the actual curves for $3 < l/b < 5$ do not actually coincide, the line drawn is accurate to within $\pm 5\%$. Figs 13 and 14 give similar influence coefficients for differential displacement. Fig. 14 provides values of I_{AB}, I_{AC}, I_{AD} directly for $3 \leqslant l/b \leqslant 5$. The curves for these values of l/b do not coincide exactly but are accurate within $\pm 5\%$. Figs 15 and 16 provide values of maximum bending moment M for d/b equal to infinity and 1 respectively. In Fig. 16 values for $\nu_s = 0{\cdot}3$ only are given. For K values ranging from flexible to $K = 1$ they are accurate for all positive values of Poisson's ratio to within $\pm 10\%$ and for $1 \leqslant K \leqslant 10$ to within $\pm 30\%$. For $\nu_s = 0$ the value indicated increases, and for $\nu_s = 0{\cdot}5$ it decreases.

For values of d/b not equal to 1 or ∞, the influence coefficients can be obtained by interpolation. Charts similar to those in Figs 4, 6, 8 and 10 should be constructed by drawing a smooth curve of similar shape through the influence coefficient points for $d/b = 0$, 1 and ∞.

NUMERICAL EXAMPLE

Consider a square raft foundation of dimensions 10 m by 10 m and 0·5 m thick, subject to a uniform load of 0·1 MPa resting on a soil layer of thickness $d = 40$ m. The raft Young's modulus, E_r, is 15 000 MPa and Poisson's ratio $\nu_r = 0{\cdot}2$, and for the soil the values are $E_s = 83{\cdot}2$ MPa and $\nu_s = 0{\cdot}3$. Using $E_r = 15\,000$ MPa, $\nu_r = 0{\cdot}2$, $t = 0{\cdot}5$ m, $b = 10{\cdot}0$ m, $E_s = 81{\cdot}9$ MPa, $\nu_s = 0{\cdot}3$, eqn (1) gives $K = 0{\cdot}0289$.

Central settlement

For a semi-infinite soil mass, Fig. 3 gives $I_A^{si} = 1{\cdot}10$. Eqn (2) then gives:

$$\rho_A^{si} = pb\,\frac{(1 - \nu_s^2)}{E_s}\,I_A^{si}$$

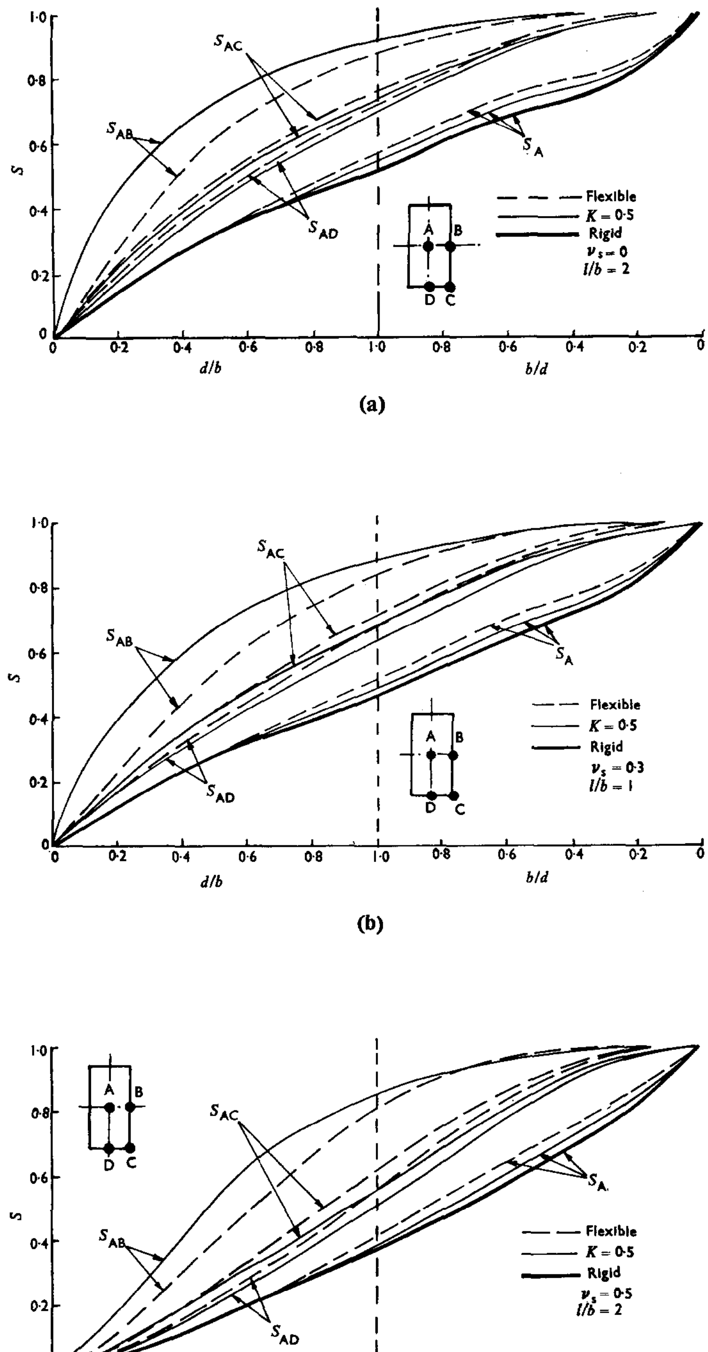


Fig. 8. Settlement correction factor $S(l/b=2)$: (a) $\nu_s=0$; (b) $\nu_s=0{\cdot}3$; (c) $\nu_s=0{\cdot}5$

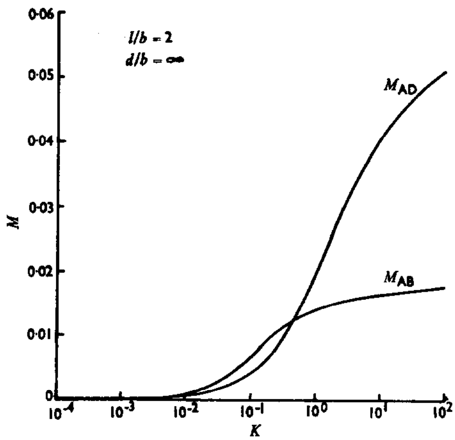


Fig. 9. Bending moment influence factor M for $d/b=\infty$, $(l/b=2)$

$$= \frac{0{\cdot}1 \times 10{\cdot}0 \times 0{\cdot}91 \times 1{\cdot}10}{81{\cdot}9}$$
$$= 0{\cdot}0122 \text{ m}$$

The correction factor S for the effect of the finite layer depth is obtained from Fig. 4(b). Since $K=0{\cdot}0289$ represents a very flexible raft, $S_A=0{\cdot}88$ for $d/b=4{\cdot}0$. Eqn (4) then gives:

$$\rho_A = S_A \rho_A^{si}$$
$$= 0{\cdot}88 \times 0{\cdot}0122$$
$$= 0{\cdot}0107 \text{ m}$$

Differential settlement

From Fig. 3, $I_{AB}=0{\cdot}26$, giving $\rho_{AB}^{si}=0{\cdot}0029$. Multiplying by the correction factor, $S_{AB}=1{\cdot}00$ gives:

$$\rho_{AB} = 0{\cdot}0029 \text{ m}$$

Maximum bending moment

For a semi-infinite soil mass, Fig. 5 gives $M^{si}=0{\cdot}005$, and from eqn (3)

$$m^{si} = 0{\cdot}1 \times 10{\cdot}0 \times 10{\cdot}0 \times 0{\cdot}005$$
$$= 0{\cdot}05 \text{ MN m/m}$$

From Fig. 6(b), the correction factor R for the effect of the finite layer thickness is 1·00. Eqn. (5) then gives

$$m = 1{\cdot}00 \times 0{\cdot}05$$
$$= 0{\cdot}05 \text{ MN m/m}$$

RESULTS FOR MULTI-LAYERED SYSTEMS

Although the computer model program FOCALS can explicitly consider multi-layered systems, an approximate graphical design method is needed for many routine design problems. By weighting the elastic parameters of each layer in a multi-layered system according to its influence on settlement an 'equivalent' modulus and Poisson's ratio can be determined for

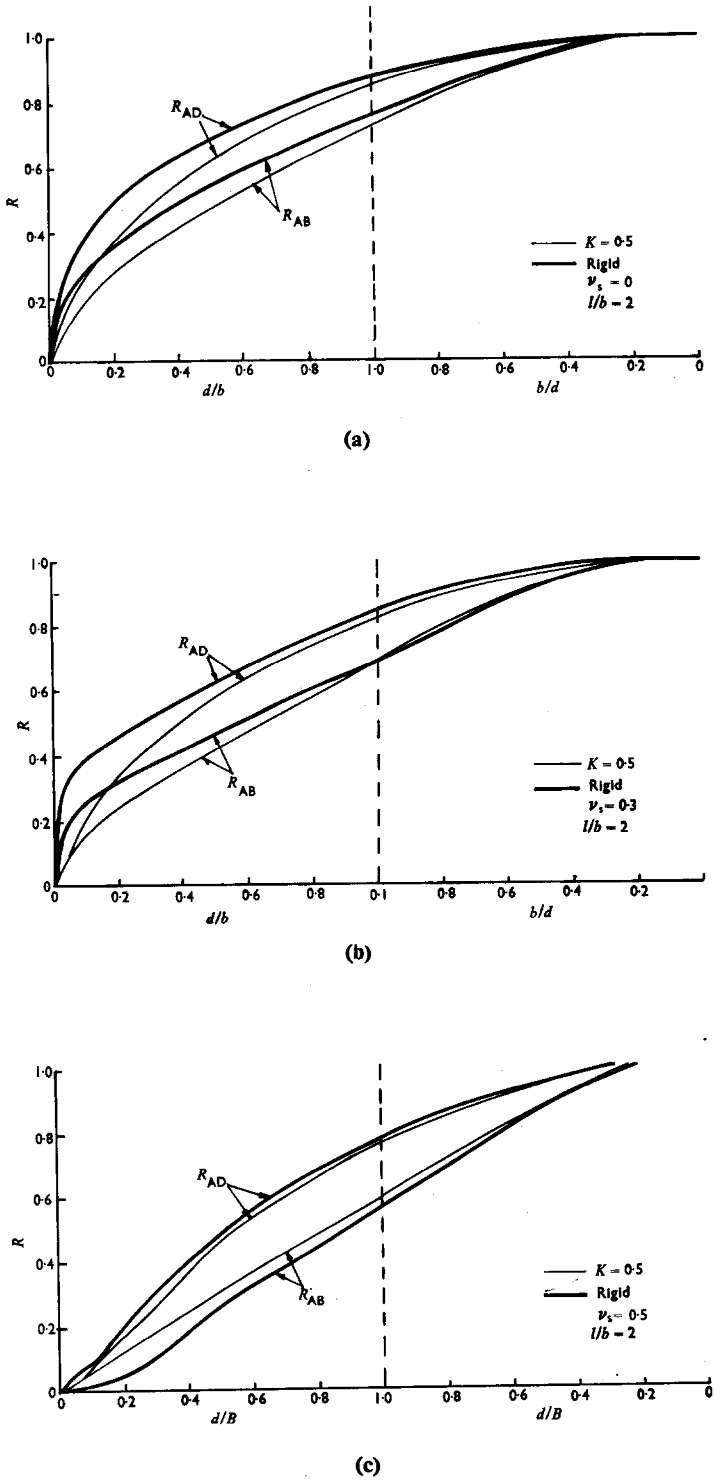
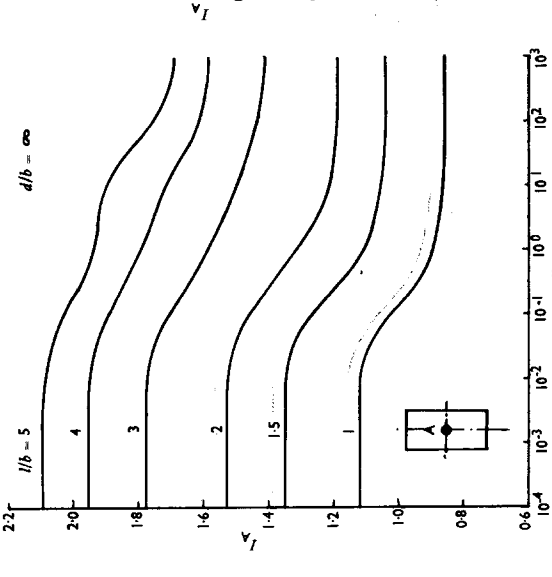
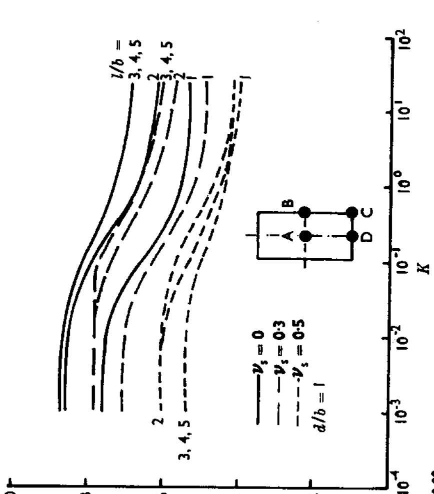
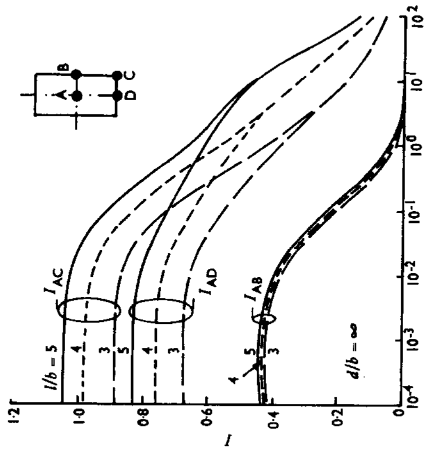
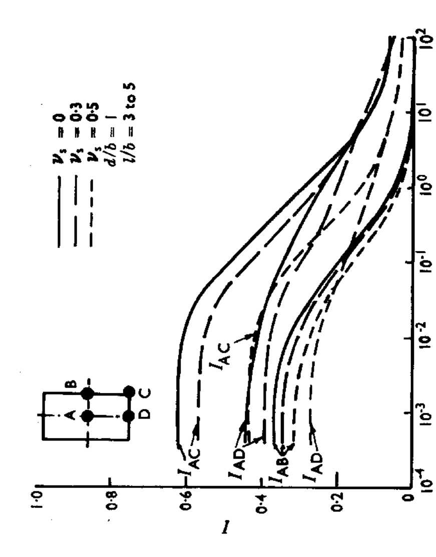


Fig. 10. Bending moment correction factor $R(l/b=2)$: (a) $\nu_s=0$; (b) $\nu_s=0{\cdot}3$; (c) $\nu_s=0{\cdot}5$









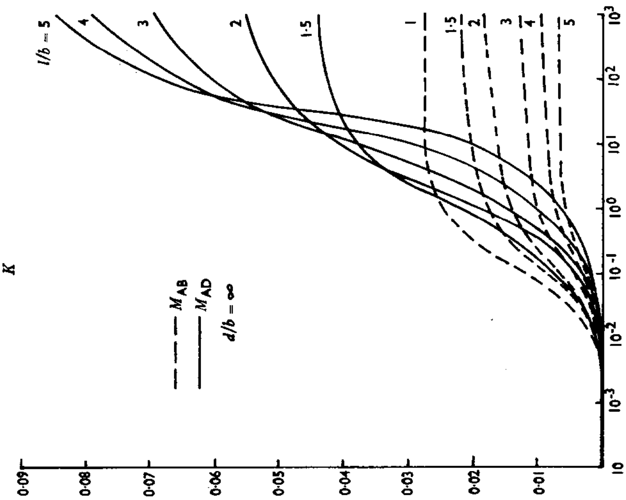


Fig. 11 (above left). Settlement influence factor I_A for $d/b=\infty$, $(l/b \leq 5)$

Fig. 12 (above centre). Settlement influence factor I_A for $d/b=1$, $(l/b \leq 5)$

Fig. 13 (above right). Differential settlement influence factors I_{AB}, I_{AC}, I_{AD} for $d/b=\infty$, $(3<l/b<5)$

Fig. 14 (far left). Differential settlement influence factors I_{AB}, I_{AC}, I_{AD} for $d/b=1$, $(3<l/b<5)$

Fig. 15 (left). Bending moment influence factor M for $d/b=\infty$, $(l/b \leq 5)$

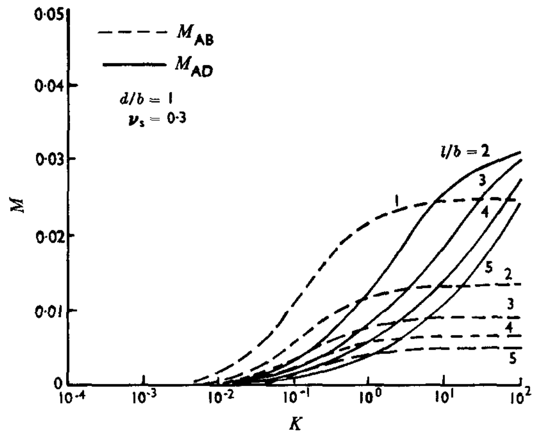


Fig. 16. Bending moment influence factor M for $d/b = 1$, ($l/b \leq 5$)

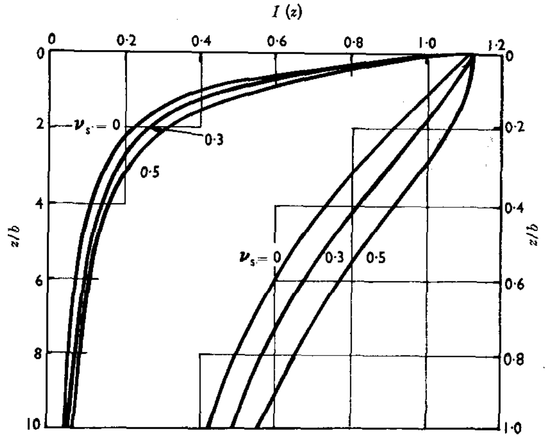


Fig. 17. Vertical settlement influence factor

the overall system. The equivalent elastic parameters can then be used to obtain solutions from eqns (2) and (3).

The approximate equivalent elastic parameters can be obtained as follows. The vertical settlement at depth z below the centre of a uniformly loaded square flexible raft is given by Harr (1966)

$$\rho(z) = pb\frac{(1-\nu^2)}{E}I(z) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

where $I(z)$ is plotted in Fig. 17.

By assuming that the vertical deformation of a layer i in an n-layered system is approximately equal to the deformation of that layer in a system where all layers have been replaced by material from layer i, the settlement contribution of that layer can be approximated using eqn (6). Summing these contributions for n layers the total settlement can be equated to the settlement for an equivalent single homogeneous layer, and the equivalent modulus $\bar{E}$ and equivalent Poisson's ratio are given by

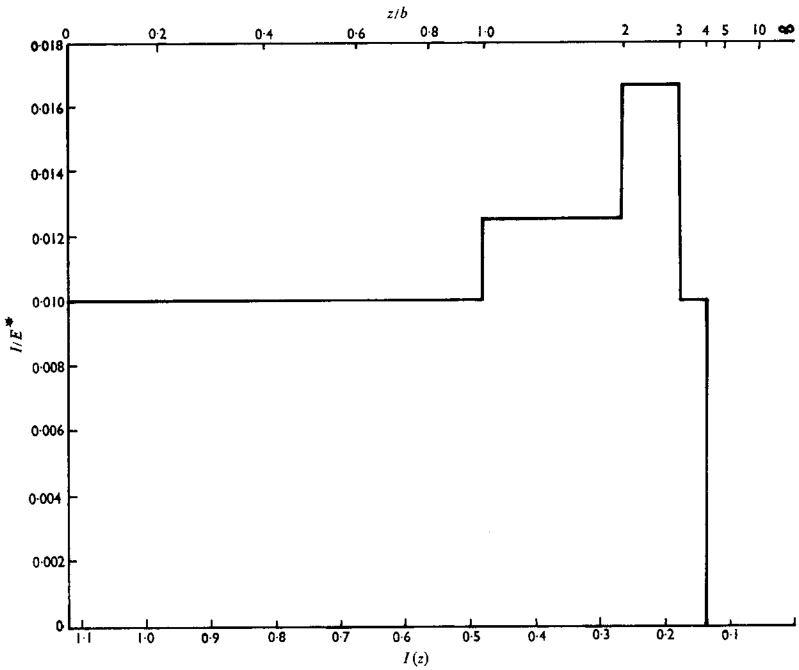


Fig. 18. Variation of $1/E^*$ with depth z/b

$$\frac{1}{\bar{E}^*} = \sum_{i=1}^{n} \frac{1}{E^*_i} \Delta I^i / \Delta I^{\text{total}} \qquad \text{(7a)}$$

and

$$\bar{\nu} = \sum_{i=1}^{n} \nu_i \Delta I^i / \Delta I^{\text{total}} \qquad \text{(7b)}$$

where $E^* = E/(1-\nu^2)$.

E^*_i, ν_i are the elastic parameters for layer number i in the n-layered system, and $\Delta I^i = I(z^i_{\text{top}}) - I(z^i_{\text{bottom}})$ where z^i_{top}, z^i_{bottom} are the depths below the surface of the top and bottom of layer number i, and $\Delta I^{\text{total}} = I(0) - I(d)$ where d is the depth of the base of the bottom layer.

The task of determining the equivalent modulus is simplified by plotting values of $1/E^*_i$ using a horizontal scale which is linear with respect to $I(z)$, but for convenience is labelled with values of z/b (see Fig. 18). The value of $1/\bar{E}^*$ is then simply the 'average' value of $1/E^*$, weighted according to the special horizontal scale.

For a system with unequal Poisson's ratios, $\bar{\nu}$ can be obtained by plotting ν against z/b using the special scale provided in Fig. 18.

For a system with all Poisson's ratios equal, $\bar{\nu} = \nu_i$ and eqn (7a) becomes

$$\frac{1}{\bar{E}} = \sum_{i=1}^{n} \frac{1}{E_i} \Delta I^i / \Delta I^{\text{total}} \qquad \text{(8)}$$

An example that demonstrates the approximate method follows; the example consists of a square raft and four different soil layers resting on a rigid base (Fig. 19). The variation of $1/E^*$ is plotted against the special z/b scale as shown on Fig. 18. Summing the areas under the curve gives

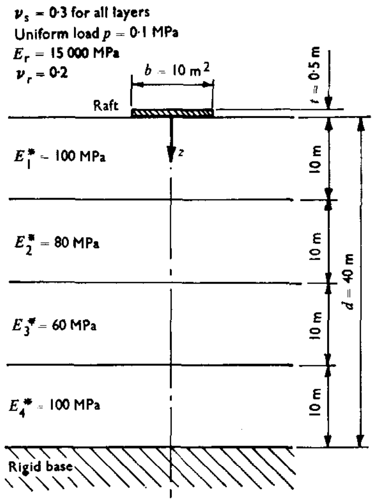


Fig. 19. Details of example

$$\text{Area} = \frac{1{\cdot}12-0{\cdot}48}{100{\cdot}0}+\frac{0{\cdot}48-0{\cdot}26}{80{\cdot}0}+\frac{0{\cdot}26-0{\cdot}18}{60{\cdot}0}+\frac{0{\cdot}18-0{\cdot}14}{100{\cdot}00} = 0{\cdot}01088$$

Giving

$$\bar{E}^*{}_s = \frac{1{\cdot}12-0{\cdot}14}{0{\cdot}01088} = 90{\cdot}0 \text{ MPa}$$

and since ν of each of the layers equals 0·3, $\bar{\nu}=0{\cdot}3$ giving $\bar{E}_s=81{\cdot}9$ MPa.

The approximate settlements and maximum bending moment for the multi-layered medium are obtained by considering a homogeneous layer with the 'equivalent' elastic parameters $E_s=81{\cdot}9$ MPa and $\nu_s=0{\cdot}3$. The same rigid base depth ($d/b=4{\cdot}0$) is used for both the actual medium and the 'equivalent' medium. The results for the settlements and maximum bending moment of the equivalent medium (these were determined in the numerical example presented earlier) are given below. The quantities in brackets are the exact results obtained from the computer model.

Central settlement, ρ_A = 0·0107 m (0·0114 m)
Differential settlement, ρ_{AB} = 0·0029 m (0·0027 m)
Maximum bending moment, m = 0·050 MN m/m (0·044 MN m/m)

CONCLUSIONS

Graphical solutions for settlements, differential settlements and maximum bending moment for uniformly loaded rectangular rafts of arbitrary rigidity have been presented.

The relative stiffness factor K of the raft–soil system is a major factor in determining its performance.

The detailed variation of soil properties with depth must be taken into account in a rational raft design. For example, for a square raft on a layer thickness equal to the raft width, predictions of total settlement differ by as much as 55%, differential settlement by 18% and maximum bending moment by 15%, when compared with solutions for a semi-infinite soil.

By weighting the elastic parameters of a multi-layered soil system according to their approximate contribution to vertical settlement, an approximate 'equivalent' modulus can be obtained. Hence the solutions for a single soil layer can be used for multi-layer systems.

The solutions for uniformly loaded rafts presented should be adequate for preliminary design purposes. However, for a complete analysis, taking into account actual column loads and superstructure rigidity, a computer program such as FOCALS must be used.

ACKNOWLEDGEMENT

Thanks are due to Mr G. Bonner for assistance with the computational work.

APPENDIX: CROSS-ANISOTROPIC SEMI-INFINITE MEDIUM

The results presented for the isotropic semi-infinite medium can also be applied to a cross-anisotropic semi-infinite medium. The stress–strain relationships for a cross-anisotropic material whose axis of elastic symmetry (z) is vertical can be written

$$\left.\begin{aligned}\epsilon_x &= \frac{\sigma_x}{E_h} - \nu_h \frac{\sigma_y}{E_h} - \nu_{vh}\frac{\sigma_z}{E_v}\\ \epsilon_y &= -\nu_h\frac{\sigma_x}{E_h} + \frac{\sigma_y}{E_h} - \nu_{vh}\frac{\sigma_z}{E_v}\\ \epsilon_z &= -\nu_{hv}\frac{\sigma_x}{E_h} - \nu_{hv}\frac{\sigma_y}{E_h} + \frac{\sigma_z}{E_v}\\ \gamma_{xy} &= (1+\nu_h)\frac{\tau_{xy}}{E_h}\\ \gamma_{xz} &= \frac{\tau_{xz}}{f}\\ \gamma_{yz} &= \frac{\tau_{yz}}{f}\end{aligned}\right\} \quad (9)$$

The two Poisson's ratios ν_{hv} and ν_{hv} are related by

$$\nu_{vh}/E_v = \nu_{hv}/E_h \quad (10)$$

The vertical settlement $\rho(r)$ at the surface of a cross-anisotropic semi-infinite medium loaded by a concentrated vertical force P is given by Gerrard and Wardle (1973) as

$$\rho(r) = \frac{\alpha(a_{11}a_{33})^{1/2}}{a_{11}a_{33}-a_{13}^2}\frac{P}{\pi r} \quad (11)$$

where r is the distance from the load to the point of interest, and

$$\left.\begin{aligned}a_{11} &= E_h(1-\nu_{hv}\nu_{vh})(1+\nu_h)^{-1}(1-\nu_h-2\nu_{hv}\nu_{vh})^{-1}\\ a_{33} &= E_h\nu_{vh}(1-\nu_h-2\nu_{hv}\nu_{vh})^{-1}\\ a_{13} &= E_v(1-\nu_h)(1-\nu_h-2\nu_{hv}\nu_{vh})^{-1}\\ \alpha^2 &= [a_{11}a_{33}-a_{13}^2-a_{13}f+f(a_{11}a_{33})^{1/2}](2a_{33}f)^{-1}\end{aligned}\right\} \quad (12)$$

For an isotropic semi-infinite medium, eqn (11) becomes

$$\rho(r) = \frac{E_s}{1-\nu_s^2}\frac{P}{\pi r} \quad (13)$$

Comparison of eqns (11) and (13) shows that the vertical load/surface vertical settlement response of a given cross-anisotropic semi-infinite medium will be the same as that of an isotropic medium for which

$$\frac{E_s}{1-\nu_s^2} = \frac{\alpha(a_{11}a_{33})^{1/2}}{a_{11}a_{33}-a_{13}^2} \quad (14)$$

Using eqn (14), the results for the isotropic semi-infinite medium can be applied to cross-anisotropic semi-infinite media. Note that only the constant $E_s/(1-\nu_s^2)$ needs to be determined; actual values of E_s and ν_s are not required.

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APPENDIX H

DOWNDRAG ESTIMATION

APPENDIX H-Downdrag Estimation for Piles

SOUTH BATTERY PAR CITY RESILIENCEY
OEI PROJECT No. 17-NY165-01
CALCULATED BY: SG DATE: 2/9/2021
CHECKED BY: JM DATE: 2/23/2021

Downdrag load is the downward force induced in piles where the soil around the piles moves downward relative to the piles. According to NYSDOT Geotechnical Design Manual (11.6.2), downdrag should be evaluated on piles, shafts or other deep foundations during design when the settlement of the soil around the elements, after the elements are installed, will be be larger than 0.4 in. This appendix presents the results of downdrag estimation for deep foundation types inlcuding Micropiles, H-Piles, Closed End Pipe Piles, and Timber Piles.

Notes:

1. See Table 4 in the Geotechnical Report for generalized soil profile for pavilion foundation design.
2. Frictional model from NAVFAC DM-7.2-193 is used to estimate the downdrag on the pile due to non-liquefibles layers over the liquefiable layer, which is presented as follows:

$$DD := \int_0^z A_s \beta \sigma_z \, dz$$

where

DD = downdrag

A_s = pile skin surface area per unit length

$\beta = K_{hc} \tan\delta$, and K_{hc}=coefficient of earth pressure when pile is in compression, δ=angle of friction between soil and pile

σ_z = effective vertical stress at depth of z

3. Assume water table is at EL.0.0 for downdrag estimation.

Downdrag for Micropile

Section Properties:

Diameter =1 unit of D (D is in foot)

Strength Parameters:

$khc := 0.7$ *(for compression, Reference: DM 7.2.194)*

$delta := 20deg$ *(friction anlge beween granular soil and steel, Reference: DM 7.2.194)*

$belta := khc \cdot \tan(delta)$

$belta = 0.255$

$gamma := 125$ *(pcf, ave.saturated unit of soil for existing and new fill above EL.0.0)*

Downdrag of Each Section of Micropile:

Elevation 15~10:

$dd1 := belta \cdot \pi \cdot 5 \cdot gamma \cdot 2.5$ *(in unit of D, lbs)*

Elevation 10~0:

$dd2 := belta \cdot \pi \cdot 10 \cdot (gamma \cdot 5 + gamma \cdot 5)$ *(in unit of D, lbs)*

Elevation 0~-5:

$dd3 := belta \cdot \pi \cdot 5 \cdot (gamma \cdot 5 + gamma \cdot 10 + 55.6 \times 2.5)$

Assume horizontal pressure become constant at depth of 20ft from top of pile (DM7.2.193)

Elevation -5~-22.5:

$dd4 := 0.08 \pi \cdot 17.5 \cdot (gamma \cdot 5 + gamma \cdot 10 + 55.6 \times 5)$

$$Downdrag := \frac{(dd1 + dd2 + dd3 + dd4)}{1000}$$

$Downdrag = 28.785$ *(in unit of D, kips)*

Downdrag for Driven H Piles

Section Properties:

Diameter =1 unit of Equivalent Diameter D_{eq} (in foot), Where D_{eq} is equal to periment of selected H pile section divided by π.

Strength Parameters:

$khc := 0.8$ *(for compression, Reference: DM 7.2.194)*

$delta := 20deg$ *(friction anlge beween granular soil and steel, Reference: DM 7.2.194)*

$belta := khc \cdot \tan(delta)$

$belta = 0.291$

$gamma := 125$ *(pcf, ave.saturated unit of soil for existing and new fill above EL.0.0)*

Downdrag of Each Section of H-Piles:

Elevation 15~10:

$dd1 := belta \cdot \pi \cdot 5 \cdot gamma \cdot 2.5$ *(in unit of D_{eq}, lbs)*

Elevation 10~0:

$dd2 := belta \cdot \pi \cdot 10 \cdot (gamma \cdot 5 + gamma \cdot 5)$ *(in unit of D_{eq}, lbs)*

Elevation 0~-5:

$dd3 := belta \cdot \pi \cdot 5 \cdot (gamma \cdot 5 + gamma \cdot 10 + 55.6 \cdot 2.5)$

Assume horizontal pressure become constant at depth of 20ft from top of pile (DM7.2.193)

Elevation -5~-22.5:

$dd4 := 0.08 \pi \cdot 17.5 \cdot (gamma \cdot 5 + gamma \cdot 10 + 55.6 \cdot 5)$

$$Downdrag := \frac{(dd1 + dd2 + dd3 + dd4)}{1000}$$

$Downdrag = 31.545$ *(in unit of D_{eq}, kips)*

For HP12 by 53

$$downdragH1 := (11.8 + 12 \cdot 2) \cdot \frac{2 \cdot 31.5}{12 \cdot \pi}$$

$downdragH1 = 59.826$ *kips*

For HP12 by 63

$$downdragH2 := (11.9 + 12.1 \cdot 2) \cdot \frac{2 \cdot 31.5}{12 \cdot \pi}$$

$downdragH2 = 60.328$ *kips*

For HP12 by 74

$$downdragH3 := (12.1 + 12.2 \cdot 2) \cdot \frac{2 \cdot 31.5}{12 \cdot \pi}$$

$downdragH3 = 60.996$ *kips*

For HP12 by 84

$$downdragH4 := (12.3 + 12.3 \cdot 2) \cdot \frac{2 \cdot 31.5}{12 \cdot \pi}$$

$downdragH4 = 61.665$ *kips*

Downdrag for Closed End Pipe Pile

Section Properties:

Diameter =1 unit of D (D is in foot)

Strength Parameters:

$khc := 1.25$ *(for compression, Reference: DM 7.2.194)*

$delta := 20deg$ *(friction anlge beween granular soil and steel, Reference: DM 7.2.194)*

$belta := khc \cdot \tan(delta)$

$belta = 0.455$

$gamma := 125$

Downdrag of Each Section of Closed End Pipe Piles:

Elevation 15~10:

$dd1 := belta \cdot \pi \cdot 5 \cdot gamma \cdot 2.5$ *(in unit of D, lbs)*

Elevation 10~0:

$dd2 := belta \cdot \pi \cdot 10 \cdot (gamma \cdot 5 + gamma \cdot 5)$ *(in unit of D, lbs)*

Elevation 0~-5:

$dd3 := belta \cdot \pi \cdot 5 \cdot (gamma \cdot 5 + gamma \cdot 10 + 55.6 \cdot 2.5)$ *(in unit of D, lbs)*

Assume horizontal pressure become constant at depth of 20ft from top of pile (DM7.2.193)

Elevation -5~-22.5:

$dd4 := 0.08\pi \cdot 17.5 \cdot (gamma \cdot 5 + gamma \cdot 10 + 55.6 \cdot 5)$ *(in unit of D, lbs)*

$$Downdrag := \frac{(dd1 + dd2 + dd3 + dd4)}{1000}$$ *(in unit of D, kips)*

$Downdrag = 43.962$ *(in unit of D, kips)*

Downdrag for Timber Pile

Section Properties:

Diameter =1 unit of D (D is in foot)

D_{liq}: is the average diamater of pile within liquifiable layer, Dnonliq: is the average diameter of pile within the layer above the liquifiable layer

Strength Parameters:

$khc := 1.75$ *(for compression, Reference: DM 7.2.194)*

$delta := 25deg$ *(friction anlge beween granular soil and timber 3/4Φ (ave Φ=33deg), Reference: DM 7.2.194)*

$belta := khc \cdot \tan(delta)$

$belta = 0.816$

$gamma := 125$ *(pcf, ave.saturated unit of soil for existing and new fill above EL.0.0)*

Downdrag of Each Section of Micropile:

Elevation 15~10:

$dd1 := belta \cdot \pi \cdot 5 \cdot gamma \cdot 2.5$ *(in unit of D, lbs)*

Elevation 10~0:

$dd2 := belta \cdot \pi \cdot 10 \cdot (gamma \cdot 5 + gamma \cdot 5)$ *(in unit of D, lbs)*

Elevation 0~-5:

$dd3 := belta \cdot \pi \cdot 5 \cdot (gamma \cdot 5 + gamma \cdot 10 + 55.6 \times 2.5)$

Assume horizontal pressure become constant at depth of 20ft from top of pile (DM7.2.193)

Elevation -5~-22.5:

$dd4 := 0.08\pi \cdot 17.5 \cdot (gamma \cdot 5 + gamma \cdot 10 + 55.6 \times 5)$

$$downdragnonliq := \frac{(dd1 + dd2 + dd3)}{1000}$$

$downdragnonliq = 61.868$ *(in unit of D_{nonliq} kips)*

$$downdragliq := \frac{(dd4)}{1000}$$

$downdragliq = 9.469$ *(in unit of D_{liq} kips)*

SUMMARY OF RESULTS

The estimated downdrag on deep foundations are summarized in the following table:

Pile Type	Primary Parameter	Total Downdrag
Micropile	Ave. G.L. at EL.15 $K_h = 0.7$ $\delta = 20°$	28.8D[1] (kips)
Driven H Pile	Ave. G.L.=EL.15 $K_h = 0.8$ $\delta = 20°$	31.5 D_{eq}[2] (kips)
Displacement Pile-Closed End Pipe Pile	Ave. G.L. at EL.15 $K_h = 1.25$ $\delta = 20°$	44.0D[1] (kips)
Displacement Pile-Timber Pile	Ave. G.L.=EL.15 $K_h = 1.75$ $\delta = 25°$	61.9D_{ave1} +9.5 D_{ave2}[3] (kips)

Notes: [1] D is the outer diameter of the steel casing/pile in foot. [2] D_{eq} is the equivalent diameter of H-pile which can be estimated by perimeter of H-pile divided by pi (π). [3] D_{ave1} and D_{ave1} are the average diameter of the timber piles within the non-liquefiable layers above the liquefiable layer and the liquefiable layer, respectively.

APPENDIX I

CALCULATIONS OF PILE CAPACITY AND PILE STIFFNESS
I-1: COMPRESSIVE CAPACITY
I-2: TENSILE CAPACITY
I-3A: MICROPILE DESIGN FOR WP4~WP6
I-3B: GEOTECHNICAL LATERAL CAPACITY OF PILES
I-4: VERTICAL AND LATERAL STIFFNESS OF HP12×63

APPENDIX I-1

CALCULATIONS OF PILE CAPACITY AND PILE STIFFNESS
I-1: COMPRESSIVE CAPACITY

APPENDIX I1-Compressive Capactiy of Piles

SOUTH BATTERY PAR CITY RESILIENCEY
OEI PROJECT No. 17-NY165-01
CALCULATED BY: SG DATE: 2/9/2021
CHECKED BY: JM DATE: 2/23/2021

This appendix presents the compressive capacity of deep foundations including Closed-End Pile Piles, H-Piles, and Micropiles.

Notes:

1. See Table 4 in the Geotechnical Report for generalized soil profile for pavilion foundation design.
2. For driven piles which include H-Piles and Closed End Pipe Piles, since they are going to driven into rock, the structural capacity will control the design. Hence, only of the structural capacity of them are presented here. For the drilled micropile, both geotechnical and structural capacities are presented and compared.

Structural Capacity of Closed End Pipe Pile

Section Properties:

$od := 9 + \frac{5}{8}$ (outside Diameter in inches)

$t := 0.545$ (thickness in inches)

$yield1 := 35$ (ASTM A 252-Grade 2)

$yield2 := 45$ (ASTM A 252-Grade 3)

$id := od - 2 \cdot t$ (inside Diameter in inches)

$area := \pi \frac{\left(od^2 - id^2\right)}{4}$ (area inch square)

$area = 15.546$ (inch^2)

Allowable Stress of Steel Used for Driving $0.9 \cdot \frac{yield}{2.5}$:

Structural Capacity:

$cap1 := area \cdot yield1 \cdot \frac{0.9}{2.5}$ $cap1 = 195.886$ kips

$cap2 := area \cdot yield2 \cdot \frac{0.9}{2.5}$ $cap2 = 251.853$ kips

Structural Capacity of H-Piles

For HP 12 by 53

Section Properties:

$area1 := 15.5$ (area inch square)

$yieldh1 := 50$ (ksi, minimum yield strength)

Allowable Stress of Steel Used for Driving $0.9 \cdot \frac{yield}{2.5}$*:*

Structural Capacity:

$yielduse1 := 0.9 \cdot \frac{yieldh1}{2.5}$ ksi

$yielduse1 = 18$ ksi

$caph1 := area1 \cdot yielduse1$

$caph1 = 279$ kips

(smaller than basic maximum allowable pile loads of 300kips according to Table 1808.4.1.3 of NYC Building Code)

$caph1 = 279$ kips

For HP 12 by 63

Section Properties:

$area1 := 18.4$ (area inch square)

$yieldh1 := 50$ (ksi, minimum yield strength)

Allowable Stress of Steel Used for Driving $0.9 \cdot \frac{yield}{2.5}$*:*

Structural Capacity:

$$yielduse1 := 0.9 \cdot \frac{yieldh1}{2.5}$$

$yielduse1 = 18$ ksi

$caph1 := area1 \cdot yielduse1$

$caph1 = 331.2$ kips

(greater than basic maximum allowable pile loads of 300kips according to Table 1808.4.1.3 of NYC Building Code)

$caph1 := \min(caph1, 300)$ kips

$caph1 = 300$ kips

For HP 12 by 74

Section Properties:

$area1 := 21.8$ (area inch square)

$yieldh1 := 50$ (ksi, minimum yield strength)

Allowable Stress of Steel Used for Driving $0.9 \cdot \frac{yield}{2.5}$*:*

Structural Capacity:

$$yielduse1 := 0.9 \cdot \frac{yieldh1}{2.5}$$

$yielduse1 = 18$ ksi

$caph1 := area1 \cdot yielduse1$

$caph1 = 392.4$ kips

(greater than basic maximum allowable pile loads of 300kips according to Table 1808.4.1.3 of NYC Building Code)

$caph1 := \min(caph1, 300)$ kips

$caph1 = 300$ kips

For HP 12 by 84

Section Properties:

$area1 := 24.6$ (area inch square)

$yieldh1 := 50$ (ksi, minimum yield strength)

Allowable Stress of Steel Used for Driving $0.9 \cdot \frac{yield}{2.5}$*:*

Structural Capacity:

$yielduse1 = 18$ ksi

$caph1 := area1 \cdot yielduse1$

$caph1 = 442.8$ kips

(greater than basic maximum allowable pile loads of 300kips according to Table 1808.4.1.3 of NYC Building Code)

$caph1 := \min(caph1, 300)$ kips

$caph1 = 300$ kips

Compressive Capacity of Micropile-9.625" O.D.

Section Properties:

$od := 9 + \frac{5}{8}$ (outside Diameter in inches)

$t := 0.545$ (thickness in inches)

$yield := 45$ (ksi)

$id := od - 2 \cdot t$ (inside Diameter in inches)

$$areasteel := \pi \frac{\left(od^2 - id^2\right)}{4}$$

$areasteel = 15.546$ (inch^2)

$$areatip := \pi \cdot \frac{id^2}{4}$$

$areatip = 57.213$ (inch^2)

Geotechnical capacity

Tip Resistance

$$qpallow := 60 \cdot \frac{2000}{144} \text{ psi}$$

(Maximum Allowable Bearing Pressure of Bedrock 1B is 40tsf according to NYC Building Code Table 1804-1. According to Note 7 of the table, for a minimum of 5ft penetration, the maximum allowable bearing can be increased by 50% which gives 60tsf.)

$$rtip := qpallow \cdot areatip$$

$rtip = 4.768 \times 10^4$ lbs

Bond Resistance

$bondlen1 := 5$ ft

$bondlen2 := 7.5$ ft

$bondlen3 := 10$ ft

$$sidenominal := 20 \cdot \frac{1000}{144} \text{ psi}$$

(Reference: AASHTO Table C10.9.3.5.2-1: Typical Range of Grount-Grount Bond Nominal Reistance for Micropile)

$$sideallow := sidenominal \cdot 0.55$$

(Reference: AASHTO Table C10.5.5.2.5-1: Resistance Factor of 0.55)

$sideallow = 76.389$ psi

$$rside1 := \pi \, id \cdot bondlen1 \cdot 12 \cdot \frac{sideallow}{1000} \qquad rside1 = 122.895 \text{ kips}$$

$$rside2 := \pi \, id \cdot bondlen2 \cdot 12 \cdot \frac{sideallow}{1000} \qquad rside2 = 184.343 \text{ kips}$$

$$rside3 := \pi \, id \cdot bondlen3 \cdot 12 \cdot \frac{sideallow}{1000} \qquad rside3 = 245.79 \text{ kips}$$

$$rtotal1 := rside1 + \frac{rtip}{1000} \qquad rtotal1 = 170.573 \text{ kips}$$

$rtotal2 := rside2 + \frac{rtip}{1000}$ $rtotal2 = 232.021$ kips

$rtotal3 := rside3 + \frac{rtip}{1000}$ $rtotal3 = 293.468$ kips

Structural Capacity (Ignore Uncased Part)

Cased Part (ignore reinforcement):

Steel:

$\sigma all := \min(0.4yield, 32)$ (Maximum allowable stress of pipe for micropile in compression: 0.4fy<=32,000psi according to Table 1808.8 in NYC Building Code)

$\sigma all = 18$ ksi

$rcasing := \sigma all \cdot areasteel$

$rcasing = 279.837$ kips

Concrete:

$fc := 5$ ksi

$rconcrete := 0.33 fc \cdot \pi \cdot \frac{id^2}{4}$ (Maximum allowable stress of concreteaccording to Table 1808.8 in NYC Building Code: 0.33fc)

$rconcrete = 94.402$ kips

$rtotalcase := rcasing + rconcrete$

$rtotalcase = 374.239$

The calculated structural capacity is greater than geotechnical capacity, as a result, the geotechnical capacity of micropile controls the design of pile capacity in compression.

Compressive Capacity of Micropile-11.875" O.D.

Section Properties:

$od := 11.875$ (outside Diameter in inches)

$t := 0.582$ (thickness in inches)

$yield := 80$ (ksi)

$id := od - 2 \cdot t$ (inside Diameter in inches)

$$areasteel := \pi \frac{\left(od^2 - id^2\right)}{4}$$

$areasteel = 20.648$ (inch^2)

$$areatip := \pi \cdot \frac{id^2}{4}$$

$areatip = 90.105$ (inch^2)

Geotechnical capacity

Tip Resistance

$$qpallow := 60 \cdot \frac{2000}{144} \text{ psi}$$

(Maximum Allowable Bearing Pressure of Bedrock 1B is 40tsf according to NYC Building Code Table 1804-1. According to Note 7 of the table, for a minimum of 5ft penetration, the maximum allowable bearing can be increased by 50% which gives 60tsf.)

$rtip := qpallow \cdot areatip$

$rtip = 7.509 \times 10^4$ lbs

Bond Resistance

$bondlen1 := 5$ ft

$bondlen2 := 7.5$ ft

$$sidenominal := 20 \cdot \frac{1000}{144} \text{ psi}$$

(Reference: AASHTO Table C10.9.3.5.2-1: Typical Range of Grount-Grount Bond Nominal Reistance for Micropile)

$sideallow := sidenominal \cdot 0.55$

(Reference: AASHTO Table C10.5.5.2.5-1: Resistance Factor of 0.55)

$sideallow = 76.389$ psi

$$rside1 := \pi \, id \cdot bondlen1 \cdot 12 \cdot \frac{sideallow}{1000}$$

$rside1 = 154.227$ kips

$$rside2 := \pi \, id \cdot bondlen2 \cdot 12 \cdot \frac{sideallow}{1000}$$ $rside2 = 231.341$ kips

$$rtotal1 := rside1 + \frac{rtip}{1000}$$ $rtotal1 = 229.315$ kips

$$rtotal2 := rside2 + \frac{rtip}{1000}$$ $rtotal2 = 306.429$ kips

Structural Capacity (Ignore Uncased Part)

Cased Part (ignore reinforcement):

Steel:

$$\sigma all := \min(0.4yield, 32)$$

(Maximum allowable stress of pipe for micropile in compression: 0.4fy<=32,000psi according to Table 1808.8 in NYC Building Code)

$\sigma all = 32$ ksi

$$rcasing := \sigma all \cdot areasteel$$

$rcasing = 660.742$ kips

Concrete:

$fc := 5$ ksi

$$rconcrete := 0.33 fc \cdot \pi \cdot \frac{id^2}{4}$$

(Maximum allowable stress of concreteaccording to Table 1808.8 in NYC Building Code: 0.33fc)

$rconcrete = 148.674$ kips

$$rtotalcase := rcasing + rconcrete$$

$rtotalcase = 809.416$

<u>The calculated structural capacity is greater than geotechnical capacity, as a result, the geotechnical capacity of micropile controls the design of pile capacity in compression.</u>

SUMMARY OF RESTULS

The estimated compressive capacity of piles are summarized in the following tables:

Capacity of Closed End Pipe Piles (1/2" Plate or Conical Tip)

Pile Diameter (OD) (Inches)	**Wall Thickness (inches)**	**Area (in^2)**	**Steel Grade**	**Pile Capacity in Compression (Not Concrete Filled)**	
				Allowable Structural Capacity[1]	Net Allowable Capacity[2]
9-5/8	0.500	14.334	ASTM A 252- Grade 2	*180kips*	145kips
			ASTM A 252- Grade 3	*232kips*	197kips
9-5/8	0.545	15.546	ASTM A 252- Grade 2	*195kips*	160kips
			ASTM A 252- Grade 3	*251kips*	216kips

Notes: [1] Allowable stresses of steel used in the design=$\frac{0.9f_y}{2.5}$, where f_y is the yield strength of steel, 35kis for ASTM A 252- Grade 2 and 45ksi for ASTM A 252- Grade 3. [2] Adjusted for downdrag. If no verification borings to reevaluate the liquefaction potential post the pile installation, the downdrag due to liquefaction should be considered in the design. According to preliminary downdrag estimation, total downdrag for closed end pipe pile is 44D=44*9.625/12=35.3kips.

Capacity of H-Piles

H-Pile	Area (in^2)	Steel Yield Strength	Pile Capacity in Compression	
			Allowable Structural Capacity in Compression[1]	Net Allowable Capacity[2]
HP 12×53	15.5	50ksi	*279kips*	219kips
HP 12×63	18.4	50ksi	*300kips*	240kips
HP 12×74	21.8	50ksi	*300kips*	239kips
HP 12×84	24.6	50ksi	*300kips*	238kips

[1] Allowable stresses of steel used in the design=$\frac{0.9f_y}{2.5}$, where f_y is the yield strength of steel. 300kips is the maximum allowable pipe capacity for H-piles according to Table 1808.4.1.3 New York City Building Code. [2] Adjusted for downdrag. If no verification borings to reevaluate the liquefaction potential post ground improvement, the downdrag due to liquefaction should be considered in the design. According to preliminary downdrag estimation, total downdrag for H-piles of HP12×53, HP12×63, HP 12×74, and HP 12×84 are 59.8kips, 60.3kips, 61.0kips and 61.7kips, respectively.

Capacity of Micropiles

Micropile O.D.	Casing Thickness	Socket Length in Bedrock	Casing Yield Strength	Pile Capacity in Compression with 5000psi Concrete	
				Allowable Pile Capacity	Net Allowable Capacity[1]
9 5/8	0.50 inches	5.0ft.	45ksi	173kips	150kips
		7.5ft.		235kips	212kips
		10.0ft.		297kips	274kips
9 5/8	0.545 inches	5.0ft		171kips	148kips
		7.5ft.		232kips	209kips
		10.0ft.		294kips	271kips
11 7/8	0.582 inches	5.0ft	80ksi	229kips	203kips
		7.5ft		306kips	280kips

[1] Adjusted for downdrag. If no verification borings to reevaluate the liquefaction potential post ground improvement, the downdrag due to liquefaction should be considered in the design. According to preliminary downdrag estimation, total downdrag for micropile is 28.8D=28.8*9.625/12=23.1kips for 9.625" O.D. casing and 28.8*11.875=25.2kips for 11.875" O.D. casing.

APPENDIX I-2

CALCULATIONS OF PILE CAPACITY AND PILE STIFFNESS
I-2: TENSILE CAPACITY

APPENDIX I2- Tensile Capactiy of Piles

SOUTH BATTERY PAR CITY RESILIENCEY
OEI PROJECT No. 17-NY165-01
CALCULATED BY: SG DATE: 2/9/2021
CHECKED BY: JM DATE: 2/23/2021

This appendix presents the tensile capacity of deep foundations including Closed-End Pile Piles, H-Piles, and Micropiles.

Notes:

1. See Table 4 in the Geotechnical Report for generalized soil profile for pavilion foundation design.
2. For driven piles which include H-Piles and Closed End Pipe Piles, as the geotechnical capacity in tension will control the design, only the estimation of the geotechnical capacity is presented here. For the drilled micropile, both geotechnical and structural capacities in tension are presented and compared.
3. Frictional model from NAVFAC DM-7.2-193 is used to estimate the ultimate load capacity in tesion in the granular layers, which is presented as follows:

where $$Tult := \int_0^Z A_S \beta \sigma_Z \, dz$$

Tult = Ultimate load capacity in tension

A_s = pile skin surface area per unit length

$\beta = K_{ht} \tan\delta$, and K_{ht}=coefficient of earth pressure when pile is in tension, δ=angle of friction between soil and pile

σ_z = effective vertical stress at depth of z

<u>For allowable load capacity in tension:</u>

$$Tall := \frac{Tult}{3} + Wp$$

Where: Tult is the ultimate load capacity in tension;
3 is the safety factor;
and Wp is the effective weight of the pile.

4. In cohesive layer the ultimate load capacity in tension is, $Tult=C_A A_s Z$

   Where: C_A is the adjusted adhesive according to DM7.2-196, A_s is the pile skin surface area per unit length, Z is the length of pile in cohesive layer.

5. Assume water table is at EL.3.0 for pile load capacity in tension.

Geotechnical Capacity in Tension for Closed End Pipe Pile

Section Properties:

$od := 9 + \frac{5}{8}$ (outside Diameter in inches)

$t := 0.545$ (thickness in inches)

$id := od - 2 \cdot t$ (inside Diameter in inches)

$area := \pi \frac{\left(od^2 - id^2\right)}{4}$ (area of steel inch square)

$area = 15.546$ (inch^2)

Strength Parameters:

$kht := 0.8$ *(for tension, Reference: DM 7.2.194)*

$delta := 20deg$ *(friction anlge beween granular soil and steel, Reference: DM 7.2.194)*

$belta := kht \cdot \tan(delta)$

$belta = 0.291$

$gamma := 125$ *(pcf, ave.saturated unit of soil for existing and new fill above EL.0.0)*

Uplift Resistance of Each Section of Pile:

Assuming constant earth pressure after depth of 20diameter according to DM7.2-193

$ll := 20 \cdot \frac{od}{12}$

$ll = 16.042$ ft

<u>Constant earth pressure after depth of 16ft</u>

Elevation 15~10:

$up1 := belta \cdot \pi \cdot 5 \cdot gamma \cdot 2.5$ *(in unit of D, lbs)*

Elevation 10~0:

Elevation 10~3:

$up2a := belta \cdot \pi \cdot 7 \cdot (gamma \cdot 5 + gamma \cdot 3.5)$ *(in unit of D, lbs)*

Elevation 3~0:

$up2b := belta \cdot \pi \cdot 3 \cdot [gamma \cdot 12 + (gamma - 62.4) \cdot 1.5]$ *(in unit of D, lbs)*

Elevation 0~-5:

Constant earth pressure after depth of 16ft

$up3 := belta \cdot \pi \cdot 5 \cdot [gamma \cdot 12 + (gamma - 62.4) \cdot 3 + 55.6 \cdot 1]$ *(in unit of D, lbs)*

Elevation -5~-22.5:

$up4 := 0.08\pi \cdot 17.5 \cdot [gamma \cdot 12 + (gamma - 62.4) \cdot 3 + 55.6 \cdot 1]$ *(in unit of D, lbs)*

Elevation -22.5~-32:

$up5 := belta\pi \cdot 9.5 \cdot [gamma \cdot 12 + (gamma - 62.4) \cdot 3 + 55.6 \cdot 1]$ *(in unit of D, lbs)*

$$up5 \cdot \frac{od}{12} = 1.215 \times 10^4$$

Elevation -32~-41.5:

$up6 := 300\pi \cdot 9.5$ *(in unit of D, lbs)*

$$up6 \cdot \frac{od}{12} = 7.181 \times 10^3$$

Case I: Closed End but Not Filled With Concrete:

$weights := area \cdot (15 + 41.5) \cdot \frac{490}{144}$ *(unit weigth of steel: 490pcf)* *(total weight of steel in lbs)*

$Wseff := weights - \pi \frac{od^2}{4} (3 + 41.5) \cdot \frac{62.4}{144}$ *(assuming water level at EL.3.0, effective weight of steel in lbs)*

$Wseff = 1.586 \times 10^3$ lbs

$$skinf := \frac{(up1 + up2a + up2b + up3 + up4 + up5 + up6) \cdot \frac{od}{12}}{3}$$

$$Tall := \frac{skinf + Wseff}{1000} \quad kips$$

$$Tall = 15.583 \quad kips$$

Case II: Closed End and Filled With Concrete:

$$weightc := \pi \frac{id^2}{4} \cdot \frac{145}{144} \cdot (15 + 41.5)$$

(unit weigth of concrete: 145pcf)

(total weight of concrete in lbs)

$$Tall2 := Tall + \frac{weightc}{1000}$$

$$Tall2 = 18.838 \quad kips$$

Geotechnical Capacity in Tension for H-Piles

Strength Parameters:

$kht := 0.4$ *(for tension, Reference: DM 7.2.194)*

$delta := 20deg$ *(friction anlge beween granular soil and steel, Reference: DM 7.2.194)*

$belta := kht \cdot \tan(delta)$

$belta = 0.146$

$gamma := 125$ *(pcf, ave.saturated unit of soil for existing and new fill above EL.0.0)*

Uplift Resistance of Each Section of Pile:

Assuming constant earth pressure after depth of 20diameter according to DM7.2-193

For a typical H-Pile of HP12x, assuming constant earth pressure after depth of 20ft

Elevation 15~10:

$up1 := belta \cdot \pi \cdot 5 \cdot gamma \cdot 2.5$ *(in unit of D, lbs)*

Elevation 10~0:

Elevation 10~3:

$up2a := belta \cdot \pi \cdot 7 \cdot (gamma \cdot 5 + gamma \cdot 3.5)$ *(in unit of D, lbs)*

Elevation 3~0:

$up2b := belta \cdot \pi \cdot 3 \cdot [gamma \cdot 12 + (gamma - 62.4) \cdot 1.5]$ *(in unit of D, lbs)*

Elevation 0~-5:

Constant earth pressure after depth of 20ft

$up3 := belta \cdot \pi \cdot 5 \cdot [gamma \cdot 12 + (gamma - 62.4) \cdot 3 + 55.6 \cdot 5]$ *(in unit of D, lbs)*

Elevation -5~-22.5:

$up4 := 0.08\,\pi \cdot 17.5 \cdot [gamma \cdot 12 + (gamma - 62.4) \cdot 3 + 55.6 \cdot 5]$ *(in unit of D, lbs)*

Elevation -22.5~-32:

$up5 := belta\,\pi \cdot 9.5 \cdot [gamma \cdot 12 + (gamma - 62.4) \cdot 3 + 55.6 \cdot 5]$ *(in unit of D, lbs)*

Elevation -32~-41.5:

$up6 := 300\pi \cdot 9.5$ *(in unit of D, lbs)*

Section 1: HP 12 by 53

Sectin Area=15.5 in^2

Unit Weight: 53lb/ft

$weight := (15 + 41.5) \cdot 53 - 41.5 \cdot 62.4 \cdot \frac{15.5}{144}$ (effective weight of steel in lbs)

$weight = 2.716 \times 10^3$ lbs

[To be conservative, the "Plug" section was used to estimating the uplift capacity: then perimeter used in the calculation for HP12x53 is (12"+11.8") x2]

$$\text{skinf} := \frac{(\text{up1} + \text{up2a} + \text{up2b} + \text{up3} + \text{up4} + \text{up5} + \text{up6}) \cdot \frac{(12 + 11.8) \cdot 2}{12 \cdot \pi}}{3}$$

$$\text{Tall} := \frac{\text{skinf} + \text{weight}}{1000}$$

$\text{Tall} = 18.263$ kips

Section 2: HP 12 by 63

Sectin Area=18.4 in^2

Unit Weight: 63lb/ft

$$\text{weight} := (15 + 41.5) \cdot 63 - 41.5 \cdot 62.4 \cdot \frac{18.4}{144}$$ (effective weight of steel in lbs)

$\text{weight} = 3.229 \times 10^3$ lbs

[To be conservative, the "Plug" section was used to estimating the uplift capacity: then perimeter used in the calculation for HP12x63 is (12.1"+11.9") x2]

$$\text{skinf} := \frac{(\text{up1} + \text{up2a} + \text{up2b} + \text{up3} + \text{up4} + \text{up5} + \text{up6}) \cdot \frac{(12.1 + 11.9) \cdot 2}{12 \cdot \pi}}{3}$$

$$\text{Tall} := \frac{\text{skinf} + \text{weight}}{1000}$$

$\text{Tall} = 18.907$ kips

Section 3: HP 12 by 74

Sectin Area=21.8 in^2

Unit Weight: 74lb/ft

$$\text{weight} := (15 + 41.5) \cdot 74 - 41.5 \cdot 62.4 \cdot \frac{21.8}{144}$$ (effective weight of steel in lbs)

$\text{weight} = 3.789 \times 10^{3}$ lbs

[To be conservative, the "Plug" section was used to estimating the uplift capacity: then perimeter used in the calculation for HP12x74 is (12.1"+12.2") x2]

$$\text{skinf} := \frac{(\text{up1} + \text{up2a} + \text{up2b} + \text{up3} + \text{up4} + \text{up5} + \text{up6}) \cdot \frac{(12.1 + 12.2) \cdot 2}{12 \cdot \pi}}{3}$$

$$\text{Tall} := \frac{\text{skinf} + \text{weight}}{1000}$$

$\text{Tall} = 19.663$ kips

Section 4: HP 12 by 84

Sectin Area=24.6 in^2

Unit Weight: 84lb/ft

$$\text{weight} := (15 + 41.5) \cdot 84 - 41.5 \cdot 62.4 \cdot \frac{24.6}{144}$$ (effective weight of steel in lbs)

$\text{weight} = 4.304 \times 10^{3}$ lbs

[To be conservative, the "Plug" section was used to estimating the uplift capacity: then perimeter used in the calculation for HP12x84 is (12.3"+12.3") x2]

$$\text{skinf} := \frac{(\text{up1} + \text{up2a} + \text{up2b} + \text{up3} + \text{up4} + \text{up5} + \text{up6}) \cdot \frac{(12.3 + 12.3) \cdot 2}{12 \cdot \pi}}{3}$$

$$\text{Tall} := \frac{\text{skinf} + \text{weight}}{1000}$$

$\text{Tall} = 20.373$ kips

Geotechnical Capacity in Tension for Micropile-9.625" O.D.

Section Properties:

$od := 9 + \frac{5}{8}$ (outside Diameter in inches)

$t := 0.50$ (thickness in inches)

$id := od - 2 \cdot t$ (inside Diameter in inches)

$areasteel := \pi \frac{(od^2 - id^2)}{4}$ (area of steel inch square)

$areasteel = 14.334$ ($inch^2$)

$areatip := \pi \cdot \frac{id^2}{4}$

$areatip = 58.426$ ($inch^2$)

Ignored the Cased Part:

Bond rsistance of Uncased Section:
Considering three bond lengths: 5ft, 7.5ft and 10ft

$bondlen1 := 5$ ft

$bondlen2 := 7.5$ ft

$bondlen3 := 10$ ft

$sidenominal := 20 \cdot \frac{1000}{144}$ psi (Reference: AASHTO Table C10.9.3.5.2-1: Typical Range of Grount-Grount Bond Nominal Reistance for Micropile)

$sideallow := sidenominal \cdot 0.55$ (Reference: AASHTO Table C10.5.5.2.5-1: Resistance Factor of 0.55)

$sideallow = 76.389$ psi

Allowable tensile capacity of each bond length:

$rside1 := \pi \, id \cdot bondlen1 \cdot 12 \cdot \frac{sideallow}{1000}$ For 5ft Bond Length:

$rside1 = 124.191$ kips

$rside2 := \pi \cdot id \cdot bondlen2 \cdot 12 \cdot \frac{sideallow}{1000}$ For 7.5ft Bond Length:

$rside2 = 186.287$ kips

$rside3 := \pi \cdot id \cdot bondlen3 \cdot 12 \cdot \frac{sideallow}{1000}$ For 10ft Bond Length:

$rside3 = 248.382$ kips

Structural Capacity in Tension for Micropile-9.625" O.D.

The Uncased Part Controls the Design:

Grade 75 All-Thread Rebar
Minimum Yield Strength:
#6 33kips
#7 45kips
#8 59kips

The uplift resistance with each type of rebar::

number 6 bar	$0.8 \cdot 33 = 26.4$	kips	(Reference: AASHTO Table C10.5.5.2.5-1: Resistance Factor of 0.80 for Pile Uncased Length)
number 7 bar	$0.8 \cdot 45 = 36$	kips	
number 8 bar	$0.8 \cdot 59 = 47.2$	kips	

The calculated structural capacity is less than geotechnical capacity, as a result, the structural capacity controls the design of pile capacity in tension.

Geotechnical Capacity in Tension for Micropile-11.875" O.D.

Section Properties:

$od := 11.875$ (outside Diameter in inches)

$t := 0.582$ (thickness in inches)

$id := od - 2 \cdot t$ (inside Diameter in inches)

$areasteel := \pi \frac{\left(od^2 - id^2\right)}{4}$ (area of steel inch square)

$areasteel = 20.648$ (inch^2)

$areatip := \pi \cdot \frac{id^2}{4}$

$areatip = 90.105$ (inch^2)

Ignored the Cased Part:

Bond rsistance of Uncased Section:
Considering three bond lengths: 5ft, 7.5ft and 10ft

$bondlen1 := 5$ ft

$bondlen2 := 7.5$ ft

$sidenominal := 20 \cdot \frac{1000}{144}$ psi (Reference: AASHTO Table C10.9.3.5.2-1: Typical Range of Grount-Grount Bond Nominal Reistance for Micropile)

$sideallow := sidenominal \cdot 0.55$ (Reference: AASHTO Table C10.5.5.2.5-1: Resistance Factor of 0.55)

$sideallow = 76.389$ psi

Allowable tensile capacity of each bond length:

$rside1 := \pi\, id \cdot bondlen1 \cdot 12 \cdot \frac{sideallow}{1000}$ For 5ft Bond Length:

$rside1 = 154.227$ kips

$rside2 := \pi\, id \cdot bondlen2 \cdot 12 \cdot \frac{sideallow}{1000}$ For 7.5ft Bond Length:

$rside2 = 231.341$ kips

Structural Capacity in Tension for Micropile-11.875" O.D.

The Uncased Part Controls the Design:

Grade 75 All-Thread Rebar
Minimum Yield Strength:
#6 33kips
#7 45kips
#8 59kips

The uplift resistance with each type of rebar::

number 8 bar	$0.8 \cdot 59 = 47.2$	kips	(Reference: AASHTO Table C10.5.5.2.5-1: Resistance Factor of 0.80 for Pile Uncased Length)
number 9 bar	$0.8 \cdot 75 = 60$	kips	
number 10 bar	$0.8 \cdot 95 = 76$	kips	

<u>The calculated structural capacity is less than geotechnical capacity, as a result, the structural capacity controls the design of pile capacity in tension.</u>

SUMMARY OF RESTULS

The estimated tensile capacity of piles are summarized in the following tables:

Capacity of Closed End Pipe Piles (1/2" Plate or Conical Tip)

Pile Diameter (OD) (Inches)	Wall Thickness (inches)	Area (in^2)	Steel Grade	Allowable Pile Capacity in Tension (Fill with Concrete)	Allowable Pile Capacity in Tension (Not Fill with Concrete)
9-5/8	0.500	14.334	ASTM A 252-Grade 2 / ASTM A 252-Grade 3	<u>18.6kips</u>	<u>15.3kips</u>
9-5/8	0.545	15.546	ASTM A 252-Grade 2 / ASTM A 252-Grade 3	<u>18.8kips</u>	<u>15.5kips</u>

Capacity of H-Piles

H-Pile	Area (in^2)	Steel Yield Strength	Allowable Pile Capacity in Tension
HP 12×53	15.5	50ksi	18.2kips
HP 12×63	18.4	50ksi	18.9kips
HP 12×74	21.8	50ksi	19.7kips
HP 12×84	24.6	50ksi	20.3kips

Capacity of Micropiles

<table>
<tr><th>Micropile O.D.</th><th>Casing Thickness</th><th>Socket Length in Bedrock</th><th>Casing Yield Strength</th><th>Allowable Pile Capacity in Tension[1]</th></tr>
<tr><td rowspan="3">9 5/8</td><td rowspan="3">0.50 inches</td><td>5.0ft.</td><td rowspan="6">45ksi</td><td rowspan="8">Grade 75 All-Thread Rebar (ASTM A615):

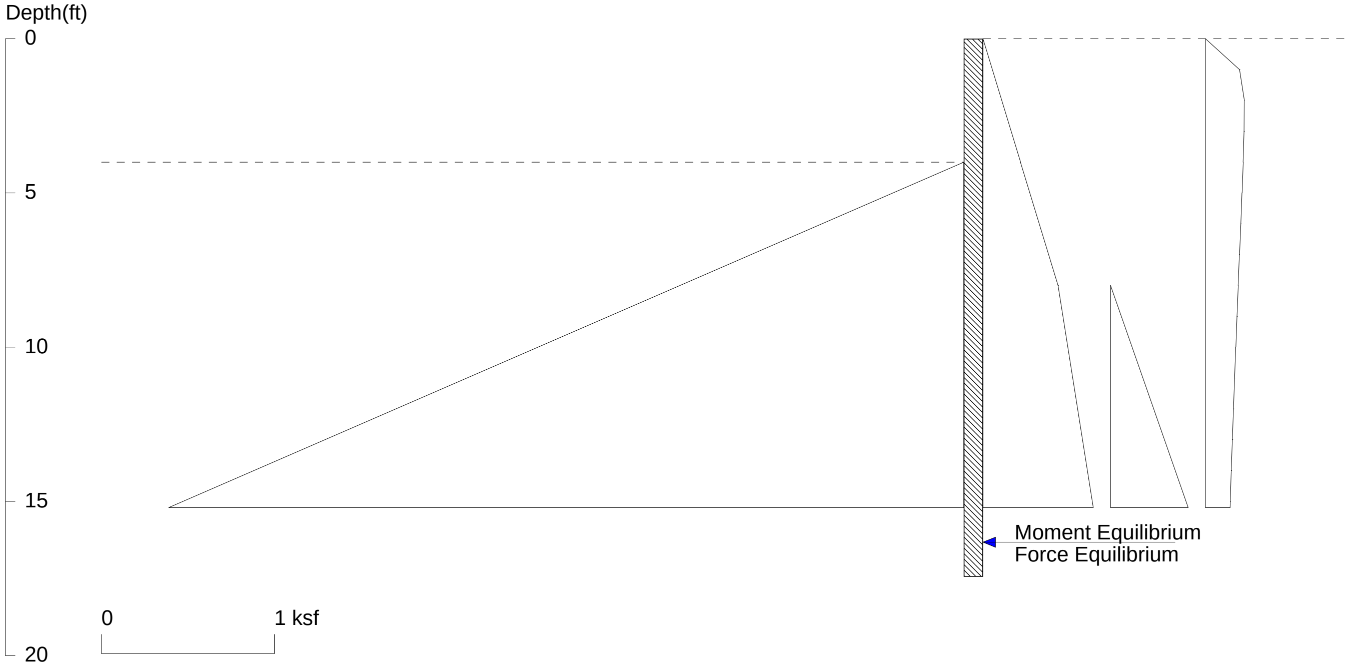
26kips for #6 bar;
36kips for #7 bar;
47kips for #8 bar;
60kips for #9 bar;
76kips for #10 bar.</td></tr>
<tr><td>7.5ft.</td></tr>
<tr><td>10.0ft.</td></tr>
<tr><td rowspan="3">9 5/8</td><td rowspan="3">0.545 inches</td><td>5.0ft</td></tr>
<tr><td>7.5ft.</td></tr>
<tr><td>10.0ft.</td></tr>
<tr><td rowspan="2">11 7/8</td><td rowspan="2">0.582 inches</td><td>5.0ft</td><td rowspan="2">80ksi</td></tr>
<tr><td>7.5ft</td></tr>
</table>

[1] Allowable tensile stress of rebar used in the design=0.8f_y, where f_y is the yield strength of rebar.

APPENDIX I-3A

I-3A: MICROPILE DESIGN FOR WP4~WP6

APPENDIX 1-3A WP4-WP6
USUAL LOADING WITH FS=1.0 (FOR STRUCTURAL DESIGN OF PILE)



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Wall Height=4.0 Pile Diameter=0.8 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=13.44 Min. Pile Length=17.44
MOMENT IN PILE: Max. Moment=56.05 per Pile Spacing=8.0 at Depth=10.15

PILE SELECTION:
Request Min. Section Modulus = 28.3 in3/pile=463.90 cm3/pile, Fy= 36 ksi = 248 MPa, Fb/Fy=0.66
-> Piles meet Min. Section Requirements: Top Deflection is shown in (in)
HP8X36 (0.56) W8X35 (0.52) HP10X42 (0.32) W10X30 (0.39) HP12X53 (0.17)
W12X26 (0.32) HP13X60 (0.13) HP14X73 (0.09) W14X22 (0.33) W16X26 (0.22)
HP16X88 (0.06) W16X89 (0.05) HP16X101 (0.05) W16X100 (0.04)

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	4.000	0.217	0.054284
*	Below	Base		
4.000	0.217	8.000	0.434	0.054284
8.000	0.434	17.50	0.703	0.028318
*	Water	Pres.		
8.000	0.000	18.77	0.672	0.062400
*	Sur-	charg		
0.000	0.000	1.000	0.197	0.196817
1.000	0.197	2.000	0.224	0.027551
2.000	0.224	3.000	0.223	-0.00103
3.000	0.223	4.000	0.218	-0.00573
4.000	0.218	5.000	0.211	-0.00684
5.000	0.211	6.000	0.204	-0.00715
6.000	0.204	7.000	0.196	-0.00721
7.000	0.196	8.000	0.189	-0.00717

8.000	0.189	9.000	0.182	-0.00707
9.000	0.182	10.00	0.175	-0.00695
10.00	0.175	11.00	0.168	-0.00681
11.00	0.168	12.00	0.162	-0.00665
12.00	0.162	13.00	0.155	-0.00648
13.00	0.155	14.00	0.149	-0.00630
14.00	0.149	15.00	0.143	-0.00612
15.00	0.143	16.00	0.137	-0.00593
16.00	0.137	17.00	0.131	-0.00574
17.00	0.131	18.00	0.126	-0.00555

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
4.000	0.000	17.50	5.542	0.410523

ACTIVE SPACING:

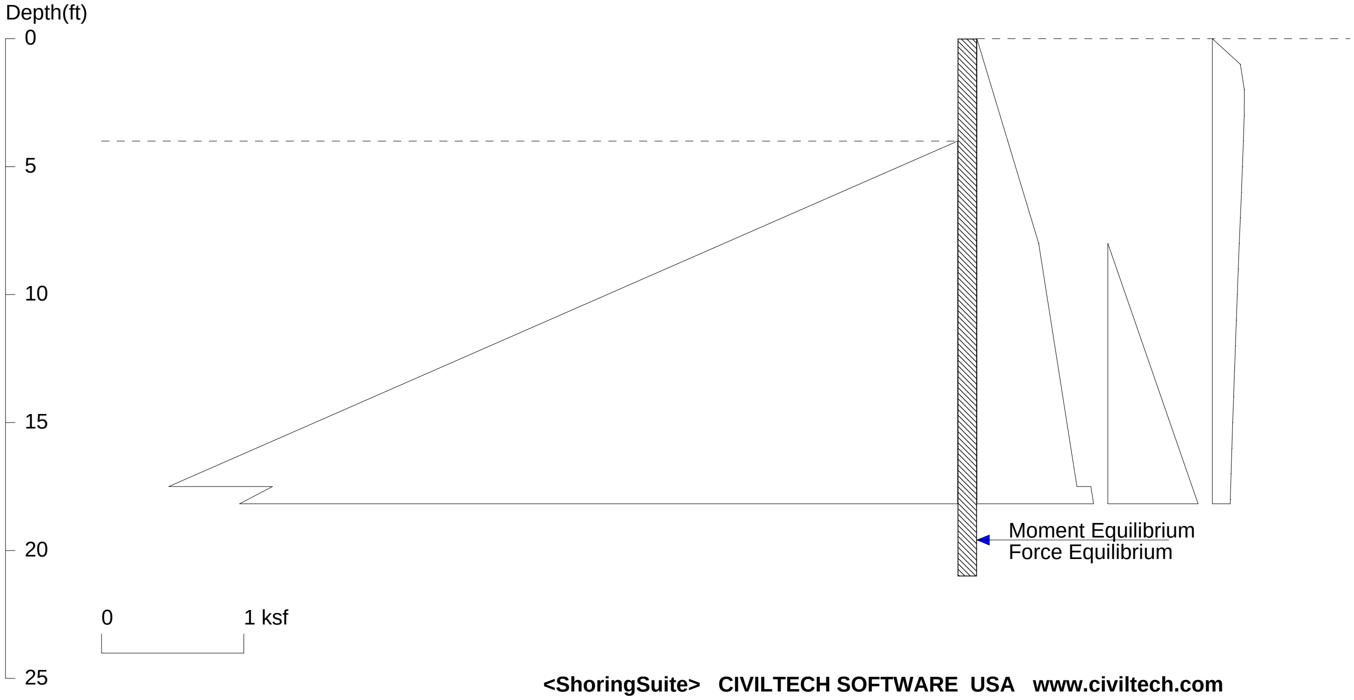
No.	Z depth	Spacing
1	0.00	8.00
2	4.00	0.80

PASSIVE SPACING:

No.	Z depth	Spacing
1	4.00	1.60

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

WP4-WP6
USUAL LOADING-FS=1.5 (FOR DETERMINATION OF PILE EMBEDMENT)



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Wall Height=4.0 Pile Diameter=0.8 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=17.01 Min. Pile Length=21.01
MOMENT IN PILE: Max. Moment=68.31 per Pile Spacing=8.0 at Depth=11.89

PILE SELECTION:
Request Min. Section Modulus = 34.5 in3/pile=565.32 cm3/pile, Fy= 36 ksi = 248 MPa, Fb/Fy=0.66
-> Piles meet Min. Section Requirements: Top Deflection is shown in (in)
W8X40 (0.73) HP10X42 (0.51) W10X33 (0.62) HP12X53 (0.27) W12X30 (0.45)
HP13X60 (0.21) HP14X73 (0.15) W14X26 (0.43) W16X26 (0.35) HP16X88 (0.10)
W16X89 (0.08) HP16X101 (0.08) W16X100 (0.07) HP16X121 (0.07)

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	4.000	0.217	0.054284
*	Below	Base		
4.000	0.217	8.000	0.434	0.054284
8.000	0.434	17.50	0.703	0.028318
17.50	0.801	36.50	1.317	0.027142
*	Water	Pres.		
8.000	0.000	18.77	0.672	0.062400
18.77	0.672	40.00	0.672	0.000000
*	Sur-	charg		
0.000	0.000	1.000	0.197	0.196817
1.000	0.197	2.000	0.224	0.027551
2.000	0.224	3.000	0.223	-0.00103
3.000	0.223	4.000	0.218	-0.00573
4.000	0.218	5.000	0.211	-0.00684
5.000	0.211	6.000	0.204	-0.00715

6.000	0.204	7.000	0.196	-0.00721
7.000	0.196	8.000	0.189	-0.00717
8.000	0.189	9.000	0.182	-0.00707
9.000	0.182	10.00	0.175	-0.00695
10.00	0.175	11.00	0.168	-0.00681
11.00	0.168	12.00	0.162	-0.00665
12.00	0.162	13.00	0.155	-0.00648
13.00	0.155	14.00	0.149	-0.00630
14.00	0.149	15.00	0.143	-0.00612
15.00	0.143	16.00	0.137	-0.00593
16.00	0.137	17.00	0.131	-0.00574
17.00	0.131	18.00	0.126	-0.00555
18.00	0.126	19.00	0.120	-0.00535
19.00	0.120	20.00	0.115	-0.00516
20.00	0.115	22.00	0.105	-0.00487

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
*	Below	Base		
4.000	0.000	17.50	5.542	0.410523
17.50	4.813	18.77	5.249	0.343475
18.77	5.249	36.50	8.084	0.159933

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	4.00	0.80

PASSIVE SPACING:

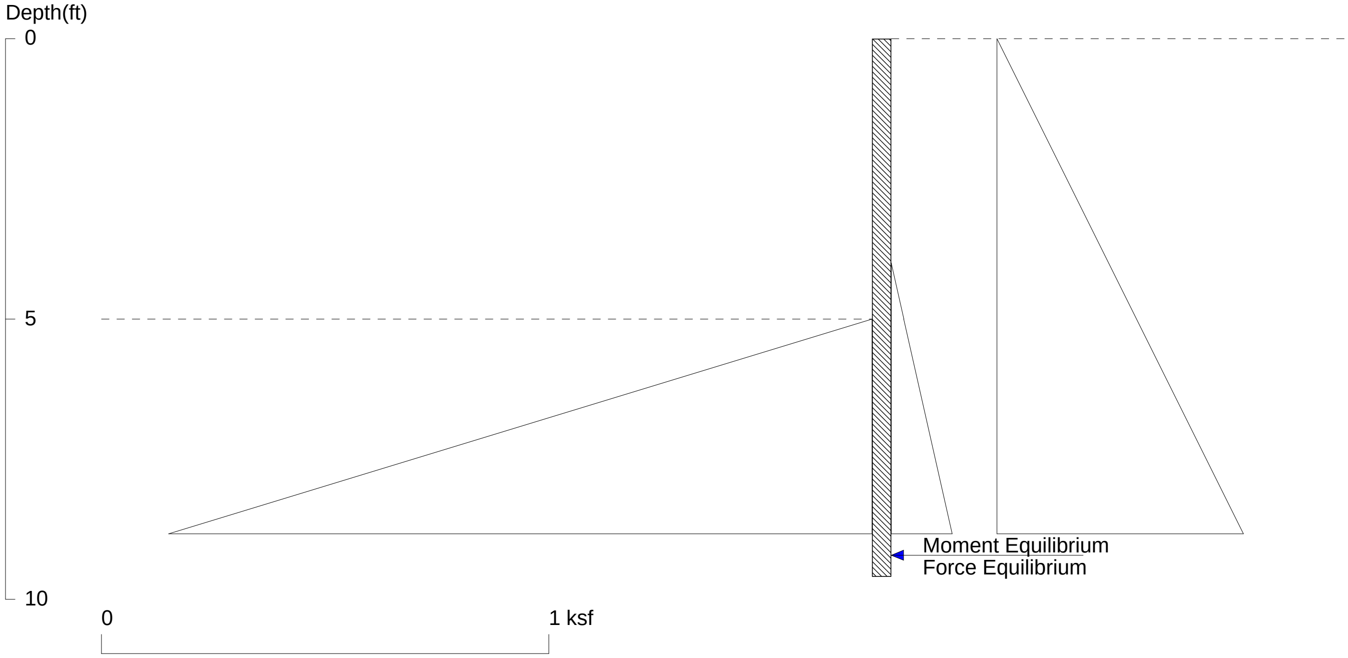
No.	Z depth	Spacing
1	4.00	1.60

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

WP4-WP6

UNUSUAL LOADING WITH FS=1.0 (FOR STRUCTURAL DESIGN OF PILE)

Micropile-Diamter =9.625",Spacing =8ft



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File: R:\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calc

Wall Height=5.0 Pile Diameter=0.8 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=4.60 (5~10ft is recommended!!!) Min. Pile Length=9.60
MOMENT IN PILE: Max. Moment=2.60 per Pile Spacing=8.0 at Depth=7.01

PILE SELECTION:
Request Min. Section Modulus = 1.3 in3/pile=21.51 cm3/pile, Fy= 36 ksi = 248 MPa, Fb/Fy=0.66
-> Piles meet Min. Section Requirements: Top Deflection is shown in (in)
W4X13 (0.71) W5X16 (0.37) W6X8.5 (0.54) HP8X36 (0.07) W8X10 (0.26)
HP10X42 (0.04) W10X12 (0.15) HP12X53 (0.02) W12X14 (0.09) HP13X60 (0.02)
HP14X73 (0.01) W14X22 (0.04) W16X26 (0.03) HP16X88 (0.01)

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
4.000	0.000	5.000	0.028	0.028318
*	Below	Base		
5.000	0.028	17.50	0.382	0.028318
*	Water	Pres.		
0.000	0.000	18.77	1.171	0.062400

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
5.000	0.000	17.50	5.132	0.410523

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	5.00	1.00

PASSIVE SPACING:

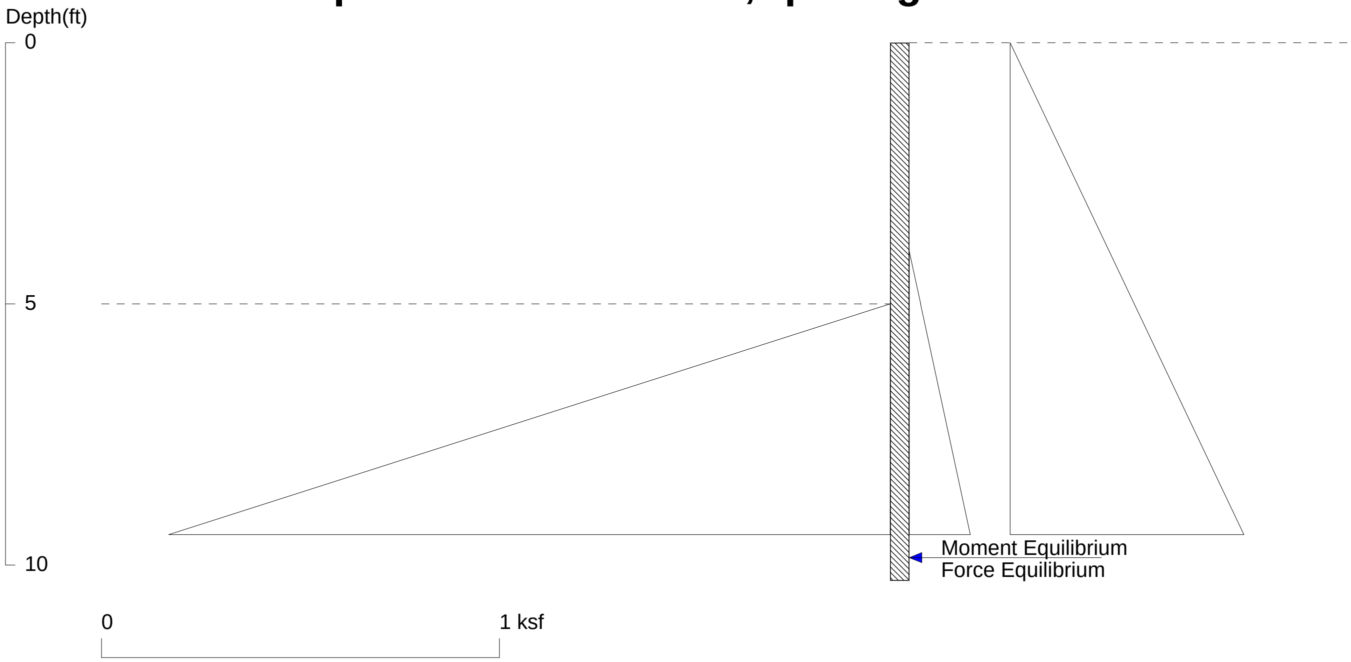
No.	Z depth	Spacing
1	5.00	2.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

WP4-WP6

UNUSUAL LOADING WITH FS=1.25 (FOR DETERMINATION OF PILE EMBEDEMENT)

Micropile-Diamter =9.625",Spacing =8ft



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Wall Height=5.0 Pile Diameter=0.8 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=5.30 Min. Pile Length=10.30

MOMENT IN PILE: Max. Moment=2.89 per Pile Spacing=8.0 at Depth=7.38

PILE SELECTION:

Request Min. Section Modulus = 1.5 in3/pile=23.88 cm3/pile, Fy= 36 ksi = 248 MPa, Fb/Fy=0.66

-> Piles meet Min. Section Requirements: Top Deflection is shown in (in)

W4X13 (0.93) W5X16 (0.49) W6X8.5 (0.70) HP8X36 (0.09) W8X10 (0.34)

HP10X42 (0.05) W10X12 (0.19) HP12X53 (0.03) W12X14 (0.12) HP13X60 (0.02)

HP14X73 (0.01) W14X22 (0.05) W16X26 (0.03) HP16X88 (0.01)

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
4.000	0.000	5.000	0.028	0.028318
*	Below	Base		
5.000	0.028	17.50	0.382	0.028318
*	Water	Pres.		
0.000	0.000	18.77	1.171	0.062400

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.25

Z1	P1	Z2	P2	Slope
*	Below	Base		
5.000	0.000	17.50	5.132	0.410523

ACTIVE SPACING:

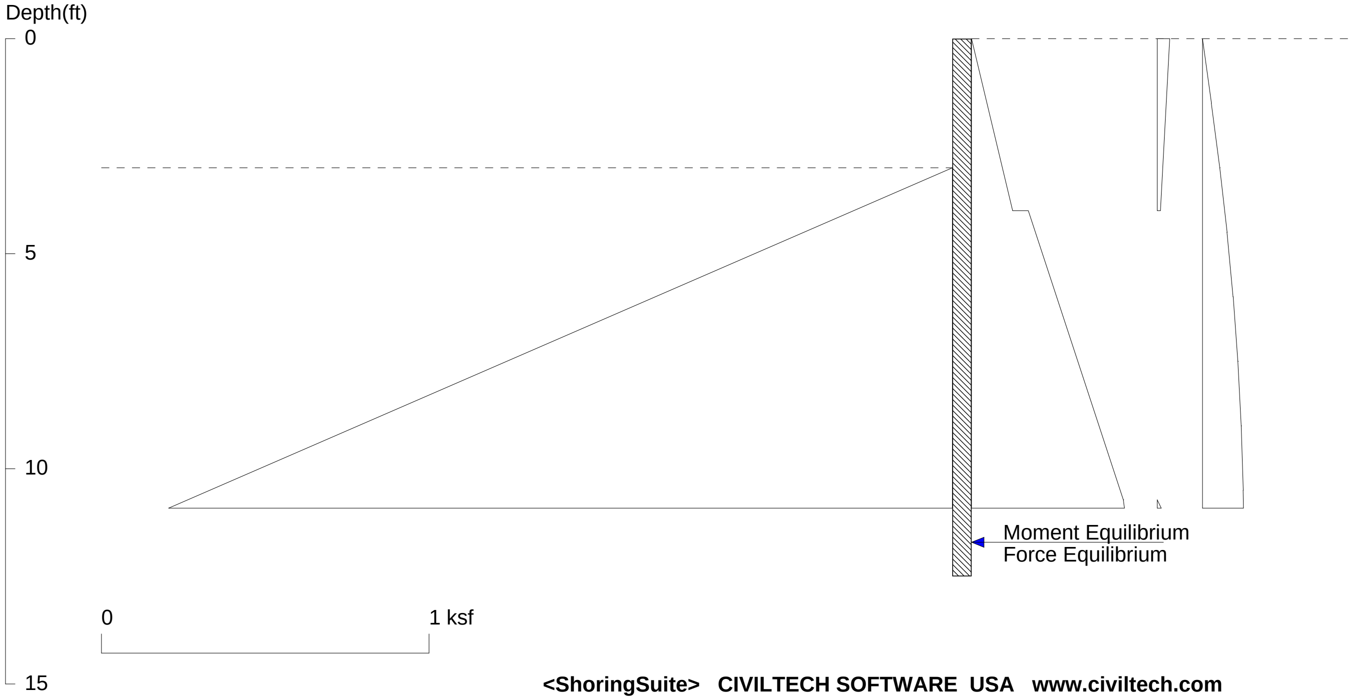
No.	Z depth	Spacing
1	0.00	1.00
2	5.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	5.00	2.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

WP4-WP6
EARTHQUAKE LOADING-FS=1.0 (FOR STRUCTURAL DESIGN OF PILE)



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File: R:\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calc

Wall Height=3.0 Pile Diameter=0.8 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=9.50 Min. Pile Length=12.50
MOMENT IN PILE: Max. Moment=13.81 per Pile Spacing=8.0 at Depth=7.47

PILE SELECTION:
Request Min. Section Modulus = 7.0 in3/pile=114.30 cm3/pile, Fy= 36 ksi = 248 MPa, Fb/Fy=0.66
-> Piles meet Min. Section Requirements: Top Deflection is shown in (in)
W5X16 (0.77) W6X12 (0.75) HP8X36 (0.14) W8X10 (0.54) HP10X42 (0.08)
W10X12 (0.31) HP12X53 (0.04) W12X14 (0.19) HP13X60 (0.03) HP14X73 (0.02)
W14X22 (0.08) W16X26 (0.05) HP16X88 (0.01) W16X89 (0.01)

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	4.000	0.125	0.031360
*	Below	Base		
4.000	0.173	10.72	0.463	0.043200
10.72	0.463	16.50	0.573	0.018943
*	Earth	Queck		
0.000	0.038	4.000	0.009	-0.00710
*	Water	Pres.		
10.72	0.000	17.77	0.440	0.062400
*	Sur-	charg		
0.000	0.000	1.500	0.027	0.018268
1.500	0.027	3.000	0.053	0.017057
3.000	0.053	4.500	0.075	0.014900
4.500	0.075	6.000	0.094	0.012206
6.000	0.094	7.500	0.108	0.009383
7.500	0.108	9.000	0.118	0.006734

9.000	0.118	10.50	0.124	0.004427
10.50	0.124	12.00	0.128	0.002523
12.00	0.128	13.50	0.130	0.001009

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
3.000	0.000	16.50	4.081	0.302270

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	4.00	0.80

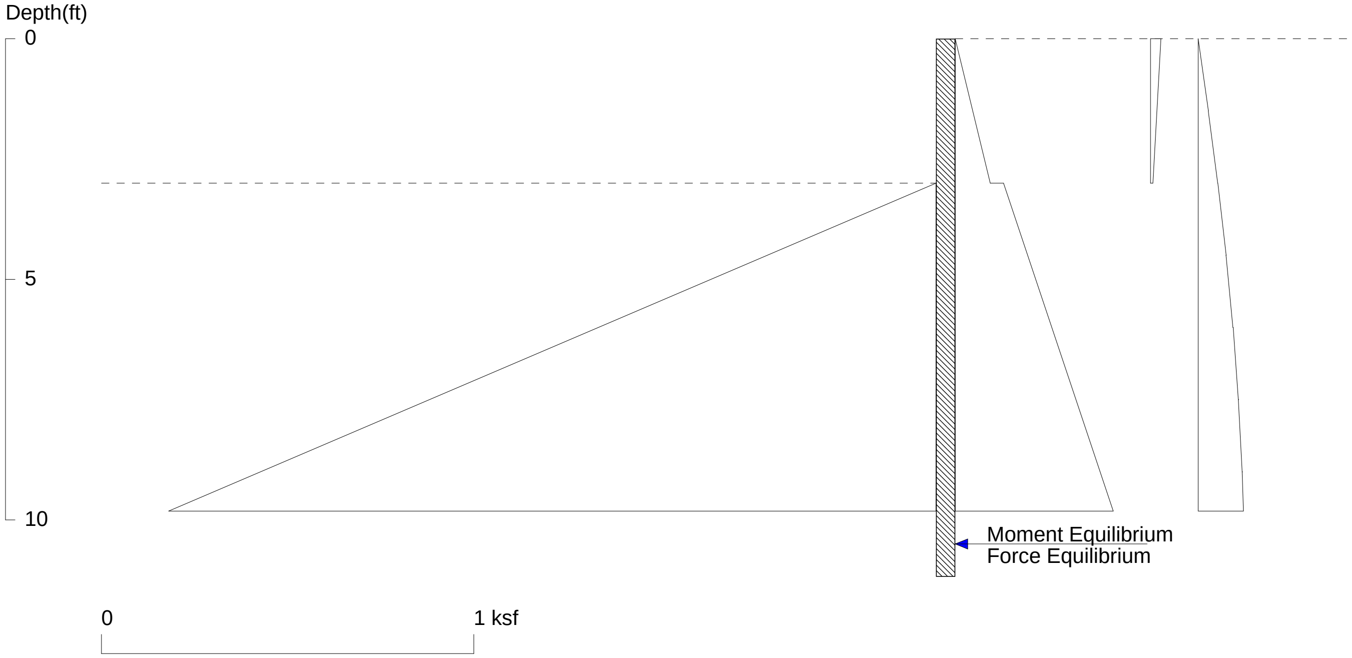
PASSIVE SPACING:

No.	Z depth	Spacing
1	3.00	1.60

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

WP4-WP6

EARTHQUAKE LOADING WITH FS=1.1 (FOR DETERMINATION OF PILE EMBEDMENT)



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File: R:\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calc

Wall Height=3.0 Pile Diameter=0.8 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=8.18 Min. Pile Length=11.18
MOMENT IN PILE: Max. Moment=8.30 per Pile Spacing=8.0 at Depth=6.72

PILE SELECTION:
Request Min. Section Modulus = 4.2 in3/pile=68.71 cm3/pile, Fy= 36 ksi = 248 MPa, Fb/Fy=0.66
-> Piles meet Min. Section Requirements: Top Deflection is shown in (in)
W4X13 (1.00) W5X16 (0.53) W6X8.5 (0.76) HP8X36 (0.10) W8X10 (0.37)
HP10X42 (0.05) W10X12 (0.21) HP12X53 (0.03) W12X14 (0.13) HP13X60 (0.02)
HP14X73 (0.02) W14X22 (0.06) W16X26 (0.04) HP16X88 (0.01)

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	3.000	0.094	0.031360
*	Below	Base		
3.000	0.130	10.72	0.463	0.043200
10.72	0.463	16.50	0.573	0.018943
*	Earth	Queck		
0.000	0.028	3.000	0.007	-0.00710
*	Water	Pres.		
10.72	0.000	17.77	0.440	0.062400
*	Sur-	charg		
0.000	0.000	1.500	0.027	0.018268
1.500	0.027	3.000	0.053	0.017057
3.000	0.053	4.500	0.075	0.014900
4.500	0.075	6.000	0.094	0.012206
6.000	0.094	7.500	0.108	0.009383
7.500	0.108	9.000	0.118	0.006734

9.000	0.118	10.50	0.124	0.004427
10.50	0.124	12.00	0.128	0.002523

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.1

Z1	P1	Z2	P2	Slope
*	Below	Base		
3.000	0.000	16.50	4.081	0.302270

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	3.00	0.80

PASSIVE SPACING:

No.	Z depth	Spacing
1	3.00	1.60

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

APPENDIX I-3B

I-3B: GEOTECHNICAL LATERAL CAPACITY OF PILES

APPENDIX I-3B: GEOTEHNICAL LATERAL CAPACITY OF PILE FOUNDAITON

This appendix presents the detailed calculations of geotechnical lateral capacity of pile foundations for the proposed pavilion and flood walls. Software L-Pile was used in the calculations and the estimated geotechnical lateral capacity refers to the lateral load applied to top of a single vertical pile which results in one-inch deflection at top of the pile.

The results and detailed calculations are summarized as follows:

Pavilion- Geotechnical Lateral Capacity of Closed End Pipe Piles

Pile Diameter (OD) (Inches)	Wall Thickness (inches)	Area (in^2)	Steel Grade	Geotechnical Lateral Capacity [1]
9-5/8	0.500	14.334	ASTM A 252- Grade 2 ASTM A 252- Grade 3	19.3kips
9-5/8	0.545	15.546	ASTM A 252- Grade 2 ASTM A 252- Grade 3	19.8kips

Notes: [1] Geotechnical lateral capacity refers to the lateral load applied to top of a single vertical pile which results in one-inch deflection at top of the pile.

Pavilion- Geotechnical Lateral Capacity of H-Piles

H-Pile	Area (in^2)	Steel Yield Strength	Geotechnical Lateral Capacity[1]
HP 12×53	15.5	50ksi	28.5kips
HP 12×63	18.4	50ksi	31.0kips
HP 12×74	21.8	50ksi	33.5kips
HP 12×84	24.6	50ksi	35.5kips

[1] Geotechnical lateral capacity refers to the lateral load applied to top of a single vertical pile which results in one-inch deflection at top of the pile.

Pavilion- Geotechnical Lateral Capacity of Micropiles

<table>
<tr><th>Micropile O.D.</th><th>Casing Thickness</th><th>Socket Length in Bedrock</th><th>Casing Yield Strength</th><th>Geotechnical Lateral Capacity[1]</th></tr>
<tr><td rowspan="3">9 5/8</td><td rowspan="3">0.50 inches</td><td>5.0ft.</td><td rowspan="6">45ksi</td><td rowspan="3">19.3kips</td></tr>
<tr><td>7.5ft.</td></tr>
<tr><td>10.0ft.</td></tr>
<tr><td rowspan="3">9 5/8</td><td rowspan="3">0.545 inches</td><td>5.0ft</td><td rowspan="3">20.0kips</td></tr>
<tr><td>7.5ft.</td></tr>
<tr><td>10.0ft.</td></tr>
<tr><td rowspan="2">11 7/8</td><td rowspan="2">0.582 inches</td><td>5.0ft</td><td rowspan="2">80ksi</td><td rowspan="2">28.0kips</td></tr>
<tr><td>7.5ft</td></tr>
</table>

[1] Geotechnical lateral capacity refers to the lateral load applied to top of a single vertical pile with #6 bar at center which results in one-inch deflection at top of the pile.

PILE TYPE	SIZE	GEOTECHNICAL LATERAL CAPACITY [1] [2]		
		WP6 ~ WP11 Sta. 10+00 ~ 11+25	**WP26 ~ WP33 Sta. 19+50 ~ 23+00**	**WP33 ~ WP40 Sta. 23+00 ~ 25+00**
Closed End Pipe Piles O.D.=9 5/8	Casing Thickness=0.5"	17.8 kips	14.2 kips	15.7 kips
	Casing Thickness = 0.545"	18.4 kips	14.6 kips	16.2 kips
H-Pile	HP12x53	27.7 kips	21.5 kips	24.5 kips
	HP12x63	30.0 kips	23.2 kips	26.5 kips
	HP12x74	32.6 kips	25.0 kips	28.9 kips
	HP12x84	34.9 kips	26.5 kips	30.8 kips
Micropile O.D.=9 5/8	Casing Thickness=0.5"	18.6 kips	14.8 kips	16.3 kips
	Casing Thickness=0.545"	19.2 kips	15.2 kips	16.8 kips
Micropile (N80) O.D.=11.875"	Casing Thickness=0.582"	27.1 kips	21.2 kips	22.9 kips

[1] Geotechnical lateral capacity refers to the lateral load applied to top of a single vertical pile which results in one-inch deflection at top of the pile. [2] Structural capacity in bending to be evaluated by others.

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

                     LPile for Windows, Version 2019-11.006

                 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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park
Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation
Package\

Name of input data file:
Floodwal 1000-1125 HP12X53.lp11d

Name of output report file:
Floodwal 1000-1125 HP12X53.lp11o

Name of plot output file:
Floodwal 1000-1125 HP12X53.lp11p

Name of runtime message file:
Floodwal 1000-1125 HP12X53.lp11r


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

Date: July 16, 2021   Time: 9:41:27

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:
- Maximum number of iterations allowed = 500
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 100.0000 in
- Number of pile increments = 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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 56.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.0000
2	56.000	12.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a H strong axis steel pile
Length of section = 56.000000 ft

```
   Pile width                                             =    12.000000 in
   Shear capacity of section                              =       0.0000 lbs



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

Ground Slope Angle                                        =        0.000 degrees
                                                          =        0.000 radians

Pile Batter Angle                                         =        0.000 degrees
                                                          =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 7 layers

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

   Distance from top of pile to top of layer              =       0.0000 ft
   Distance from top of pile to bottom of layer           =     7.500000 ft
   Effective unit weight at top of layer                  =   125.000000 pcf
   Effective unit weight at bottom of layer               =   125.000000 pcf
   Friction angle at top of layer                         =    33.200000 deg.
   Friction angle at bottom of layer                      =    33.200000 deg.
   Subgrade k at top of layer                             =       0.0000 pci
   Subgrade k at bottom of layer                          =       0.0000 pci

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

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

   Distance from top of pile to top of layer              =     7.500000 ft
   Distance from top of pile to bottom of layer           =    13.000000 ft
   Effective unit weight at top of layer                  =    62.600000 pcf
   Effective unit weight at bottom of layer               =    62.600000 pcf
   Friction angle at top of layer                         =    33.200000 deg.
   Friction angle at bottom of layer                      =    33.200000 deg.
   Subgrade k at top of layer                             =       0.0000 pci
   Subgrade k at bottom of layer                          =       0.0000 pci

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

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

```
   Distance from top of pile to top of layer          =    13.000000 ft
   Distance from top of pile to bottom of layer       =    32.000000 ft
   Effective unit weight at top of layer              =    52.600000 pcf
   Effective unit weight at bottom of layer           =    52.600000 pcf
   Friction angle at top of layer                     =    30.000000 deg.
   Friction angle at bottom of layer                  =    30.000000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

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

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

   Distance from top of pile to top of layer          =    32.000000 ft
   Distance from top of pile to bottom of layer       =    45.000000 ft
   Effective unit weight at top of layer              =    57.600000 pcf
   Effective unit weight at bottom of layer           =    57.600000 pcf
   Friction angle at top of layer                     =    31.800000 deg.
   Friction angle at bottom of layer                  =    31.800000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

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

Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer          =    45.000000 ft
   Distance from top of pile to bottom of layer       =    49.000000 ft
   Effective unit weight at top of layer              =    44.600000 pcf
   Effective unit weight at bottom of layer           =    44.600000 pcf
   Undrained cohesion at top of layer                 =   600.000000 psf
   Undrained cohesion at bottom of layer              =   600.000000 psf
   Epsilon-50 at top of layer                         =       0.0000
   Epsilon-50 at bottom of layer                      =       0.0000

   NOTE: Default values for Epsilon-50 will be computed for this layer.


Layer 6 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =    49.000000 ft
   Distance from top of pile to bottom of layer       =    53.500000 ft
   Effective unit weight at top of layer              =    57.600000 pcf
   Effective unit weight at bottom of layer           =    57.600000 pcf
   Friction angle at top of layer                     =    30.900000 deg.
   Friction angle at bottom of layer                  =    30.900000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci
```

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

Layer 7 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	53.500000 ft
Distance from top of pile to bottom of layer	=	63.500000 ft
Effective unit weight at top of layer	=	87.600000 pcf
Effective unit weight at bottom of layer	=	87.600000 pcf
Uniaxial compressive strength at top of layer	=	500.000000 psi
Uniaxial compressive strength at bottom of layer	=	500.000000 psi
Initial modulus of rock at top of layer	=	1500000. psi
Initial modulus of rock at bottom of layer	=	1500000. psi
RQD of rock at top of layer	=	75.000000 %
RQD of rock at bottom of layer	=	75.000000 %
k rm of rock at top of layer	=	0.0001000
k rm of rock at bottom of layer	=	0.0001000

(Depth of the lowest soil layer extends 7.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	7.5000	125.0000	--	33.2000	--	--	--	default	--
2	Sand	7.5000	62.6000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	13.0000	62.6000	--	33.2000	--	--	--	default	--
3	Sand	13.0000	52.6000	--	30.0000	--	--	--	default	--
	(Reese, et al.)	32.0000	52.6000	--	30.0000	--	--	--	default	--
4	Sand	32.0000	57.6000	--	31.8000	--	--	--	default	--
	(Reese, et al.)	45.0000	57.6000	--	31.8000	--	--	--	default	--

```
  5           Soft              45.0000     44.6000    600.0000      --
 --          --         default       --           --
              Clay              49.0000     44.6000    600.0000      --
 --          --         default       --           --
  6           Sand              49.0000     57.6000      --         30.9000
 --          --           --        default        --
         (Reese, et al.)        53.5000     57.6000      --         30.9000
 --          --           --        default        --
  7           Weak              53.5000     87.6000      --           --
500.0000     75.0000    1.00E-04      --         1500000.
              Rock              63.5000     87.6000      --           --
500.0000     75.0000    1.00E-04      --         1500000.


--------------------------------------------------------------------------------
                               Static Loading Type
--------------------------------------------------------------------------------

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



--------------------------------------------------------------------------------
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------

Number of loads specified = 1

Load    Load         Condition                Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type             1                        2                Force, lbs
vs. Pile Length
-----   ----   --------------------   ----------------------   ----------------
---------------    ------------
   1     1     V =       27700. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel H Strong Axis:

Length of Section	=	56.000000 ft
Flange Width	=	12.000000 in
Section Depth	=	11.800000 in
Flange Thickness	=	0.435000 in
Web Thickness	=	0.435000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	15.194550 sq. in.
Moment of Inertia	=	384.614130 in^4
Elastic Bending Stiffness	=	11153810. kip-in^2
Plastic Modulus, Z	=	72.317108in^3
Plastic Moment Capacity = Fy Z	=	2603.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	547.004 kips
Nominal Axial Tensile Capacity	=	-547.004 kips

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

Number	Axial Thrust Force kips
1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips

1	1.0000000000	2595.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	51688.
2	7.5000	7.5000	Yes	No	51688.	158223.
3	13.0000	14.9397	Yes	No	209911.	857099.
4	32.0000	31.8182	Yes	No	1067010.	1090558.
5	45.0000	402.8165	No	No	2157568.	21600.
6	49.0000	49.1423	No	No	2179168.	424516.
7	53.5000	53.5000	No	Yes	N.A.	N.A.

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

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	27700.	M, in-lb	0.00	1000.0000	0.9945	-0.01271	27700.	1378682.

Maximum pile-head deflection = 0.9945393511 inches
Maximum pile-head rotation = -0.0127134706 radians = -0.728428 deg.

The analysis ended normally.

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Floodwal 1000-1125 HP12X63.lp11d

Name of output report file:
Floodwal 1000-1125 HP12X63.lp11o

Name of plot output file:
Floodwal 1000-1125 HP12X63.lp11p

Name of runtime message file:
Floodwal 1000-1125 HP12X63.lp11r

Date and Time of Analysis

```
--------------------------------------------------------------------------------

               Date:  July 16, 2021              Time:  10:10:18


--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: South Battery Park City Resiliency



Job Number: 17-NY165-01



Client: AECOM



Engineer: SG



Description:





--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

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

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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                                      =       56.000 ft
Depth of ground surface below top of pile                 =       0.0000 ft
```

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.1000
2	56.000	12.1000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

```
   Section 1 is a H strong axis steel pile
   Length of section                                      =    56.000000 ft
```

```
   Pile width                                               =    12.100000 in
   Shear capacity of section                                =       0.0000 lbs



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

Ground Slope Angle                                          =        0.000 degrees
                                                            =        0.000 radians

Pile Batter Angle                                           =        0.000 degrees
                                                            =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 7 layers

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

   Distance from top of pile to top of layer                =       0.0000 ft
   Distance from top of pile to bottom of layer             =     7.500000 ft
   Effective unit weight at top of layer                    =   125.000000 pcf
   Effective unit weight at bottom of layer                 =   125.000000 pcf
   Friction angle at top of layer                           =    33.200000 deg.
   Friction angle at bottom of layer                        =    33.200000 deg.
   Subgrade k at top of layer                               =       0.0000 pci
   Subgrade k at bottom of layer                            =       0.0000 pci

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

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

   Distance from top of pile to top of layer                =     7.500000 ft
   Distance from top of pile to bottom of layer             =    13.000000 ft
   Effective unit weight at top of layer                    =    62.600000 pcf
   Effective unit weight at bottom of layer                 =    62.600000 pcf
   Friction angle at top of layer                           =    33.200000 deg.
   Friction angle at bottom of layer                        =    33.200000 deg.
   Subgrade k at top of layer                               =       0.0000 pci
   Subgrade k at bottom of layer                            =       0.0000 pci

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

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

```
   Distance from top of pile to top of layer          =    13.000000 ft
   Distance from top of pile to bottom of layer       =    32.000000 ft
   Effective unit weight at top of layer              =    52.600000 pcf
   Effective unit weight at bottom of layer           =    52.600000 pcf
   Friction angle at top of layer                     =    30.000000 deg.
   Friction angle at bottom of layer                  =    30.000000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

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

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

   Distance from top of pile to top of layer          =    32.000000 ft
   Distance from top of pile to bottom of layer       =    45.000000 ft
   Effective unit weight at top of layer              =    57.600000 pcf
   Effective unit weight at bottom of layer           =    57.600000 pcf
   Friction angle at top of layer                     =    31.800000 deg.
   Friction angle at bottom of layer                  =    31.800000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

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

Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer          =    45.000000 ft
   Distance from top of pile to bottom of layer       =    49.000000 ft
   Effective unit weight at top of layer              =    44.600000 pcf
   Effective unit weight at bottom of layer           =    44.600000 pcf
   Undrained cohesion at top of layer                 =   600.000000 psf
   Undrained cohesion at bottom of layer              =   600.000000 psf
   Epsilon-50 at top of layer                         =       0.0000
   Epsilon-50 at bottom of layer                      =       0.0000

   NOTE: Default values for Epsilon-50 will be computed for this layer.


Layer 6 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =    49.000000 ft
   Distance from top of pile to bottom of layer       =    53.500000 ft
   Effective unit weight at top of layer              =    57.600000 pcf
   Effective unit weight at bottom of layer           =    57.600000 pcf
   Friction angle at top of layer                     =    30.900000 deg.
   Friction angle at bottom of layer                  =    30.900000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci
```

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

Layer 7 is weak rock, p-y criteria by Reese, 1997

```
   Distance from top of pile to top of layer              =    53.500000 ft
   Distance from top of pile to bottom of layer           =    63.500000 ft
   Effective unit weight at top of layer                  =    87.600000 pcf
   Effective unit weight at bottom of layer               =    87.600000 pcf
   Uniaxial compressive strength at top of layer          =   500.000000 psi
   Uniaxial compressive strength at bottom of layer       =   500.000000 psi
   Initial modulus of rock at top of layer                =     1500000. psi
   Initial modulus of rock at bottom of layer             =     1500000. psi
   RQD of rock at top of layer                            =    75.000000 %
   RQD of rock at bottom of layer                         =    75.000000 %
   k rm of rock at top of layer                           =    0.0001000
   k rm of rock at bottom of layer                        =    0.0001000
```

(Depth of the lowest soil layer extends 7.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	7.5000	125.0000	--	33.2000	--	--	--	default	--
2	Sand	7.5000	62.6000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	13.0000	62.6000	--	33.2000	--	--	--	default	--
3	Sand	13.0000	52.6000	--	30.0000	--	--	--	default	--
	(Reese, et al.)	32.0000	52.6000	--	30.0000	--	--	--	default	--
4	Sand	32.0000	57.6000	--	31.8000	--	--	--	default	--
	(Reese, et al.)	45.0000	57.6000	--	31.8000	--	--	--	default	--

```
  5           Soft              45.0000      44.6000     600.0000       --
 --           --         default        --           --
              Clay              49.0000      44.6000     600.0000       --
 --           --         default        --           --
  6           Sand              49.0000      57.6000       --          30.9000
 --           --           --         default        --
         (Reese, et al.)        53.5000      57.6000       --          30.9000
 --           --           --         default        --
  7           Weak              53.5000      87.6000       --           --
500.0000      75.0000     1.00E-04       --         1500000.
              Rock              63.5000      87.6000       --           --
500.0000      75.0000     1.00E-04       --         1500000.


--------------------------------------------------------------------------------
                               Static Loading Type
--------------------------------------------------------------------------------

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



--------------------------------------------------------------------------------
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------

Number of loads specified = 1

Load    Load         Condition                Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                        2                  Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       30050. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel H Strong Axis:
---------------------------------------------

Length of Section                                        =    56.000000 ft
Flange Width                                             =    12.100000 in
Section Depth                                            =    11.900000 in
Flange Thickness                                         =     0.515000 in
Web Thickness                                            =     0.515000 in
Yield Stress of Pipe                                     =    36.000000 ksi
Elastic Modulus                                          =       29000. ksi
Cross-sectional Area                                     =    18.061050 sq. in.
Moment of Inertia                                        =   459.254129 in^4
Elastic Bending Stiffness                                =    13318370. kip-in^2
Plastic Modulus, Z                                       =    86.158328in^3
Plastic Moment Capacity = Fy Z                           =        3102.in-kip

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = Fy As                   =      650.198 kips
Nominal Axial Tensile Capacity                           =     -650.198 kips



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

   Number     Axial Thrust Force
                   kips
   ------     ------------------
      1              1.000


--------------------------------------------------------------------------------
   Summary of Results for Nominal Moment Capacity for Section 1
--------------------------------------------------------------------------------

                                            Nominal
Load                 Axial                  Moment
 No.                Thrust                 Capacity
                     kips                   in-kips
```

1	1.0000000000	3092.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	51838.
2	7.5000	7.4999	Yes	No	51838.	158361.
3	13.0000	14.9315	Yes	No	210199.	864242.
4	32.0000	31.8151	Yes	No	1074440.	1099646.
5	45.0000	402.5703	No	No	2174087.	21780.
6	49.0000	49.1365	No	No	2195867.	428054.
7	53.5000	53.5000	No	Yes	N.A.	N.A.

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

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	30050.	M, in-lb	0.00	1000.0000	0.9984	-0.01235	30050.	1547958.

Maximum pile-head deflection = 0.9983985082 inches
Maximum pile-head rotation = -0.0123540300 radians = -0.707834 deg.

The analysis ended normally.

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

                   LPile for Windows, Version 2019-11.006

                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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park
Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation
Package\

Name of input data file:
Floodwal 1000-1125 HP12X74.lp11d

Name of output report file:
Floodwal 1000-1125 HP12X74.lp11o

Name of plot output file:
Floodwal 1000-1125 HP12X74.lp11p

Name of runtime message file:
Floodwal 1000-1125 HP12X74.lp11r


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

Date: July 16, 2021 Time: 10:22:52

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 56.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.2000
2	56.000	12.2000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a H strong axis steel pile
Length of section = 56.000000 ft

```
   Pile width                                              =    12.200000 in
   Shear capacity of section                               =       0.0000 lbs



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

Ground Slope Angle                                         =        0.000 degrees
                                                           =        0.000 radians

Pile Batter Angle                                          =        0.000 degrees
                                                           =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 7 layers

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

   Distance from top of pile to top of layer               =       0.0000 ft
   Distance from top of pile to bottom of layer            =     7.500000 ft
   Effective unit weight at top of layer                   =   125.000000 pcf
   Effective unit weight at bottom of layer                =   125.000000 pcf
   Friction angle at top of layer                          =    33.200000 deg.
   Friction angle at bottom of layer                       =    33.200000 deg.
   Subgrade k at top of layer                              =       0.0000 pci
   Subgrade k at bottom of layer                           =       0.0000 pci

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

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

   Distance from top of pile to top of layer               =     7.500000 ft
   Distance from top of pile to bottom of layer            =    13.000000 ft
   Effective unit weight at top of layer                   =    62.600000 pcf
   Effective unit weight at bottom of layer                =    62.600000 pcf
   Friction angle at top of layer                          =    33.200000 deg.
   Friction angle at bottom of layer                       =    33.200000 deg.
   Subgrade k at top of layer                              =       0.0000 pci
   Subgrade k at bottom of layer                           =       0.0000 pci

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

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

```
   Distance from top of pile to top of layer          =    13.000000 ft
   Distance from top of pile to bottom of layer       =    32.000000 ft
   Effective unit weight at top of layer              =    52.600000 pcf
   Effective unit weight at bottom of layer           =    52.600000 pcf
   Friction angle at top of layer                     =    30.000000 deg.
   Friction angle at bottom of layer                  =    30.000000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

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

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

   Distance from top of pile to top of layer          =    32.000000 ft
   Distance from top of pile to bottom of layer       =    45.000000 ft
   Effective unit weight at top of layer              =    57.600000 pcf
   Effective unit weight at bottom of layer           =    57.600000 pcf
   Friction angle at top of layer                     =    31.800000 deg.
   Friction angle at bottom of layer                  =    31.800000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

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

Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer          =    45.000000 ft
   Distance from top of pile to bottom of layer       =    49.000000 ft
   Effective unit weight at top of layer              =    44.600000 pcf
   Effective unit weight at bottom of layer           =    44.600000 pcf
   Undrained cohesion at top of layer                 =   600.000000 psf
   Undrained cohesion at bottom of layer              =   600.000000 psf
   Epsilon-50 at top of layer                         =       0.0000
   Epsilon-50 at bottom of layer                      =       0.0000

   NOTE: Default values for Epsilon-50 will be computed for this layer.


Layer 6 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =    49.000000 ft
   Distance from top of pile to bottom of layer       =    53.500000 ft
   Effective unit weight at top of layer              =    57.600000 pcf
   Effective unit weight at bottom of layer           =    57.600000 pcf
   Friction angle at top of layer                     =    30.900000 deg.
   Friction angle at bottom of layer                  =    30.900000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci
```

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

Layer 7 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	53.500000 ft
Distance from top of pile to bottom of layer	=	63.500000 ft
Effective unit weight at top of layer	=	87.600000 pcf
Effective unit weight at bottom of layer	=	87.600000 pcf
Uniaxial compressive strength at top of layer	=	500.000000 psi
Uniaxial compressive strength at bottom of layer	=	500.000000 psi
Initial modulus of rock at top of layer	=	1500000. psi
Initial modulus of rock at bottom of layer	=	1500000. psi
RQD of rock at top of layer	=	75.000000 %
RQD of rock at bottom of layer	=	75.000000 %
k rm of rock at top of layer	=	0.0001000
k rm of rock at bottom of layer	=	0.0001000

(Depth of the lowest soil layer extends 7.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	7.5000	125.0000	--	33.2000	--	--	--	default	--
2	Sand	7.5000	62.6000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	13.0000	62.6000	--	33.2000	--	--	--	default	--
3	Sand	13.0000	52.6000	--	30.0000	--	--	--	default	--
	(Reese, et al.)	32.0000	52.6000	--	30.0000	--	--	--	default	--
4	Sand	32.0000	57.6000	--	31.8000	--	--	--	default	--
	(Reese, et al.)	45.0000	57.6000	--	31.8000	--	--	--	default	--

```
  5           Soft              45.0000      44.6000     600.0000       --
 --           --         default        --            --
              Clay              49.0000      44.6000     600.0000       --
 --           --         default        --            --
  6           Sand              49.0000      57.6000       --          30.9000
 --           --           --         default         --
         (Reese, et al.)        53.5000      57.6000       --          30.9000
 --           --           --         default         --
  7           Weak              53.5000      87.6000       --           --
500.0000      75.0000     1.00E-04       --         1500000.
              Rock              63.5000      87.6000       --           --
500.0000      75.0000     1.00E-04       --         1500000.
```

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition               Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type           1                       2                   Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       32600. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel H Strong Axis:

Length of Section	=	56.000000 ft
Flange Width	=	12.200000 in
Section Depth	=	12.100000 in
Flange Thickness	=	0.605000 in
Web Thickness	=	0.610000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	21.404900 sq. in.
Moment of Inertia	=	553.744203 in^4
Elastic Bending Stiffness	=	16058582. kip-in^2
Plastic Modulus, Z	=	102.929890in^3
Plastic Moment Capacity = Fy Z	=	3705.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	770.576 kips
Nominal Axial Tensile Capacity	=	-770.576 kips

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

Number	Axial Thrust Force kips
1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips

----	----------------	----------------
1	1.0000000000	3695.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	51992.
2	7.5000	7.5001	Yes	No	51992.	158506.
3	13.0000	14.9245	Yes	No	210498.	871384.
4	32.0000	31.8126	Yes	No	1081882.	1108734.
5	45.0000	402.3305	No	No	2190616.	21960.
6	49.0000	49.1312	No	No	2212576.	431591.
7	53.5000	53.5000	No	Yes	N.A.	N.A.

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

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs

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


Load Load                Load                  Axial    Pile-head  Pile-head  Max
Shear Max Moment
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in
Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  1  V, lb     32600.  M, in-lb        0.00  1000.0000     0.9960   -0.01191
32600.   1739986.


Maximum pile-head deflection = 0.9960343873 inches
Maximum pile-head rotation   = -0.0119139630 radians = -0.682620 deg.

The analysis ended normally.
```

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

                   LPile for Windows, Version 2019-11.006

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               Subjected to Lateral Loading Using the p-y Method
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-------------------------------------------------------------------------------
                             Files Used for Analysis
-------------------------------------------------------------------------------

Path to file locations:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park
Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation
Package\

Name of input data file:
Floodwal 1000-1125 HP12X84.lp11d

Name of output report file:
Floodwal 1000-1125 HP12X84.lp11o

Name of plot output file:
Floodwal 1000-1125 HP12X84.lp11p

Name of runtime message file:
Floodwal 1000-1125 HP12X84.lp11r


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

Date: July 16, 2021 Time: 10:31:40

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:
- Maximum number of iterations allowed = 500
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 100.0000 in
- Number of pile increments = 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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 56.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.3000
2	56.000	12.3000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a H strong axis steel pile
Length of section = 56.000000 ft

```
   Pile width                                                =    12.300000 in
   Shear capacity of section                                 =       0.0000 lbs



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

Ground Slope Angle                                           =        0.000 degrees
                                                             =        0.000 radians

Pile Batter Angle                                            =        0.000 degrees
                                                             =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 7 layers

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

   Distance from top of pile to top of layer                 =       0.0000 ft
   Distance from top of pile to bottom of layer              =     7.500000 ft
   Effective unit weight at top of layer                     =   125.000000 pcf
   Effective unit weight at bottom of layer                  =   125.000000 pcf
   Friction angle at top of layer                            =    33.200000 deg.
   Friction angle at bottom of layer                         =    33.200000 deg.
   Subgrade k at top of layer                                =       0.0000 pci
   Subgrade k at bottom of layer                             =       0.0000 pci

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

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

   Distance from top of pile to top of layer                 =     7.500000 ft
   Distance from top of pile to bottom of layer              =    13.000000 ft
   Effective unit weight at top of layer                     =    62.600000 pcf
   Effective unit weight at bottom of layer                  =    62.600000 pcf
   Friction angle at top of layer                            =    33.200000 deg.
   Friction angle at bottom of layer                         =    33.200000 deg.
   Subgrade k at top of layer                                =       0.0000 pci
   Subgrade k at bottom of layer                             =       0.0000 pci

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

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

```
   Distance from top of pile to top of layer          =    13.000000 ft
   Distance from top of pile to bottom of layer       =    32.000000 ft
   Effective unit weight at top of layer              =    52.600000 pcf
   Effective unit weight at bottom of layer           =    52.600000 pcf
   Friction angle at top of layer                     =    30.000000 deg.
   Friction angle at bottom of layer                  =    30.000000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

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

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

   Distance from top of pile to top of layer          =    32.000000 ft
   Distance from top of pile to bottom of layer       =    45.000000 ft
   Effective unit weight at top of layer              =    57.600000 pcf
   Effective unit weight at bottom of layer           =    57.600000 pcf
   Friction angle at top of layer                     =    31.800000 deg.
   Friction angle at bottom of layer                  =    31.800000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

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

Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer          =    45.000000 ft
   Distance from top of pile to bottom of layer       =    49.000000 ft
   Effective unit weight at top of layer              =    44.600000 pcf
   Effective unit weight at bottom of layer           =    44.600000 pcf
   Undrained cohesion at top of layer                 =   600.000000 psf
   Undrained cohesion at bottom of layer              =   600.000000 psf
   Epsilon-50 at top of layer                         =       0.0000
   Epsilon-50 at bottom of layer                      =       0.0000

   NOTE: Default values for Epsilon-50 will be computed for this layer.


Layer 6 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =    49.000000 ft
   Distance from top of pile to bottom of layer       =    53.500000 ft
   Effective unit weight at top of layer              =    57.600000 pcf
   Effective unit weight at bottom of layer           =    57.600000 pcf
   Friction angle at top of layer                     =    30.900000 deg.
   Friction angle at bottom of layer                  =    30.900000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci
```

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

Layer 7 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	53.500000 ft
Distance from top of pile to bottom of layer	=	63.500000 ft
Effective unit weight at top of layer	=	87.600000 pcf
Effective unit weight at bottom of layer	=	87.600000 pcf
Uniaxial compressive strength at top of layer	=	500.000000 psi
Uniaxial compressive strength at bottom of layer	=	500.000000 psi
Initial modulus of rock at top of layer	=	1500000. psi
Initial modulus of rock at bottom of layer	=	1500000. psi
RQD of rock at top of layer	=	75.000000 %
RQD of rock at bottom of layer	=	78.000000 %
k rm of rock at top of layer	=	0.0001000
k rm of rock at bottom of layer	=	0.0001000

(Depth of the lowest soil layer extends 7.500 ft below the pile tip)

Summary of Input Soil Properties

Layer Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	7.5000	125.0000	--	33.2000	--	--	--	default	--
2	Sand	7.5000	62.6000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	13.0000	62.6000	--	33.2000	--	--	--	default	--
3	Sand	13.0000	52.6000	--	30.0000	--	--	--	default	--
	(Reese, et al.)	32.0000	52.6000	--	30.0000	--	--	--	default	--
4	Sand	32.0000	57.6000	--	31.8000	--	--	--	default	--
	(Reese, et al.)	45.0000	57.6000	--	31.8000	--	--	--	default	--

```
  5           Soft              45.0000      44.6000     600.0000       --
 --           --         default        --           --
              Clay              49.0000      44.6000     600.0000       --
 --           --         default        --           --
  6           Sand              49.0000      57.6000       --          30.9000
 --           --           --         default        --
         (Reese, et al.)        53.5000      57.6000       --          30.9000
 --           --           --         default        --
  7           Weak              53.5000      87.6000       --            --
500.0000     75.0000    1.00E-04       --         1500000.
              Rock              63.5000      87.6000       --            --
500.0000     78.0000    1.00E-04       --         1500000.
```

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition                Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                        2                  Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       34900. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel H Strong Axis:

Length of Section	=	56.000000 ft
Flange Width	=	12.300000 in
Section Depth	=	12.300000 in
Flange Thickness	=	0.685000 in
Web Thickness	=	0.685000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	24.338050 sq. in.
Moment of Inertia	=	643.530174 in^4
Elastic Bending Stiffness	=	18662375. kip-in^2
Plastic Modulus, Z	=	118.320547in^3
Plastic Moment Capacity = Fy Z	=	4260.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	876.170 kips
Nominal Axial Tensile Capacity	=	-876.170 kips

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

Number	Axial Thrust Force kips
1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips

----	----------------	----------------
1	1.0000000000	4246.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	52144.
2	7.5000	7.5000	Yes	No	52144.	158643.
3	13.0000	14.9182	Yes	No	210786.	878527.
4	32.0000	31.8105	Yes	No	1089313.	1117822.
5	45.0000	402.0929	No	No	2207135.	22140.
6	49.0000	49.1261	No	No	2229275.	435129.
7	53.5000	53.5000	No	Yes	N.A.	N.A.

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

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs

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


Load Load                Load                  Axial    Pile-head  Pile-head  Max
Shear Max Moment
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in
Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  1  V, lb     34900.  M, in-lb        0.00  1000.0000     0.9985   -0.01162
34900.   1913086.


Maximum pile-head deflection = 0.9984660120 inches
Maximum pile-head rotation   = -0.0116222363 radians = -0.665905 deg.

The analysis ended normally.
```

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

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

Path to file locations:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park
Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation
Package\

Name of input data file:
Floodwal 1000-1125 micropile 9.625 inch OD 0.5inch Wall.lp11d

Name of output report file:
Floodwal 1000-1125 micropile 9.625 inch OD 0.5inch Wall.lp11o

Name of plot output file:
Floodwal 1000-1125 micropile 9.625 inch OD 0.5inch Wall.lp11p

Name of runtime message file:
Floodwal 1000-1125 micropile 9.625 inch OD 0.5inch Wall.lp11r


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

```
--------------------------------------------------------------------------------

               Date:  July 16, 2021              Time:  10:48:27


--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: South Battery Park City Resiliency



Job Number: 17-NY165-01



Client: AECOM



Engineer: SG



Description:





--------------------------------------------------------------------------------
                         Program Options and Settings
--------------------------------------------------------------------------------

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

Analysis Control Options:
 - Maximum number of iterations allowed                =         500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =         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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 56.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	9.6250
2	56.000	9.6250

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a drilled shaft with permanent casing
Length of section = 56.000000 ft

```
   Casing outside diameter                                =     9.625000 in
   Shear capacity of section                              =       0.0000 lbs
```

Ground Slope and Pile Batter Angles

```
Ground Slope Angle                                        =        0.000 degrees
                                                          =        0.000 radians

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

Soil and Rock Layering Information

```
The soil profile is modelled using 7 layers

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

   Distance from top of pile to top of layer              =       0.0000 ft
   Distance from top of pile to bottom of layer           =     7.500000 ft
   Effective unit weight at top of layer                  =   125.000000 pcf
   Effective unit weight at bottom of layer               =   125.000000 pcf
   Friction angle at top of layer                         =    33.200000 deg.
   Friction angle at bottom of layer                      =    33.200000 deg.
   Subgrade k at top of layer                             =       0.0000 pci
   Subgrade k at bottom of layer                          =       0.0000 pci

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

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

   Distance from top of pile to top of layer              =     7.500000 ft
   Distance from top of pile to bottom of layer           =    13.000000 ft
   Effective unit weight at top of layer                  =    62.600000 pcf
   Effective unit weight at bottom of layer               =    62.600000 pcf
   Friction angle at top of layer                         =    33.200000 deg.
   Friction angle at bottom of layer                      =    33.200000 deg.
   Subgrade k at top of layer                             =       0.0000 pci
   Subgrade k at bottom of layer                          =       0.0000 pci

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

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

```
   Distance from top of pile to top of layer          =    13.000000 ft
   Distance from top of pile to bottom of layer       =    32.000000 ft
   Effective unit weight at top of layer              =    52.600000 pcf
   Effective unit weight at bottom of layer           =    52.600000 pcf
   Friction angle at top of layer                     =    30.000000 deg.
   Friction angle at bottom of layer                  =    30.000000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

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

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

   Distance from top of pile to top of layer          =    32.000000 ft
   Distance from top of pile to bottom of layer       =    45.000000 ft
   Effective unit weight at top of layer              =    57.600000 pcf
   Effective unit weight at bottom of layer           =    57.600000 pcf
   Friction angle at top of layer                     =    31.800000 deg.
   Friction angle at bottom of layer                  =    31.800000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

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

Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer          =    45.000000 ft
   Distance from top of pile to bottom of layer       =    49.000000 ft
   Effective unit weight at top of layer              =    44.600000 pcf
   Effective unit weight at bottom of layer           =    44.600000 pcf
   Undrained cohesion at top of layer                 =   600.000000 psf
   Undrained cohesion at bottom of layer              =   600.000000 psf
   Epsilon-50 at top of layer                         =       0.0000
   Epsilon-50 at bottom of layer                      =       0.0000

   NOTE: Default values for Epsilon-50 will be computed for this layer.


Layer 6 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =    49.000000 ft
   Distance from top of pile to bottom of layer       =    53.500000 ft
   Effective unit weight at top of layer              =    57.600000 pcf
   Effective unit weight at bottom of layer           =    57.600000 pcf
   Friction angle at top of layer                     =    30.900000 deg.
   Friction angle at bottom of layer                  =    30.900000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci
```

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

Layer 7 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	53.500000 ft
Distance from top of pile to bottom of layer	=	63.500000 ft
Effective unit weight at top of layer	=	87.600000 pcf
Effective unit weight at bottom of layer	=	87.600000 pcf
Uniaxial compressive strength at top of layer	=	500.000000 psi
Uniaxial compressive strength at bottom of layer	=	500.000000 psi
Initial modulus of rock at top of layer	=	1500000. psi
Initial modulus of rock at bottom of layer	=	1500000. psi
RQD of rock at top of layer	=	75.000000 %
RQD of rock at bottom of layer	=	75.000000 %
k rm of rock at top of layer	=	0.0001000
k rm of rock at bottom of layer	=	0.0001000

(Depth of the lowest soil layer extends 7.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	7.5000	125.0000	--	33.2000	--	--	--	default	--
2	Sand	7.5000	62.6000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	13.0000	62.6000	--	33.2000	--	--	--	default	--
3	Sand	13.0000	52.6000	--	30.0000	--	--	--	default	--
	(Reese, et al.)	32.0000	52.6000	--	30.0000	--	--	--	default	--
4	Sand	32.0000	57.6000	--	31.8000	--	--	--	default	--
	(Reese, et al.)	45.0000	57.6000	--	31.8000	--	--	--	default	--

```
  5            Soft               45.0000      44.6000     600.0000       --
 --           --         default        --           --
               Clay               49.0000      44.6000     600.0000       --
 --           --         default        --           --
  6            Sand               49.0000      57.6000       --          30.9000
 --           --           --         default        --
          (Reese, et al.)         53.5000      57.6000       --          30.9000
 --           --           --         default        --
  7            Weak               53.5000      87.6000       --           --
500.0000      75.0000     1.00E-04       --         1500000.
               Rock               63.5000      87.6000       --           --
500.0000      75.0000     1.00E-04       --         1500000.


--------------------------------------------------------------------------------
                               Static Loading Type
--------------------------------------------------------------------------------

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



--------------------------------------------------------------------------------
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------

Number of loads specified = 1

Load    Load         Condition                Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type           1                        2                  Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       18600. lbs   M =       0.0000 in-lbs    1000.000000000
    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) with Permanent Casing:
------------------------------------------------------------------------------

Length of Section                                      =    56.000000 ft
Outer Diameter of Casing                               =     9.625000 in
Casing Wall Thickness                                  =     0.500000 in
Moment of Inertia of Steel Casing                      =   149.634073 in^4
Yield Stress of Casing                                 =       50000. psi
Elastic Modulus of Casing                              =    29000000. psi
Number of Reinforcing Bars                             =            0 bars
Area of Single Reinforcing Bar                         =       0.0000 sq. in.
Offset of Center of Rebar Cage from Center of Pile     =       0.0000 in
Yield Stress of Reinforcing Bars                       =       0.0000 psi
Modulus of Elasticity of Reinforcing Bars              =       0.0000 psi
Gross Area of Pile                                     =    72.759777 sq. in.
Area of Concrete                                       =    58.426260 sq. in.
Cross-sectional Area of Steel Casing                   =    14.333516 sq. in.
Area of All Steel (Casing and Bars)                    =    14.333516 sq. in.
Area Ratio of All Steel to Gross Area of Pile          =        19.70 percent

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As    =      915.325 kips
Tensile Load for Cracking of Concrete                  =      -72.256 kips
Nominal Axial Tensile Capacity                         =     -716.676 kips



Concrete Properties:
--------------------

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


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

Number	Axial Thrust Force kips
1	1.000

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
1	1.000	2128.858	0.00300000

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

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

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

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

Axial 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	1.000000	2129.	0.650000	1384.	4733868.
1	0.75	1.000000	2129.	0.750000	1597.	4718875.
1	0.90	1.000000	2129.	0.900000	1916.	4328784.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	48423.
2	7.5000	7.4999	Yes	No	48423.	154570.
3	13.0000	15.4351	Yes	No	202993.	687465.
4	32.0000	32.0552	Yes	No	890458.	874719.
5	45.0000	410.2633	No	No	1765177.	17325.
6	49.0000	49.3996	No	No	1782502.	340497.
7	53.5000	53.5000	No	Yes	N.A.	N.A.

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

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	18600.	M, in-lb	0.00	1000.0000	0.9933	-0.01484		

```
18600.    824788.


Maximum pile-head deflection = 0.9932587274 inches
Maximum pile-head rotation   = -0.0148395444 radians = -0.850243 deg.

The analysis ended normally.
```

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Floodwal 1000-1125 micropile 9.625 inch OD 0.545inch Wall.lp11d

Name of output report file:
Floodwal 1000-1125 micropile 9.625 inch OD 0.545inch Wall.lp11o

Name of plot output file:
Floodwal 1000-1125 micropile 9.625 inch OD 0.545inch Wall.lp11p

Name of runtime message file:
Floodwal 1000-1125 micropile 9.625 inch OD 0.545inch Wall.lp11r

----
Date and Time of Analysis

Date: July 16, 2021 Time: 10:56:35

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 56.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	9.6250
2	56.000	9.6250

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a drilled shaft with permanent casing
Length of section = 56.000000 ft

```
   Casing outside diameter                                  =     9.625000 in
   Shear capacity of section                                =       0.0000 lbs
```

Ground Slope and Pile Batter Angles

```
Ground Slope Angle                                          =        0.000 degrees
                                                            =        0.000 radians

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

Soil and Rock Layering Information

```
The soil profile is modelled using 7 layers

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

   Distance from top of pile to top of layer                =       0.0000 ft
   Distance from top of pile to bottom of layer             =     7.500000 ft
   Effective unit weight at top of layer                    =   125.000000 pcf
   Effective unit weight at bottom of layer                 =   125.000000 pcf
   Friction angle at top of layer                           =    33.200000 deg.
   Friction angle at bottom of layer                        =    33.200000 deg.
   Subgrade k at top of layer                               =       0.0000 pci
   Subgrade k at bottom of layer                            =       0.0000 pci

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

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

   Distance from top of pile to top of layer                =     7.500000 ft
   Distance from top of pile to bottom of layer             =    13.000000 ft
   Effective unit weight at top of layer                    =    62.600000 pcf
   Effective unit weight at bottom of layer                 =    62.600000 pcf
   Friction angle at top of layer                           =    33.200000 deg.
   Friction angle at bottom of layer                        =    33.200000 deg.
   Subgrade k at top of layer                               =       0.0000 pci
   Subgrade k at bottom of layer                            =       0.0000 pci

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

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

```
   Distance from top of pile to top of layer          =    13.000000 ft
   Distance from top of pile to bottom of layer       =    32.000000 ft
   Effective unit weight at top of layer              =    52.600000 pcf
   Effective unit weight at bottom of layer           =    52.600000 pcf
   Friction angle at top of layer                     =    30.000000 deg.
   Friction angle at bottom of layer                  =    30.000000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

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

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

   Distance from top of pile to top of layer          =    32.000000 ft
   Distance from top of pile to bottom of layer       =    45.000000 ft
   Effective unit weight at top of layer              =    57.600000 pcf
   Effective unit weight at bottom of layer           =    57.600000 pcf
   Friction angle at top of layer                     =    31.800000 deg.
   Friction angle at bottom of layer                  =    31.800000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

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

Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer          =    45.000000 ft
   Distance from top of pile to bottom of layer       =    49.000000 ft
   Effective unit weight at top of layer              =    44.600000 pcf
   Effective unit weight at bottom of layer           =    44.600000 pcf
   Undrained cohesion at top of layer                 =   600.000000 psf
   Undrained cohesion at bottom of layer              =   600.000000 psf
   Epsilon-50 at top of layer                         =       0.0000
   Epsilon-50 at bottom of layer                      =       0.0000

   NOTE: Default values for Epsilon-50 will be computed for this layer.


Layer 6 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =    49.000000 ft
   Distance from top of pile to bottom of layer       =    53.500000 ft
   Effective unit weight at top of layer              =    57.600000 pcf
   Effective unit weight at bottom of layer           =    57.600000 pcf
   Friction angle at top of layer                     =    30.900000 deg.
   Friction angle at bottom of layer                  =    30.900000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci
```

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

Layer 7 is weak rock, p-y criteria by Reese, 1997

```
Distance from top of pile to top of layer             =    53.500000 ft
Distance from top of pile to bottom of layer          =    63.500000 ft
Effective unit weight at top of layer                 =    87.600000 pcf
Effective unit weight at bottom of layer              =    87.600000 pcf
Uniaxial compressive strength at top of layer         =   500.000000 psi
Uniaxial compressive strength at bottom of layer      =   500.000000 psi
Initial modulus of rock at top of layer               =     1500000. psi
Initial modulus of rock at bottom of layer            =     1500000. psi
RQD of rock at top of layer                           =    75.000000 %
RQD of rock at bottom of layer                        =    75.000000 %
k rm of rock at top of layer                          =    0.0001000
k rm of rock at bottom of layer                       =    0.0001000
```

(Depth of the lowest soil layer extends 7.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	7.5000	125.0000	--	33.2000	--	--	--	default	--
2	Sand	7.5000	62.6000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	13.0000	62.6000	--	33.2000	--	--	--	default	--
3	Sand	13.0000	52.6000	--	30.0000	--	--	--	default	--
	(Reese, et al.)	32.0000	52.6000	--	30.0000	--	--	--	default	--
4	Sand	32.0000	57.6000	--	31.8000	--	--	--	default	--
	(Reese, et al.)	45.0000	57.6000	--	31.8000	--	--	--	default	--

```
  5           Soft              45.0000      44.6000     600.0000       --
 --           --          default        --           --
              Clay              49.0000      44.6000     600.0000       --
 --           --          default        --           --
  6           Sand              49.0000      57.6000       --          30.9000
 --           --            --         default        --
         (Reese, et al.)        53.5000      57.6000       --          30.9000
 --           --            --         default        --
  7           Weak              53.5000      87.6000       --           --
500.0000      75.0000     1.00E-04       --         1500000.
              Rock              63.5000      87.6000       --           --
500.0000      75.0000     1.00E-04       --         1500000.
```

```
--------------------------------------------------------------------------------
                               Static Loading Type
--------------------------------------------------------------------------------
```

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

```
--------------------------------------------------------------------------------
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------
```

Number of loads specified = 1

```
Load    Load         Condition               Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                       2                  Force, lbs
vs. Pile Length
-----   ----   --------------------   ----------------------   ----------------
---------------    ------------
   1     1     V =       19200. lbs   M =       0.0000 in-lbs    1000.000000000
    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) with Permanent Casing:
------------------------------------------------------------------------------

Length of Section                                       =    56.000000 ft
Outer Diameter of Casing                                =     9.625000 in
Casing Wall Thickness                                   =     0.545000 in
Moment of Inertia of Steel Casing                       =   160.796181 in^4
Yield Stress of Casing                                  =       50000. psi
Elastic Modulus of Casing                               =    29000000. psi
Number of Reinforcing Bars                              =            0 bars
Area of Single Reinforcing Bar                          =       0.0000 sq. in.
Offset of Center of Rebar Cage from Center of Pile     =       0.0000 in
Yield Stress of Reinforcing Bars                        =       0.0000 psi
Modulus of Elasticity of Reinforcing Bars               =       0.0000 psi
Gross Area of Pile                                      =    72.759777 sq. in.
Area of Concrete                                        =    57.213291 sq. in.
Cross-sectional Area of Steel Casing                    =    15.546485 sq. in.
Area of All Steel (Casing and Bars)                     =    15.546485 sq. in.
Area Ratio of All Steel to Gross Area of Pile           =        21.37 percent

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As    =      971.849 kips
Tensile Load for Cracking of Concrete                   =      -75.810 kips
Nominal Axial Tensile Capacity                          =     -777.324 kips



Concrete Properties:
--------------------

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


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

Number	Axial Thrust Force kips
1	1.000

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
1	1.000	2280.020	0.00300000

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

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

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

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

Axial 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	1.000000	2280.	0.650000	1482.	5046184.
1	0.75	1.000000	2280.	0.750000	1710.	5031444.
1	0.90	1.000000	2280.	0.900000	2052.	4640384.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	48423.
2	7.5000	7.4999	Yes	No	48423.	154570.
3	13.0000	15.4351	Yes	No	202993.	687465.
4	32.0000	32.0552	Yes	No	890458.	874719.
5	45.0000	410.2633	No	No	1765177.	17325.
6	49.0000	49.3996	No	No	1782502.	340497.
7	53.5000	53.5000	No	Yes	N.A.	N.A.

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

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	19200.	M, in-lb	0.00	1000.0000	0.9994	-0.01475		

```
19200.    863159.


Maximum pile-head deflection = 0.9993985532 inches
Maximum pile-head rotation   = -0.0147508265 radians = -0.845160 deg.

The analysis ended normally.
```

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Floodwal 1000-1125 micropile 11.875 inch OD 0.582inch Wall.lp11d

Name of output report file:
Floodwal 1000-1125 micropile 11.875 inch OD 0.582inch Wall.lp11o

Name of plot output file:
Floodwal 1000-1125 micropile 11.875 inch OD 0.582inch Wall.lp11p

Name of runtime message file:
Floodwal 1000-1125 micropile 11.875 inch OD 0.582inch Wall.lp11r

----

Date and Time of Analysis

Date: July 16, 2021   Time: 11:05:52

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:
- Maximum number of iterations allowed = 500
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 100.0000 in
- Number of pile increments = 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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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                                     =       56.000 ft
Depth of ground surface below top of pile                =       0.0000 ft
```

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	11.8750
2	56.000	11.8750

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a drilled shaft with permanent casing

```
Length of section                                     =    56.000000 ft
```

```
   Casing outside diameter                                 =    11.875000 in
   Shear capacity of section                               =       0.0000 lbs



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

Ground Slope Angle                                         =        0.000 degrees
                                                           =        0.000 radians

Pile Batter Angle                                          =        0.000 degrees
                                                           =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 7 layers

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

   Distance from top of pile to top of layer               =       0.0000 ft
   Distance from top of pile to bottom of layer            =     7.500000 ft
   Effective unit weight at top of layer                   =   125.000000 pcf
   Effective unit weight at bottom of layer                =   125.000000 pcf
   Friction angle at top of layer                          =    33.200000 deg.
   Friction angle at bottom of layer                       =    33.200000 deg.
   Subgrade k at top of layer                              =       0.0000 pci
   Subgrade k at bottom of layer                           =       0.0000 pci

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

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

   Distance from top of pile to top of layer               =     7.500000 ft
   Distance from top of pile to bottom of layer            =    13.000000 ft
   Effective unit weight at top of layer                   =    62.600000 pcf
   Effective unit weight at bottom of layer                =    62.600000 pcf
   Friction angle at top of layer                          =    33.200000 deg.
   Friction angle at bottom of layer                       =    33.200000 deg.
   Subgrade k at top of layer                              =       0.0000 pci
   Subgrade k at bottom of layer                           =       0.0000 pci

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

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

```
   Distance from top of pile to top of layer          =    13.000000 ft
   Distance from top of pile to bottom of layer       =    32.000000 ft
   Effective unit weight at top of layer              =    52.600000 pcf
   Effective unit weight at bottom of layer           =    52.600000 pcf
   Friction angle at top of layer                     =    30.000000 deg.
   Friction angle at bottom of layer                  =    30.000000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

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

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

   Distance from top of pile to top of layer          =    32.000000 ft
   Distance from top of pile to bottom of layer       =    45.000000 ft
   Effective unit weight at top of layer              =    57.600000 pcf
   Effective unit weight at bottom of layer           =    57.600000 pcf
   Friction angle at top of layer                     =    31.800000 deg.
   Friction angle at bottom of layer                  =    31.800000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci

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

Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer          =    45.000000 ft
   Distance from top of pile to bottom of layer       =    49.000000 ft
   Effective unit weight at top of layer              =    44.600000 pcf
   Effective unit weight at bottom of layer           =    44.600000 pcf
   Undrained cohesion at top of layer                 =   600.000000 psf
   Undrained cohesion at bottom of layer              =   600.000000 psf
   Epsilon-50 at top of layer                         =       0.0000
   Epsilon-50 at bottom of layer                      =       0.0000

   NOTE: Default values for Epsilon-50 will be computed for this layer.


Layer 6 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer          =    49.000000 ft
   Distance from top of pile to bottom of layer       =    53.500000 ft
   Effective unit weight at top of layer              =    57.600000 pcf
   Effective unit weight at bottom of layer           =    57.600000 pcf
   Friction angle at top of layer                     =    30.900000 deg.
   Friction angle at bottom of layer                  =    30.900000 deg.
   Subgrade k at top of layer                         =       0.0000 pci
   Subgrade k at bottom of layer                      =       0.0000 pci
```

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

Layer 7 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	53.500000 ft
Distance from top of pile to bottom of layer	=	63.500000 ft
Effective unit weight at top of layer	=	87.600000 pcf
Effective unit weight at bottom of layer	=	87.600000 pcf
Uniaxial compressive strength at top of layer	=	500.000000 psi
Uniaxial compressive strength at bottom of layer	=	500.000000 psi
Initial modulus of rock at top of layer	=	1500000. psi
Initial modulus of rock at bottom of layer	=	1500000. psi
RQD of rock at top of layer	=	75.000000 %
RQD of rock at bottom of layer	=	75.000000 %
k rm of rock at top of layer	=	0.0001000
k rm of rock at bottom of layer	=	0.0001000

(Depth of the lowest soil layer extends 7.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	7.5000	125.0000	--	33.2000	--	--	--	default	--
2	Sand	7.5000	62.6000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	13.0000	62.6000	--	33.2000	--	--	--	default	--
3	Sand	13.0000	52.6000	--	30.0000	--	--	--	default	--
	(Reese, et al.)	32.0000	52.6000	--	30.0000	--	--	--	default	--
4	Sand	32.0000	57.6000	--	31.8000	--	--	--	default	--
	(Reese, et al.)	45.0000	57.6000	--	31.8000	--	--	--	default	--

```
  5            Soft              45.0000      44.6000     600.0000       --
 --           --         default        --           --
               Clay              49.0000      44.6000     600.0000       --
 --           --         default        --           --
  6            Sand              49.0000      57.6000       --          30.9000
 --           --           --         default        --
          (Reese, et al.)        53.5000      57.6000       --          30.9000
 --           --           --         default        --
  7            Weak              53.5000      87.6000       --            --
500.0000      75.0000     1.00E-04       --         1500000.
               Rock              63.5000      87.6000       --            --
500.0000      75.0000     1.00E-04       --         1500000.
```

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition                Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                         2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   ----------------------   ----------------
---------------    ------------
   1     1     V =       27100. lbs   M =       0.0000 in-lbs    1000.000000000
    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) with Permanent Casing:

Length of Section	=	56.000000	ft
Outer Diameter of Casing	=	11.875000	in
Casing Wall Thickness	=	0.582000	in
Moment of Inertia of Steel Casing	=	330.037136	in^4
Yield Stress of Casing	=	50000.	psi
Elastic Modulus of Casing	=	29000000.	psi
Number of Reinforcing Bars	=	0	bars
Area of Single Reinforcing Bar	=	0.0000	sq. in.
Offset of Center of Rebar Cage from Center of Pile	=	0.0000	in
Yield Stress of Reinforcing Bars	=	0.0000	psi
Modulus of Elasticity of Reinforcing Bars	=	0.0000	psi
Gross Area of Pile	=	110.753413	sq. in.
Area of Concrete	=	90.105213	sq. in.
Cross-sectional Area of Steel Casing	=	20.648199	sq. in.
Area of All Steel (Casing and Bars)	=	20.648199	sq. in.
Area Ratio of All Steel to Gross Area of Pile	=	18.64	percent

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	1338.768	kips
Tensile Load for Cracking of Concrete	=	-106.559	kips
Nominal Axial Tensile Capacity	=	-1032.410	kips

Concrete Properties:

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

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

Number	Axial Thrust Force kips
1	1.000

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
1	1.000	3814.487	0.00300000

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

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

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

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

Axial 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	1.000000	3814.	0.650000	2479.	10500974.
1	0.75	1.000000	3814.	0.750000	2861.	10463591.
1	0.90	1.000000	3814.	0.900000	3433.	9566972.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	51501.
2	7.5000	7.5000	Yes	No	51501.	158049.
3	13.0000	14.9511	Yes	No	209549.	848171.
4	32.0000	31.8228	Yes	No	1057720.	1079198.
5	45.0000	403.1301	No	No	2136919.	21375.
6	49.0000	49.1499	No	No	2158294.	420094.
7	53.5000	53.5000	No	Yes	N.A.	N.A.

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

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	27100.	M, in-lb	0.00	1000.0000	0.9951	-0.01282		

```
27100.   1340456.


Maximum pile-head deflection = 0.9951032342 inches
Maximum pile-head rotation   = -0.0128165775 radians = -0.734336 deg.

The analysis ended normally.
```

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Floodwal 1000-1125pipe pile 0.5inch Wall.lp11d

Name of output report file:
Floodwal 1000-1125pipe pile 0.5inch Wall.lp11o

Name of plot output file:
Floodwal 1000-1125pipe pile 0.5inch Wall.lp11p

Name of runtime message file:
Floodwal 1000-1125pipe pile 0.5inch Wall.lp11r

Date and Time of Analysis

Date: July 16, 2021 Time: 11:15:14

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:
- Maximum number of iterations allowed = 500
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 100.0000 in
- Number of pile increments = 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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 56.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	9.6250
2	56.000	9.6250

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a steel pipe pile
Length of section = 56.000000 ft

```
   Pile diameter                                           =     9.625000 in
   Shear capacity of section                               =       0.0000 lbs



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

Ground Slope Angle                                         =        0.000 degrees
                                                           =        0.000 radians

Pile Batter Angle                                          =        0.000 degrees
                                                           =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 7 layers

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

   Distance from top of pile to top of layer               =       0.0000 ft
   Distance from top of pile to bottom of layer            =     7.500000 ft
   Effective unit weight at top of layer                   =   125.000000 pcf
   Effective unit weight at bottom of layer                =   125.000000 pcf
   Friction angle at top of layer                          =    33.200000 deg.
   Friction angle at bottom of layer                       =    33.200000 deg.
   Subgrade k at top of layer                              =       0.0000 pci
   Subgrade k at bottom of layer                           =       0.0000 pci

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

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

   Distance from top of pile to top of layer               =     7.500000 ft
   Distance from top of pile to bottom of layer            =    13.000000 ft
   Effective unit weight at top of layer                   =    62.600000 pcf
   Effective unit weight at bottom of layer                =    62.600000 pcf
   Friction angle at top of layer                          =    33.200000 deg.
   Friction angle at bottom of layer                       =    33.200000 deg.
   Subgrade k at top of layer                              =       0.0000 pci
   Subgrade k at bottom of layer                           =       0.0000 pci

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

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

```
   Distance from top of pile to top of layer           =    13.000000 ft
   Distance from top of pile to bottom of layer        =    32.000000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Friction angle at top of layer                      =    30.000000 deg.
   Friction angle at bottom of layer                   =    30.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

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

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

   Distance from top of pile to top of layer           =    32.000000 ft
   Distance from top of pile to bottom of layer        =    45.000000 ft
   Effective unit weight at top of layer               =    57.600000 pcf
   Effective unit weight at bottom of layer            =    57.600000 pcf
   Friction angle at top of layer                      =    31.800000 deg.
   Friction angle at bottom of layer                   =    31.800000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

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

Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer           =    45.000000 ft
   Distance from top of pile to bottom of layer        =    49.000000 ft
   Effective unit weight at top of layer               =    44.600000 pcf
   Effective unit weight at bottom of layer            =    44.600000 pcf
   Undrained cohesion at top of layer                  =   600.000000 psf
   Undrained cohesion at bottom of layer               =   600.000000 psf
   Epsilon-50 at top of layer                          =       0.0000
   Epsilon-50 at bottom of layer                       =       0.0000

   NOTE: Default values for Epsilon-50 will be computed for this layer.


Layer 6 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =    49.000000 ft
   Distance from top of pile to bottom of layer        =    53.500000 ft
   Effective unit weight at top of layer               =    57.600000 pcf
   Effective unit weight at bottom of layer            =    57.600000 pcf
   Friction angle at top of layer                      =    30.900000 deg.
   Friction angle at bottom of layer                   =    30.900000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci
```

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

Layer 7 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	53.500000 ft
Distance from top of pile to bottom of layer	=	63.500000 ft
Effective unit weight at top of layer	=	87.600000 pcf
Effective unit weight at bottom of layer	=	87.600000 pcf
Uniaxial compressive strength at top of layer	=	500.000000 psi
Uniaxial compressive strength at bottom of layer	=	500.000000 psi
Initial modulus of rock at top of layer	=	1500000. psi
Initial modulus of rock at bottom of layer	=	1500000. psi
RQD of rock at top of layer	=	75.000000 %
RQD of rock at bottom of layer	=	75.000000 %
k rm of rock at top of layer	=	0.0001000
k rm of rock at bottom of layer	=	0.0001000

(Depth of the lowest soil layer extends 7.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	7.5000	125.0000	--	33.2000	--	--	--	default	--
2	Sand	7.5000	62.6000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	13.0000	62.6000	--	33.2000	--	--	--	default	--
3	Sand	13.0000	52.6000	--	30.0000	--	--	--	default	--
	(Reese, et al.)	32.0000	52.6000	--	30.0000	--	--	--	default	--
4	Sand	32.0000	57.6000	--	31.8000	--	--	--	default	--
	(Reese, et al.)	45.0000	57.6000	--	31.8000	--	--	--	default	--

```
  5           Soft              45.0000     44.6000    600.0000      --
 --          --         default       --          --
              Clay              49.0000     44.6000    600.0000      --
 --          --         default       --          --
  6           Sand              49.0000     57.6000      --         30.9000
 --          --           --         default      --
         (Reese, et al.)        53.5000     57.6000      --         30.9000
 --          --           --         default      --
  7           Weak              53.5000     87.6000      --           --
500.0000     75.0000    1.00E-04      --        1500000.
              Rock              63.5000     87.6000      --           --
500.0000     75.0000    1.00E-04      --        1500000.


--------------------------------------------------------------------------------
                              Static Loading Type
--------------------------------------------------------------------------------

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



--------------------------------------------------------------------------------
               Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------

Number of loads specified = 1

Load    Load         Condition               Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                        2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   ----------------------   ----------------
---------------    ------------
   1     1     V =       17800. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel Pipe Pile:

Length of Section	=	56.000000 ft
Outer Diameter of Pipe	=	9.625000 in
Pipe Wall Thickness	=	0.500000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	14.333516 sq. in.
Moment of Inertia	=	149.634073 in^4
Elastic Bending Stiffness	=	4339388. kip-in^2
Plastic Modulus, Z	=	41.674479in^3
Plastic Moment Capacity = Fy Z	=	1500.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	516.007 kips
Nominal Axial Tensile Capacity	=	-516.007 kips

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

Number	Axial Thrust Force kips
1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	1489.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	48423.
2	7.5000	7.4999	Yes	No	48423.	154570.
3	13.0000	15.4351	Yes	No	202993.	687465.
4	32.0000	32.0552	Yes	No	890458.	874719.
5	45.0000	410.2633	No	No	1765177.	17325.
6	49.0000	49.3996	No	No	1782502.	340497.
7	53.5000	53.5000	No	Yes	N.A.	N.A.

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

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

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

```
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians


Load Load                Load                  Axial    Pile-head  Pile-head  Max
Shear Max Moment
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in
Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  1  V, lb     17800.  M, in-lb        0.00  1000.0000     0.9928   -0.01512
17800.    773913.


Maximum pile-head deflection = 0.9928004874 inches
Maximum pile-head rotation   = -0.0151194070 radians = -0.866278 deg.

The analysis ended normally.
```

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Floodwal 1000-1125 pipe pile 0.545inch Wall.lp11d

Name of output report file:
Floodwal 1000-1125 pipe pile 0.545inch Wall.lp11o

Name of plot output file:
Floodwal 1000-1125 pipe pile 0.545inch Wall.lp11p

Name of runtime message file:
Floodwal 1000-1125 pipe pile 0.545inch Wall.lp11r

Date and Time of Analysis

Date: July 16, 2021   Time: 11:24:26

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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                                   =       56.000 ft
Depth of ground surface below top of pile              =       0.0000 ft
```

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	9.6250
2	56.000	9.6250

Input Structural Properties for Pile Sections:

Pile Section No. 1:

```
   Section 1 is a steel pipe pile
   Length of section                                   =    56.000000 ft
```

```
   Pile diameter                                          =     9.625000 in
   Shear capacity of section                              =       0.0000 lbs



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

Ground Slope Angle                                        =        0.000 degrees
                                                          =        0.000 radians

Pile Batter Angle                                         =        0.000 degrees
                                                          =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 7 layers

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

   Distance from top of pile to top of layer              =       0.0000 ft
   Distance from top of pile to bottom of layer           =     7.500000 ft
   Effective unit weight at top of layer                  =   125.000000 pcf
   Effective unit weight at bottom of layer               =   125.000000 pcf
   Friction angle at top of layer                         =    33.200000 deg.
   Friction angle at bottom of layer                      =    33.200000 deg.
   Subgrade k at top of layer                             =       0.0000 pci
   Subgrade k at bottom of layer                          =       0.0000 pci

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

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

   Distance from top of pile to top of layer              =     7.500000 ft
   Distance from top of pile to bottom of layer           =    13.000000 ft
   Effective unit weight at top of layer                  =    62.600000 pcf
   Effective unit weight at bottom of layer               =    62.600000 pcf
   Friction angle at top of layer                         =    33.200000 deg.
   Friction angle at bottom of layer                      =    33.200000 deg.
   Subgrade k at top of layer                             =       0.0000 pci
   Subgrade k at bottom of layer                          =       0.0000 pci

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

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

```
   Distance from top of pile to top of layer           =    13.000000 ft
   Distance from top of pile to bottom of layer        =    32.000000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Friction angle at top of layer                      =    30.000000 deg.
   Friction angle at bottom of layer                   =    30.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

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

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

   Distance from top of pile to top of layer           =    32.000000 ft
   Distance from top of pile to bottom of layer        =    45.000000 ft
   Effective unit weight at top of layer               =    57.600000 pcf
   Effective unit weight at bottom of layer            =    57.600000 pcf
   Friction angle at top of layer                      =    31.800000 deg.
   Friction angle at bottom of layer                   =    31.800000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

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

Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer           =    45.000000 ft
   Distance from top of pile to bottom of layer        =    49.000000 ft
   Effective unit weight at top of layer               =    44.600000 pcf
   Effective unit weight at bottom of layer            =    44.600000 pcf
   Undrained cohesion at top of layer                  =   600.000000 psf
   Undrained cohesion at bottom of layer               =   600.000000 psf
   Epsilon-50 at top of layer                          =       0.0000
   Epsilon-50 at bottom of layer                       =       0.0000

   NOTE: Default values for Epsilon-50 will be computed for this layer.


Layer 6 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =    49.000000 ft
   Distance from top of pile to bottom of layer        =    53.500000 ft
   Effective unit weight at top of layer               =    57.600000 pcf
   Effective unit weight at bottom of layer            =    57.600000 pcf
   Friction angle at top of layer                      =    30.900000 deg.
   Friction angle at bottom of layer                   =    30.900000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci
```

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

Layer 7 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	53.500000 ft
Distance from top of pile to bottom of layer	=	63.500000 ft
Effective unit weight at top of layer	=	87.600000 pcf
Effective unit weight at bottom of layer	=	87.600000 pcf
Uniaxial compressive strength at top of layer	=	500.000000 psi
Uniaxial compressive strength at bottom of layer	=	500.000000 psi
Initial modulus of rock at top of layer	=	1500000. psi
Initial modulus of rock at bottom of layer	=	1500000. psi
RQD of rock at top of layer	=	75.000000 %
RQD of rock at bottom of layer	=	75.000000 %
k rm of rock at top of layer	=	0.0001000
k rm of rock at bottom of layer	=	0.0001000

(Depth of the lowest soil layer extends 7.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	7.5000	125.0000	--	33.2000	--	--	--	default	--
2	Sand	7.5000	62.6000	--	33.2000	--	--	--	default	--
	(Reese, et al.)	13.0000	62.6000	--	33.2000	--	--	--	default	--
3	Sand	13.0000	52.6000	--	30.0000	--	--	--	default	--
	(Reese, et al.)	32.0000	52.6000	--	30.0000	--	--	--	default	--
4	Sand	32.0000	57.6000	--	31.8000	--	--	--	default	--
	(Reese, et al.)	45.0000	57.6000	--	31.8000	--	--	--	default	--

```
  5            Soft              45.0000      44.6000     600.0000       --
 --           --         default        --           --
               Clay              49.0000      44.6000     600.0000       --
 --           --         default        --           --
  6            Sand              49.0000      57.6000       --          30.9000
 --           --           --         default        --
          (Reese, et al.)        53.5000      57.6000       --          30.9000
 --           --           --         default        --
  7            Weak              53.5000      87.6000       --           --
500.0000      75.0000    1.00E-04       --         1500000.
               Rock              63.5000      87.6000       --           --
500.0000      75.0000    1.00E-04       --         1500000.
```

```
--------------------------------------------------------------------------------
                              Static Loading Type
--------------------------------------------------------------------------------
```

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

```
--------------------------------------------------------------------------------
               Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------
```

Number of loads specified = 1

```
Load    Load        Condition                Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type           1                        2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       18400. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel Pipe Pile:

Length of Section	=	56.000000 ft
Outer Diameter of Pipe	=	9.625000 in
Pipe Wall Thickness	=	0.545000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	15.546485 sq. in.
Moment of Inertia	=	160.796181 in^4
Elastic Bending Stiffness	=	4663089. kip-in^2
Plastic Modulus, Z	=	44.987248in^3
Plastic Moment Capacity = Fy Z	=	1620.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	559.673 kips
Nominal Axial Tensile Capacity	=	-559.673 kips

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

Number	Axial Thrust Force kips
1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	1608.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	48423.
2	7.5000	7.4999	Yes	No	48423.	154570.
3	13.0000	15.4351	Yes	No	202993.	687465.
4	32.0000	32.0552	Yes	No	890458.	874719.
5	45.0000	410.2633	No	No	1765177.	17325.
6	49.0000	49.3996	No	No	1782502.	340497.
7	53.5000	53.5000	No	Yes	N.A.	N.A.

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

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

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

```
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians


Load Load                Load                  Axial    Pile-head  Pile-head  Max
Shear Max Moment
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in
Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  1  V, lb     18400.  M, in-lb        0.00  1000.0000     0.9944   -0.01494
18400.    811911.


Maximum pile-head deflection = 0.9944066483 inches
Maximum pile-head rotation   = -0.0149430706 radians = -0.856175 deg.

The analysis ended normally.
```

==

LPile for Windows, Version 2019-11.006

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

==

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Serial Number of Security Device: 225625906

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Files Used for Analysis

Path to file locations:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Floodwal 2050-2300 HP12X53.lp11d

Name of output report file:
Floodwal 2050-2300 HP12X53.lp11o

Name of plot output file:
Floodwal 2050-2300 HP12X53.lp11p

Name of runtime message file:
Floodwal 2050-2300 HP12X53.lp11r

Date and Time of Analysis

Date: February 23, 2021   Time: 16:14:04

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
 - Conventional Analysis

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 56.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.0000
2	56.000	12.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a H strong axis steel pile
Length of section = 56.000000 ft

```
   Pile width                                             =    12.000000 in
   Shear capacity of section                              =       0.0000 lbs



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

Ground Slope Angle                                        =        0.000 degrees
                                                          =        0.000 radians

Pile Batter Angle                                         =        0.000 degrees
                                                          =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 5 layers

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

   Distance from top of pile to top of layer              =       0.0000 ft
   Distance from top of pile to bottom of layer           =     3.000000 ft
   Effective unit weight at top of layer                  =   123.000000 pcf
   Effective unit weight at bottom of layer               =   123.000000 pcf
   Friction angle at top of layer                         =    32.000000 deg.
   Friction angle at bottom of layer                      =    32.000000 deg.
   Subgrade k at top of layer                             =    90.000000 pci
   Subgrade k at bottom of layer                          =    90.000000 pci


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

   Distance from top of pile to top of layer              =     3.000000 ft
   Distance from top of pile to bottom of layer           =    34.000000 ft
   Effective unit weight at top of layer                  =    47.600000 pcf
   Effective unit weight at bottom of layer               =    47.600000 pcf
   Friction angle at top of layer                         =    28.300000 deg.
   Friction angle at bottom of layer                      =    28.300000 deg.
   Subgrade k at top of layer                             =    20.000000 pci
   Subgrade k at bottom of layer                          =    20.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer              =    34.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    44.000000 ft
   Effective unit weight at top of layer               =    44.600000 pcf
   Effective unit weight at bottom of layer            =    44.600000 pcf
   Undrained cohesion at top of layer                  =   360.000000 psf
   Undrained cohesion at bottom of layer               =   360.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


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

   Distance from top of pile to top of layer           =    44.000000 ft
   Distance from top of pile to bottom of layer        =    55.000000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Friction angle at top of layer                      =    29.200000 deg.
   Friction angle at bottom of layer                   =    29.200000 deg.
   Subgrade k at top of layer                          =    45.000000 pci
   Subgrade k at bottom of layer                       =    45.000000 pci


Layer 5 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    55.000000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    87.600000 pcf
   Effective unit weight at bottom of layer            =    87.600000 pcf
   Uniaxial compressive strength at top of layer       =   500.000000 psi
   Uniaxial compressive strength at bottom of layer    =   500.000000 psi
   Initial modulus of rock at top of layer             =     1500000. psi
   Initial modulus of rock at bottom of layer          =     1500000. psi
   RQD of rock at top of layer                         =    78.000000 %
   RQD of rock at bottom of layer                      =    78.000000 %
   k rm of rock at top of layer                        =    0.0001000
   k rm of rock at bottom of layer                     =    0.0001000


 (Depth of the lowest soil layer extends 9.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective    Undrained    Angle of
Uniaxial                    E50                   Rock Mass
Layer           Name             Depth       Unit Wt.    Cohesion     Friction
 qu          RQD %         or           kpy         Modulus
 Num.     (p-y Curve Type)        ft           pcf          psf           deg.
```

```
  psi                       krm          pci          psi
-----   -------------------   ----------   ----------   ----------   ----------
----------   ----------   ----------   ----------   ----------
  1            Sand                 0.00     123.0000       --          32.0000
 --           --            --           90.0000       --
         (Reese, et al.)       3.0000     123.0000       --          32.0000
 --           --            --           90.0000       --
  2            Sand               3.0000      47.6000       --          28.3000
 --           --            --           20.0000       --
         (Reese, et al.)      34.0000      47.6000       --          28.3000
 --           --            --           20.0000       --
  3            Soft              34.0000      44.6000     360.0000       --
 --           --          0.02000       --            --
               Clay              44.0000      44.6000     360.0000       --
 --           --          0.02000       --            --
  4            Sand              44.0000      52.6000       --          29.2000
 --           --            --           45.0000       --
         (Reese, et al.)      55.0000      52.6000       --          29.2000
 --           --            --           45.0000       --
  5            Weak              55.0000      87.6000       --           --
500.0000      78.0000     1.00E-04       --         1500000.
               Rock              65.0000      87.6000       --           --
500.0000      78.0000     1.00E-04       --         1500000.


--------------------------------------------------------------------------------
                               Static Loading Type
--------------------------------------------------------------------------------

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



--------------------------------------------------------------------------------
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------

Number of loads specified = 1

Load    Load         Condition               Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                        2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   ----------------------   ----------------
---------------    ------------
   1     1     V =       21500. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel H Strong Axis:
---------------------------------------------

Length of Section                                           =    56.000000 ft
Flange Width                                                =    12.000000 in
Section Depth                                               =    11.800000 in
Flange Thickness                                            =     0.435000 in
Web Thickness                                               =     0.435000 in
Yield Stress of Pipe                                        =    36.000000 ksi
Elastic Modulus                                             =       29000. ksi
Cross-sectional Area                                        =    15.194550 sq. in.
Moment of Inertia                                           =   384.614130 in^4
Elastic Bending Stiffness                                   =    11153810. kip-in^2
Plastic Modulus, Z                                          =    72.317108in^3
Plastic Moment Capacity = Fy Z                              =        2603.in-kip

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = Fy As                      =      547.004 kips
Nominal Axial Tensile Capacity                              =     -547.004 kips




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

   Number     Axial Thrust Force
                   kips
   ------     ------------------
```

1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	2595.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	5926.
2	3.0000	3.4539	Yes	No	5926.	677594.
3	34.0000	214.0364	No	No	683520.	32400.
4	44.0000	34.7000	No	No	715920.	650870.
5	55.0000	55.0000	No	Yes	N.A.	N.A.

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

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	21500.	M, in-lb	0.00	1000.0000	0.9964	-0.01137	21500.	1060701.

Maximum pile-head deflection = 0.9964055432 inches
Maximum pile-head rotation = -0.0113664199 radians = -0.651248 deg.

The analysis ended normally.

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Floodwal 2050-2300 HP12X63.lp11d

Name of output report file:
Floodwal 2050-2300 HP12X63.lp11o

Name of plot output file:
Floodwal 2050-2300 HP12X63.lp11p

Name of runtime message file:
Floodwal 2050-2300 HP12X63.lp11r

Date and Time of Analysis

Date: February 23, 2021 Time: 16:16:46

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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                                      =       56.000 ft
Depth of ground surface below top of pile                 =       0.0000 ft
```

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.1000
2	56.000	12.1000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

```
   Section 1 is a H strong axis steel pile
   Length of section                                      =    56.000000 ft
```

```
   Pile width                                            =    12.100000 in
   Shear capacity of section                             =       0.0000 lbs




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

Ground Slope Angle                                       =        0.000 degrees
                                                         =        0.000 radians

Pile Batter Angle                                        =        0.000 degrees
                                                         =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 5 layers

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

   Distance from top of pile to top of layer             =       0.0000 ft
   Distance from top of pile to bottom of layer          =     3.000000 ft
   Effective unit weight at top of layer                 =   123.000000 pcf
   Effective unit weight at bottom of layer              =   123.000000 pcf
   Friction angle at top of layer                        =    32.000000 deg.
   Friction angle at bottom of layer                     =    32.000000 deg.
   Subgrade k at top of layer                            =    90.000000 pci
   Subgrade k at bottom of layer                         =    90.000000 pci


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

   Distance from top of pile to top of layer             =     3.000000 ft
   Distance from top of pile to bottom of layer          =    34.000000 ft
   Effective unit weight at top of layer                 =    47.600000 pcf
   Effective unit weight at bottom of layer              =    47.600000 pcf
   Friction angle at top of layer                        =    28.300000 deg.
   Friction angle at bottom of layer                     =    28.300000 deg.
   Subgrade k at top of layer                            =    20.000000 pci
   Subgrade k at bottom of layer                         =    20.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer             =    34.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    44.000000 ft
   Effective unit weight at top of layer               =    44.600000 pcf
   Effective unit weight at bottom of layer            =    44.600000 pcf
   Undrained cohesion at top of layer                  =   360.000000 psf
   Undrained cohesion at bottom of layer               =   360.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


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

   Distance from top of pile to top of layer           =    44.000000 ft
   Distance from top of pile to bottom of layer        =    55.000000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Friction angle at top of layer                      =    29.200000 deg.
   Friction angle at bottom of layer                   =    29.200000 deg.
   Subgrade k at top of layer                          =    45.000000 pci
   Subgrade k at bottom of layer                       =    45.000000 pci


Layer 5 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    55.000000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    87.600000 pcf
   Effective unit weight at bottom of layer            =    87.600000 pcf
   Uniaxial compressive strength at top of layer       =   500.000000 psi
   Uniaxial compressive strength at bottom of layer    =   500.000000 psi
   Initial modulus of rock at top of layer             =     1500000. psi
   Initial modulus of rock at bottom of layer          =     1500000. psi
   RQD of rock at top of layer                         =    78.000000 %
   RQD of rock at bottom of layer                      =    78.000000 %
   k rm of rock at top of layer                        =    0.0001000
   k rm of rock at bottom of layer                     =    0.0001000


 (Depth of the lowest soil layer extends 9.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective    Undrained    Angle of
Uniaxial                     E50                   Rock Mass
Layer           Name             Depth       Unit Wt.    Cohesion     Friction
 qu          RQD %         or            kpy        Modulus
 Num.     (p-y Curve Type)        ft            pcf          psf          deg.
```

```
 psi                       krm          pci          psi
-----   -------------------   ----------   ----------   ----------   ----------
----------   ----------   ----------   ----------   ----------
  1             Sand                0.00     123.0000        --          32.0000
 --            --            --          90.0000       --
          (Reese, et al.)       3.0000     123.0000        --          32.0000
 --            --            --          90.0000       --
  2             Sand              3.0000      47.6000        --          28.3000
 --            --            --          20.0000       --
          (Reese, et al.)      34.0000      47.6000        --          28.3000
 --            --            --          20.0000       --
  3             Soft             34.0000      44.6000     360.0000        --
 --            --          0.02000       --            --
                Clay             44.0000      44.6000     360.0000        --
 --            --          0.02000       --            --
  4             Sand             44.0000      52.6000        --          29.2000
 --            --            --          45.0000       --
          (Reese, et al.)      55.0000      52.6000        --          29.2000
 --            --            --          45.0000       --
  5             Weak             55.0000      87.6000        --            --
500.0000      78.0000     1.00E-04       --         1500000.
                Rock             65.0000      87.6000        --            --
500.0000      78.0000     1.00E-04       --         1500000.
```

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition                Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                        2                  Force, lbs
vs. Pile Length
-----   ----   --------------------   ----------------------   ----------------
---------------    ------------
   1     1     V =       23200. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel H Strong Axis:
---------------------------------------------

Length of Section                                       =    56.000000 ft
Flange Width                                            =    12.100000 in
Section Depth                                           =    11.900000 in
Flange Thickness                                        =     0.515000 in
Web Thickness                                           =     0.515000 in
Yield Stress of Pipe                                    =    36.000000 ksi
Elastic Modulus                                         =       29000. ksi
Cross-sectional Area                                    =    18.061050 sq. in.
Moment of Inertia                                       =   459.254129 in^4
Elastic Bending Stiffness                               =    13318370. kip-in^2
Plastic Modulus, Z                                      =    86.158328in^3
Plastic Moment Capacity = Fy Z                          =        3102.in-kip

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = Fy As                  =      650.198 kips
Nominal Axial Tensile Capacity                          =     -650.198 kips




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

   Number     Axial Thrust Force
                   kips
   ------     ------------------
```

1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	3092.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	5979.
2	3.0000	3.4534	Yes	No	5979.	682696.
3	34.0000	213.8906	No	No	688675.	32670.
4	44.0000	34.7002	No	No	721345.	656294.
5	55.0000	55.0000	No	Yes	N.A.	N.A.

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

```
--------------------------------------------------------------------------------
            Summary of Pile-head Responses for Conventional Analyses
--------------------------------------------------------------------------------

Definitions of Pile-head Loading Conditions:

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


Load Load                Load                  Axial    Pile-head  Pile-head  Max
Shear Max Moment
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in
Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  1  V, lb     23200.  M, in-lb        0.00  1000.0000     1.0042   -0.01105
23200.   1187574.


Maximum pile-head deflection = 1.0042051005 inches
Maximum pile-head rotation   = -0.0110492407 radians = -0.633075 deg.

The analysis ended normally.
```

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Floodwal 2050-2300 HP12X74.lp11d

Name of output report file:
Floodwal 2050-2300 HP12X74.lp11o

Name of plot output file:
Floodwal 2050-2300 HP12X74.lp11p

Name of runtime message file:
Floodwal 2050-2300 HP12X74.lp11r

Date and Time of Analysis

```
--------------------------------------------------------------------------------
               Date:  February 23, 2021          Time:  16:20:03


--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: South Battery Park City Resiliency



Job Number: 17-NY165-01



Client: AECOM



Engineer: SG



Description:





--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

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

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 56.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.2000
2	56.000	12.2000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a H strong axis steel pile
Length of section = 56.000000 ft

```
   Pile width                                            =    12.200000 in
   Shear capacity of section                             =       0.0000 lbs



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

Ground Slope Angle                                       =        0.000 degrees
                                                         =        0.000 radians

Pile Batter Angle                                        =        0.000 degrees
                                                         =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 5 layers

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

   Distance from top of pile to top of layer             =       0.0000 ft
   Distance from top of pile to bottom of layer          =     3.000000 ft
   Effective unit weight at top of layer                 =   123.000000 pcf
   Effective unit weight at bottom of layer              =   123.000000 pcf
   Friction angle at top of layer                        =    32.000000 deg.
   Friction angle at bottom of layer                     =    32.000000 deg.
   Subgrade k at top of layer                            =    90.000000 pci
   Subgrade k at bottom of layer                         =    90.000000 pci


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

   Distance from top of pile to top of layer             =     3.000000 ft
   Distance from top of pile to bottom of layer          =    34.000000 ft
   Effective unit weight at top of layer                 =    47.600000 pcf
   Effective unit weight at bottom of layer              =    47.600000 pcf
   Friction angle at top of layer                        =    28.300000 deg.
   Friction angle at bottom of layer                     =    28.300000 deg.
   Subgrade k at top of layer                            =    20.000000 pci
   Subgrade k at bottom of layer                         =    20.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer             =    34.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    44.000000 ft
   Effective unit weight at top of layer               =    44.600000 pcf
   Effective unit weight at bottom of layer            =    44.600000 pcf
   Undrained cohesion at top of layer                  =   360.000000 psf
   Undrained cohesion at bottom of layer               =   360.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


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

   Distance from top of pile to top of layer           =    44.000000 ft
   Distance from top of pile to bottom of layer        =    55.000000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Friction angle at top of layer                      =    29.200000 deg.
   Friction angle at bottom of layer                   =    29.200000 deg.
   Subgrade k at top of layer                          =    45.000000 pci
   Subgrade k at bottom of layer                       =    45.000000 pci


Layer 5 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    55.000000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    87.600000 pcf
   Effective unit weight at bottom of layer            =    87.600000 pcf
   Uniaxial compressive strength at top of layer       =   500.000000 psi
   Uniaxial compressive strength at bottom of layer    =   500.000000 psi
   Initial modulus of rock at top of layer             =     1500000. psi
   Initial modulus of rock at bottom of layer          =     1500000. psi
   RQD of rock at top of layer                         =    78.000000 %
   RQD of rock at bottom of layer                      =    78.000000 %
   k rm of rock at top of layer                        =    0.0001000
   k rm of rock at bottom of layer                     =    0.0001000


 (Depth of the lowest soil layer extends 9.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective    Undrained    Angle of
Uniaxial                     E50                   Rock Mass
Layer           Name             Depth       Unit Wt.    Cohesion     Friction
 qu          RQD %         or            kpy        Modulus
 Num.     (p-y Curve Type)        ft            pcf          psf           deg.
```

```
 psi                       krm          pci          psi
-----   -------------------   ----------   ----------   ----------   ----------
----------   ----------   ----------   ----------   ----------
  1            Sand                 0.00     123.0000       --          32.0000
 --           --           --           90.0000       --
          (Reese, et al.)       3.0000     123.0000       --          32.0000
 --           --           --           90.0000       --
  2            Sand               3.0000      47.6000       --          28.3000
 --           --           --           20.0000       --
          (Reese, et al.)      34.0000      47.6000       --          28.3000
 --           --           --           20.0000       --
  3            Soft              34.0000      44.6000     360.0000       --
 --           --          0.02000       --            --
               Clay              44.0000      44.6000     360.0000       --
 --           --          0.02000       --            --
  4            Sand              44.0000      52.6000       --          29.2000
 --           --           --           45.0000       --
          (Reese, et al.)      55.0000      52.6000       --          29.2000
 --           --           --           45.0000       --
  5            Weak              55.0000      87.6000       --           --
500.0000      78.0000     1.00E-04      --         1500000.
               Rock              65.0000      87.6000       --           --
500.0000      78.0000     1.00E-04      --         1500000.
```

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition               Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                        2                 Force, lbs
vs. Pile Length
-----   ----    --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       25000. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel H Strong Axis:

Length of Section	=	56.000000 ft
Flange Width	=	12.200000 in
Section Depth	=	12.100000 in
Flange Thickness	=	0.605000 in
Web Thickness	=	0.610000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	21.404900 sq. in.
Moment of Inertia	=	553.744203 in^4
Elastic Bending Stiffness	=	16058582. kip-in^2
Plastic Modulus, Z	=	102.929890in^3
Plastic Moment Capacity = Fy Z	=	3705.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	770.576 kips
Nominal Axial Tensile Capacity	=	-770.576 kips

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

Number	Axial Thrust Force kips

1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	3695.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	6032.
2	3.0000	3.4529	Yes	No	6032.	687799.
3	34.0000	213.7476	No	No	693831.	32940.
4	44.0000	34.7008	No	No	726771.	661718.
5	55.0000	55.0000	No	Yes	N.A.	N.A.

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

```
--------------------------------------------------------------------------------
            Summary of Pile-head Responses for Conventional Analyses
--------------------------------------------------------------------------------

Definitions of Pile-head Loading Conditions:

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


Load Load                Load                  Axial    Pile-head  Pile-head  Max
Shear Max Moment
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in
Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  1  V, lb     25000.  M, in-lb        0.00  1000.0000     1.0050   -0.01065
25000.   1330741.


Maximum pile-head deflection = 1.0049877146 inches
Maximum pile-head rotation   = -0.0106457462 radians = -0.609956 deg.

The analysis ended normally.
```

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Floodwal 2050-2300 HP12X84.lp11d

Name of output report file:
Floodwal 2050-2300 HP12X84.lp11o

Name of plot output file:
Floodwal 2050-2300 HP12X84.lp11p

Name of runtime message file:
Floodwal 2050-2300 HP12X84.lp11r

Date and Time of Analysis

Date: February 23, 2021 Time: 16:21:42

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 56.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.3000
2	56.000	12.3000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a H strong axis steel pile
Length of section = 56.000000 ft

```
   Pile width                                              =    12.300000 in
   Shear capacity of section                               =       0.0000 lbs



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

Ground Slope Angle                                         =        0.000 degrees
                                                           =        0.000 radians

Pile Batter Angle                                          =        0.000 degrees
                                                           =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 5 layers

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

   Distance from top of pile to top of layer               =       0.0000 ft
   Distance from top of pile to bottom of layer            =     3.000000 ft
   Effective unit weight at top of layer                   =   123.000000 pcf
   Effective unit weight at bottom of layer                =   123.000000 pcf
   Friction angle at top of layer                          =    32.000000 deg.
   Friction angle at bottom of layer                       =    32.000000 deg.
   Subgrade k at top of layer                              =    90.000000 pci
   Subgrade k at bottom of layer                           =    90.000000 pci


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

   Distance from top of pile to top of layer               =     3.000000 ft
   Distance from top of pile to bottom of layer            =    34.000000 ft
   Effective unit weight at top of layer                   =    47.600000 pcf
   Effective unit weight at bottom of layer                =    47.600000 pcf
   Friction angle at top of layer                          =    28.300000 deg.
   Friction angle at bottom of layer                       =    28.300000 deg.
   Subgrade k at top of layer                              =    20.000000 pci
   Subgrade k at bottom of layer                           =    20.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer               =    34.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    44.000000 ft
   Effective unit weight at top of layer               =    44.600000 pcf
   Effective unit weight at bottom of layer            =    44.600000 pcf
   Undrained cohesion at top of layer                  =   360.000000 psf
   Undrained cohesion at bottom of layer               =   360.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


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

   Distance from top of pile to top of layer           =    44.000000 ft
   Distance from top of pile to bottom of layer        =    55.000000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Friction angle at top of layer                      =    29.200000 deg.
   Friction angle at bottom of layer                   =    29.200000 deg.
   Subgrade k at top of layer                          =    45.000000 pci
   Subgrade k at bottom of layer                       =    45.000000 pci


Layer 5 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    55.000000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    87.600000 pcf
   Effective unit weight at bottom of layer            =    87.600000 pcf
   Uniaxial compressive strength at top of layer       =   500.000000 psi
   Uniaxial compressive strength at bottom of layer    =   500.000000 psi
   Initial modulus of rock at top of layer             =     1500000. psi
   Initial modulus of rock at bottom of layer          =     1500000. psi
   RQD of rock at top of layer                         =    78.000000 %
   RQD of rock at bottom of layer                      =    78.000000 %
   k rm of rock at top of layer                        =    0.0001000
   k rm of rock at bottom of layer                     =    0.0001000


 (Depth of the lowest soil layer extends 9.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective    Undrained    Angle of
Uniaxial                     E50                   Rock Mass
Layer           Name             Depth       Unit Wt.    Cohesion     Friction
 qu          RQD %         or            kpy        Modulus
 Num.     (p-y Curve Type)        ft            pcf          psf          deg.
```

```
 psi                       krm          pci          psi
-----   -------------------   ----------   ----------   ----------   ----------
----------   ----------   ----------   ----------   ----------
  1            Sand                  0.00    123.0000       --          32.0000
 --           --           --          90.0000       --
          (Reese, et al.)        3.0000    123.0000       --          32.0000
 --           --           --          90.0000       --
  2            Sand                3.0000     47.6000       --          28.3000
 --           --           --          20.0000       --
          (Reese, et al.)       34.0000     47.6000       --          28.3000
 --           --           --          20.0000       --
  3            Soft               34.0000     44.6000    360.0000       --
 --           --          0.02000       --             --
               Clay               44.0000     44.6000    360.0000       --
 --           --          0.02000       --             --
  4            Sand               44.0000     52.6000       --          29.2000
 --           --           --          45.0000       --
          (Reese, et al.)       55.0000     52.6000       --          29.2000
 --           --           --          45.0000       --
  5            Weak               55.0000     87.6000       --           --
500.0000      78.0000     1.00E-04       --         1500000.
               Rock               65.0000     87.6000       --           --
500.0000      78.0000     1.00E-04       --         1500000.


--------------------------------------------------------------------------------
                               Static Loading Type
--------------------------------------------------------------------------------

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



--------------------------------------------------------------------------------
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------

Number of loads specified = 1

Load    Load         Condition               Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                       2                  Force, lbs
vs. Pile Length
-----   ----   --------------------   ----------------------   ----------------
---------------    ------------
   1     1     V =       26500. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel H Strong Axis:
---------------------------------------------

Length of Section                                        =    56.000000 ft
Flange Width                                             =    12.300000 in
Section Depth                                            =    12.300000 in
Flange Thickness                                         =     0.685000 in
Web Thickness                                            =     0.685000 in
Yield Stress of Pipe                                     =    36.000000 ksi
Elastic Modulus                                          =       29000. ksi
Cross-sectional Area                                     =    24.338050 sq. in.
Moment of Inertia                                        =   643.530174 in^4
Elastic Bending Stiffness                                =    18662375. kip-in^2
Plastic Modulus, Z                                       =   118.320547in^3
Plastic Moment Capacity = Fy Z                           =        4260.in-kip

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = Fy As                   =      876.170 kips
Nominal Axial Tensile Capacity                           =     -876.170 kips



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

   Number     Axial Thrust Force
                   kips
   ------     ------------------
```

1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	4246.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	6085.
2	3.0000	3.4524	Yes	No	6085.	692867.
3	34.0000	213.5966	No	No	698952.	33210.
4	44.0000	34.7008	No	No	732162.	667142.
5	55.0000	55.0000	No	Yes	N.A.	N.A.

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

```
--------------------------------------------------------------------------------
            Summary of Pile-head Responses for Conventional Analyses
--------------------------------------------------------------------------------

Definitions of Pile-head Loading Conditions:

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


Load Load                Load                  Axial    Pile-head  Pile-head  Max
Shear Max Moment
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in
Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  1  V, lb     26500.  M, in-lb        0.00  1000.0000     1.0024   -0.01031
26500.   1452715.


Maximum pile-head deflection = 1.0024328928 inches
Maximum pile-head rotation   = -0.0103081315 radians = -0.590612 deg.

The analysis ended normally.
```

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

                    LPile for Windows, Version 2019-11.006

                 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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park
Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation
Package\

Name of input data file:
Floodwal 2050-2300 micropile 9.625 inch OD 0.5inch Wall.lp11d

Name of output report file:
Floodwal 2050-2300 micropile 9.625 inch OD 0.5inch Wall.lp11o

Name of plot output file:
Floodwal 2050-2300 micropile 9.625 inch OD 0.5inch Wall.lp11p

Name of runtime message file:
Floodwal 2050-2300 micropile 9.625 inch OD 0.5inch Wall.lp11r


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

Date: February 23, 2021   Time: 16:33:49

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 56.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	9.6250
2	56.000	9.6250

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a drilled shaft with permanent casing
Length of section = 56.000000 ft

```
   Casing outside diameter                              =     9.625000 in
   Shear capacity of section                            =       0.0000 lbs
```

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

Ground Slope Angle                                      =        0.000 degrees
                                                        =        0.000 radians

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

```
--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 5 layers

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

   Distance from top of pile to top of layer            =       0.0000 ft
   Distance from top of pile to bottom of layer         =     3.000000 ft
   Effective unit weight at top of layer                =   123.000000 pcf
   Effective unit weight at bottom of layer             =   123.000000 pcf
   Friction angle at top of layer                       =    32.000000 deg.
   Friction angle at bottom of layer                    =    32.000000 deg.
   Subgrade k at top of layer                           =    90.000000 pci
   Subgrade k at bottom of layer                        =    90.000000 pci


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

   Distance from top of pile to top of layer            =     3.000000 ft
   Distance from top of pile to bottom of layer         =    34.000000 ft
   Effective unit weight at top of layer                =    47.600000 pcf
   Effective unit weight at bottom of layer             =    47.600000 pcf
   Friction angle at top of layer                       =    28.300000 deg.
   Friction angle at bottom of layer                    =    28.300000 deg.
   Subgrade k at top of layer                           =    20.000000 pci
   Subgrade k at bottom of layer                        =    20.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer            =    34.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    44.000000 ft
   Effective unit weight at top of layer               =    44.600000 pcf
   Effective unit weight at bottom of layer            =    44.600000 pcf
   Undrained cohesion at top of layer                  =   360.000000 psf
   Undrained cohesion at bottom of layer               =   360.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


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

   Distance from top of pile to top of layer           =    44.000000 ft
   Distance from top of pile to bottom of layer        =    55.000000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Friction angle at top of layer                      =    29.200000 deg.
   Friction angle at bottom of layer                   =    29.200000 deg.
   Subgrade k at top of layer                          =    45.000000 pci
   Subgrade k at bottom of layer                       =    45.000000 pci


Layer 5 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    55.000000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    87.600000 pcf
   Effective unit weight at bottom of layer            =    87.600000 pcf
   Uniaxial compressive strength at top of layer       =   500.000000 psi
   Uniaxial compressive strength at bottom of layer    =   500.000000 psi
   Initial modulus of rock at top of layer             =     1500000. psi
   Initial modulus of rock at bottom of layer          =     1500000. psi
   RQD of rock at top of layer                         =    78.000000 %
   RQD of rock at bottom of layer                      =    78.000000 %
   k rm of rock at top of layer                        =    0.0001000
   k rm of rock at bottom of layer                     =    0.0001000


 (Depth of the lowest soil layer extends 9.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective    Undrained    Angle of
Uniaxial                    E50                     Rock Mass
Layer           Name             Depth       Unit Wt.    Cohesion     Friction
 qu          RQD %         or            kpy        Modulus
 Num.     (p-y Curve Type)        ft           pcf          psf           deg.
```

```
 psi                       krm          pci          psi
-----   -------------------   ----------   ----------   ----------   ----------
----------   ----------   ----------   ----------   ----------
  1            Sand                0.00     123.0000       --          32.0000
 --           --            --          90.0000       --
         (Reese, et al.)         3.0000     123.0000       --          32.0000
 --           --            --          90.0000       --
  2            Sand              3.0000      47.6000       --          28.3000
 --           --            --          20.0000       --
         (Reese, et al.)        34.0000      47.6000       --          28.3000
 --           --            --          20.0000       --
  3            Soft             34.0000      44.6000     360.0000       --
 --           --          0.02000       --            --
               Clay             44.0000      44.6000     360.0000       --
 --           --          0.02000       --            --
  4            Sand             44.0000      52.6000       --          29.2000
 --           --            --          45.0000       --
         (Reese, et al.)        55.0000      52.6000       --          29.2000
 --           --            --          45.0000       --
  5            Weak             55.0000      87.6000       --           --
500.0000     78.0000     1.00E-04       --         1500000.
               Rock             65.0000      87.6000       --           --
500.0000     78.0000     1.00E-04       --         1500000.
```

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition               Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                       2                  Force, lbs
vs. Pile Length
-----   ----   --------------------   ----------------------   ----------------
---------------    ------------
   1     1     V =       14800. lbs   M =       0.0000 in-lbs    1000.000000000
    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) with Permanent Casing:
------------------------------------------------------------------------------

Length of Section                                       =    56.000000 ft
Outer Diameter of Casing                                =     9.625000 in
Casing Wall Thickness                                   =     0.500000 in
Moment of Inertia of Steel Casing                       =   149.634073 in^4
Yield Stress of Casing                                  =       50000. psi
Elastic Modulus of Casing                               =    29000000. psi
Number of Reinforcing Bars                              =            0 bars
Area of Single Reinforcing Bar                          =       0.0000 sq. in.
Offset of Center of Rebar Cage from Center of Pile      =       0.0000 in
Yield Stress of Reinforcing Bars                        =       0.0000 psi
Modulus of Elasticity of Reinforcing Bars               =       0.0000 psi
Gross Area of Pile                                      =    72.759777 sq. in.
Area of Concrete                                        =    58.426260 sq. in.
Cross-sectional Area of Steel Casing                    =    14.333516 sq. in.
Area of All Steel (Casing and Bars)                     =    14.333516 sq. in.
Area Ratio of All Steel to Gross Area of Pile           =        19.70 percent

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As     =      915.325 kips
Tensile Load for Cracking of Concrete                   =      -72.256 kips
Nominal Axial Tensile Capacity                          =     -716.676 kips



Concrete Properties:
```

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

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

Number	Axial Thrust Force kips
1	1.000

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
1	1.000	2128.858	0.00300000

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

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

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

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

Axial Resist. Nominal Nominal Ult. (Fac) Ult. (Fac) Bend. Stiff.
Load Factor Ax. Thrust Moment Cap Ax. Thrust Moment Cap at Ult Mom
No. kips in-kips kips in-kips kip-in^2

1	0.65	1.000000	2129.	0.650000	1384.	4733868.
1	0.75	1.000000	2129.	0.750000	1597.	4718875.
1	0.90	1.000000	2129.	0.900000	1916.	4328784.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	4675.
2	3.0000	3.4420	Yes	No	4675.	552682.
3	34.0000	217.0551	No	No	557358.	25987.
4	44.0000	34.6935	No	No	583345.	522052.
5	55.0000	55.0000	No	Yes	N.A.	N.A.

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

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	14800.	M, in-lb	0.00	1000.0000	1.0044	-0.01348	14800.	644954.

Maximum pile-head deflection = 1.0044206037 inches
Maximum pile-head rotation = -0.0134812152 radians = -0.772417 deg.

The analysis ended normally.

==

LPile for Windows, Version 2019-11.006

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

==

This copy of LPile is being used by:

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Serial Number of Security Device: 225625906

Files Used for Analysis

Path to file locations:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Floodwal 2050-2300 micropile 9.625 inch OD 0.545inch Wall.lp11d

Name of output report file:
Floodwal 2050-2300 micropile 9.625 inch OD 0.545inch Wall.lp11o

Name of plot output file:
Floodwal 2050-2300 micropile 9.625 inch OD 0.545inch Wall.lp11p

Name of runtime message file:
Floodwal 2050-2300 micropile 9.625 inch OD 0.545inch Wall.lp11r

----

Date and Time of Analysis

Date: February 23, 2021   Time: 16:35:08

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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                                   =       56.000 ft
Depth of ground surface below top of pile              =       0.0000 ft
```

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	9.6250
2	56.000	9.6250

Input Structural Properties for Pile Sections:

Pile Section No. 1:

```
   Section 1 is a drilled shaft with permanent casing
   Length of section                                   =    56.000000 ft
```

```
   Casing outside diameter                                =     9.625000 in
   Shear capacity of section                              =       0.0000 lbs



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

Ground Slope Angle                                        =        0.000 degrees
                                                          =        0.000 radians

Pile Batter Angle                                         =        0.000 degrees
                                                          =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 5 layers

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

   Distance from top of pile to top of layer              =       0.0000 ft
   Distance from top of pile to bottom of layer           =     3.000000 ft
   Effective unit weight at top of layer                  =   123.000000 pcf
   Effective unit weight at bottom of layer               =   123.000000 pcf
   Friction angle at top of layer                         =    32.000000 deg.
   Friction angle at bottom of layer                      =    32.000000 deg.
   Subgrade k at top of layer                             =    90.000000 pci
   Subgrade k at bottom of layer                          =    90.000000 pci


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

   Distance from top of pile to top of layer              =     3.000000 ft
   Distance from top of pile to bottom of layer           =    34.000000 ft
   Effective unit weight at top of layer                  =    47.600000 pcf
   Effective unit weight at bottom of layer               =    47.600000 pcf
   Friction angle at top of layer                         =    28.300000 deg.
   Friction angle at bottom of layer                      =    28.300000 deg.
   Subgrade k at top of layer                             =    20.000000 pci
   Subgrade k at bottom of layer                          =    20.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer              =    34.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    44.000000 ft
   Effective unit weight at top of layer               =    44.600000 pcf
   Effective unit weight at bottom of layer            =    44.600000 pcf
   Undrained cohesion at top of layer                  =   360.000000 psf
   Undrained cohesion at bottom of layer               =   360.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


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

   Distance from top of pile to top of layer           =    44.000000 ft
   Distance from top of pile to bottom of layer        =    55.000000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Friction angle at top of layer                      =    29.200000 deg.
   Friction angle at bottom of layer                   =    29.200000 deg.
   Subgrade k at top of layer                          =    45.000000 pci
   Subgrade k at bottom of layer                       =    45.000000 pci


Layer 5 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    55.000000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    87.600000 pcf
   Effective unit weight at bottom of layer            =    87.600000 pcf
   Uniaxial compressive strength at top of layer       =   500.000000 psi
   Uniaxial compressive strength at bottom of layer    =   500.000000 psi
   Initial modulus of rock at top of layer             =     1500000. psi
   Initial modulus of rock at bottom of layer          =     1500000. psi
   RQD of rock at top of layer                         =    78.000000 %
   RQD of rock at bottom of layer                      =    78.000000 %
   k rm of rock at top of layer                        =    0.0001000
   k rm of rock at bottom of layer                     =    0.0001000


 (Depth of the lowest soil layer extends 9.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective    Undrained    Angle of
Uniaxial                     E50                   Rock Mass
Layer           Name             Depth       Unit Wt.    Cohesion     Friction
 qu          RQD %         or           kpy        Modulus
 Num.     (p-y Curve Type)        ft            pcf           psf          deg.
```

```
 psi                       krm          pci          psi
-----   -------------------   ----------   ----------   ----------   ----------
----------   ----------   ----------   ----------   ----------
  1            Sand                 0.00     123.0000       --          32.0000
 --            --            --           90.0000       --
          (Reese, et al.)        3.0000     123.0000       --          32.0000
 --            --            --           90.0000       --
  2            Sand              3.0000      47.6000       --          28.3000
 --            --            --           20.0000       --
          (Reese, et al.)       34.0000      47.6000       --          28.3000
 --            --            --           20.0000       --
  3            Soft             34.0000      44.6000     360.0000       --
 --            --           0.02000       --            --
               Clay             44.0000      44.6000     360.0000       --
 --            --           0.02000       --            --
  4            Sand             44.0000      52.6000       --          29.2000
 --            --            --           45.0000       --
          (Reese, et al.)       55.0000      52.6000       --          29.2000
 --            --            --           45.0000       --
  5            Weak             55.0000      87.6000       --           --
500.0000      78.0000     1.00E-04       --         1500000.
               Rock             65.0000      87.6000       --           --
500.0000      78.0000     1.00E-04       --         1500000.
```

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition                Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                        2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   ----------------------   ----------------
---------------    ------------
   1     1     V =       15200. lbs   M =       0.0000 in-lbs    1000.000000000
    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) with Permanent Casing:

Length of Section	=	56.000000	ft
Outer Diameter of Casing	=	9.625000	in
Casing Wall Thickness	=	0.545000	in
Moment of Inertia of Steel Casing	=	160.796181	in^4
Yield Stress of Casing	=	50000.	psi
Elastic Modulus of Casing	=	29000000.	psi
Number of Reinforcing Bars	=	0	bars
Area of Single Reinforcing Bar	=	0.0000	sq. in.
Offset of Center of Rebar Cage from Center of Pile	=	0.0000	in
Yield Stress of Reinforcing Bars	=	0.0000	psi
Modulus of Elasticity of Reinforcing Bars	=	0.0000	psi
Gross Area of Pile	=	72.759777	sq. in.
Area of Concrete	=	57.213291	sq. in.
Cross-sectional Area of Steel Casing	=	15.546485	sq. in.
Area of All Steel (Casing and Bars)	=	15.546485	sq. in.
Area Ratio of All Steel to Gross Area of Pile	=	21.37	percent

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	971.849	kips
Tensile Load for Cracking of Concrete	=	-75.810	kips
Nominal Axial Tensile Capacity	=	-777.324	kips

Concrete Properties:

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

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

Number	Axial Thrust Force kips
1	1.000

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
1	1.000	2280.020	0.00300000

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

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

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

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

Axial 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	1.000000	2280.	0.650000	1482.	5046184.
1	0.75	1.000000	2280.	0.750000	1710.	5031444.
1	0.90	1.000000	2280.	0.900000	2052.	4640384.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	4675.
2	3.0000	3.4420	Yes	No	4675.	552682.
3	34.0000	217.0551	No	No	557358.	25987.
4	44.0000	34.6935	No	No	583345.	522052.
5	55.0000	55.0000	No	Yes	N.A.	N.A.

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

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	15200.	M, in-lb	0.00	1000.0000	1.0067	-0.01334	15200.	671028.

Maximum pile-head deflection = 1.0066905551 inches
Maximum pile-head rotation = -0.0133423437 radians = -0.764460 deg.

The analysis ended normally.

==

LPile for Windows, Version 2019-11.006

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

==

This copy of LPile is being used by:

OEI
100 E HANOVER CEDARKNOLLS, CEDAR KNOLLS, NJ

Serial Number of Security Device: 225625906

Files Used for Analysis

Path to file locations:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Floodwal 2050-2300 micropile 11.875 inch OD 0.582inch Wall.lp11d

Name of output report file:
Floodwal 2050-2300 micropile 11.875 inch OD 0.582inch Wall.lp11o

Name of plot output file:
Floodwal 2050-2300 micropile 11.875 inch OD 0.582inch Wall.lp11p

Name of runtime message file:
Floodwal 2050-2300 micropile 11.875 inch OD 0.582inch Wall.lp11r

----

Date and Time of Analysis

Date: February 23, 2021   Time: 16:40:02

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 56.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	11.8750
2	56.000	11.8750

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a drilled shaft with permanent casing
Length of section = 56.000000 ft

```
   Casing outside diameter                               =    11.875000 in
   Shear capacity of section                             =       0.0000 lbs
```

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

Ground Slope Angle                                       =        0.000 degrees
                                                         =        0.000 radians

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

```
--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 5 layers

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

   Distance from top of pile to top of layer             =       0.0000 ft
   Distance from top of pile to bottom of layer          =     3.000000 ft
   Effective unit weight at top of layer                 =   123.000000 pcf
   Effective unit weight at bottom of layer              =   123.000000 pcf
   Friction angle at top of layer                        =    32.000000 deg.
   Friction angle at bottom of layer                     =    32.000000 deg.
   Subgrade k at top of layer                            =    90.000000 pci
   Subgrade k at bottom of layer                         =    90.000000 pci


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

   Distance from top of pile to top of layer             =     3.000000 ft
   Distance from top of pile to bottom of layer          =    34.000000 ft
   Effective unit weight at top of layer                 =    47.600000 pcf
   Effective unit weight at bottom of layer              =    47.600000 pcf
   Friction angle at top of layer                        =    28.300000 deg.
   Friction angle at bottom of layer                     =    28.300000 deg.
   Subgrade k at top of layer                            =    20.000000 pci
   Subgrade k at bottom of layer                         =    20.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer             =    34.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    44.000000 ft
   Effective unit weight at top of layer               =    44.600000 pcf
   Effective unit weight at bottom of layer            =    44.600000 pcf
   Undrained cohesion at top of layer                  =   360.000000 psf
   Undrained cohesion at bottom of layer               =   360.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


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

   Distance from top of pile to top of layer           =    44.000000 ft
   Distance from top of pile to bottom of layer        =    55.000000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Friction angle at top of layer                      =    29.200000 deg.
   Friction angle at bottom of layer                   =    29.200000 deg.
   Subgrade k at top of layer                          =    45.000000 pci
   Subgrade k at bottom of layer                       =    45.000000 pci


Layer 5 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    55.000000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    87.600000 pcf
   Effective unit weight at bottom of layer            =    87.600000 pcf
   Uniaxial compressive strength at top of layer       =   500.000000 psi
   Uniaxial compressive strength at bottom of layer    =   500.000000 psi
   Initial modulus of rock at top of layer             =     1500000. psi
   Initial modulus of rock at bottom of layer          =     1500000. psi
   RQD of rock at top of layer                         =    78.000000 %
   RQD of rock at bottom of layer                      =    78.000000 %
   k rm of rock at top of layer                        =    0.0001000
   k rm of rock at bottom of layer                     =    0.0001000


 (Depth of the lowest soil layer extends 9.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective    Undrained    Angle of
Uniaxial                      E50                     Rock Mass
Layer           Name             Depth        Unit Wt.    Cohesion     Friction
 qu          RQD %         or            kpy        Modulus
 Num.     (p-y Curve Type)        ft            pcf          psf           deg.
```

```
 psi                       krm          pci          psi
-----   -------------------   ----------   ----------   ----------   ----------
----------   ----------   ----------   ----------   ----------
  1            Sand                  0.00     123.0000       --          32.0000
 --           --            --           90.0000       --
         (Reese, et al.)        3.0000     123.0000       --          32.0000
 --           --            --           90.0000       --
  2            Sand               3.0000      47.6000       --          28.3000
 --           --            --           20.0000       --
         (Reese, et al.)       34.0000      47.6000       --          28.3000
 --           --            --           20.0000       --
  3            Soft              34.0000      44.6000     360.0000       --
 --           --          0.02000       --             --
               Clay              44.0000      44.6000     360.0000       --
 --           --          0.02000       --             --
  4            Sand              44.0000      52.6000       --          29.2000
 --           --            --           45.0000       --
         (Reese, et al.)       55.0000      52.6000       --          29.2000
 --           --            --           45.0000       --
  5            Weak              55.0000      87.6000       --            --
500.0000      78.0000     1.00E-04       --         1500000.
               Rock              65.0000      87.6000       --            --
500.0000      78.0000     1.00E-04       --         1500000.
```

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition               Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                       2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   ----------------------   ----------------
---------------    ------------
   1     1     V =       21200. lbs   M =       0.0000 in-lbs    1000.000000000
    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) with Permanent Casing:

Length of Section	=	56.000000	ft
Outer Diameter of Casing	=	11.875000	in
Casing Wall Thickness	=	0.582000	in
Moment of Inertia of Steel Casing	=	330.037136	in^4
Yield Stress of Casing	=	50000.	psi
Elastic Modulus of Casing	=	29000000.	psi
Number of Reinforcing Bars	=	0	bars
Area of Single Reinforcing Bar	=	0.0000	sq. in.
Offset of Center of Rebar Cage from Center of Pile	=	0.0000	in
Yield Stress of Reinforcing Bars	=	0.0000	psi
Modulus of Elasticity of Reinforcing Bars	=	0.0000	psi
Gross Area of Pile	=	110.753413	sq. in.
Area of Concrete	=	90.105213	sq. in.
Cross-sectional Area of Steel Casing	=	20.648199	sq. in.
Area of All Steel (Casing and Bars)	=	20.648199	sq. in.
Area Ratio of All Steel to Gross Area of Pile	=	18.64	percent

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	1338.768	kips
Tensile Load for Cracking of Concrete	=	-106.559	kips
Nominal Axial Tensile Capacity	=	-1032.410	kips

Concrete Properties:

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

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

Number	Axial Thrust Force kips
1	1.000

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
1	1.000	3814.487	0.00300000

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

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

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

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

Axial 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	1.000000	3814.	0.650000	2479.	10500974.
1	0.75	1.000000	3814.	0.750000	2861.	10463591.
1	0.90	1.000000	3814.	0.900000	3433.	9566972.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	5859.
2	3.0000	3.4544	Yes	No	5859.	671201.
3	34.0000	214.2177	No	No	677060.	32062.
4	44.0000	34.6998	No	No	709122.	644090.
5	55.0000	55.0000	No	Yes	N.A.	N.A.

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

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	21200.	M, in-lb	0.00	1000.0000	1.0053	-0.01156	21200.	1041052.

Maximum pile-head deflection = 1.0053084768 inches
Maximum pile-head rotation = -0.0115557623 radians = -0.662096 deg.

The analysis ended normally.

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Floodwal 2050-2300 pipe pile 0.5inch Wall.lp11d

Name of output report file:
Floodwal 2050-2300 pipe pile 0.5inch Wall.lp11o

Name of plot output file:
Floodwal 2050-2300 pipe pile 0.5inch Wall.lp11p

Name of runtime message file:
Floodwal 2050-2300 pipe pile 0.5inch Wall.lp11r

Date and Time of Analysis

```
--------------------------------------------------------------------------------

               Date:  February 23, 2021          Time:  16:06:57


--------------------------------------------------------------------------------
                                 Problem Title
--------------------------------------------------------------------------------

Project Name: South Battery Park City Resiliency


Job Number: 17-NY165-01


Client: AECOM


Engineer: SG


Description:




--------------------------------------------------------------------------------
                         Program Options and Settings
--------------------------------------------------------------------------------

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

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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                                   =      56.000 ft
Depth of ground surface below top of pile              =      0.0000 ft
```

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	9.6250
2	56.000	9.6250

Input Structural Properties for Pile Sections:

Pile Section No. 1:

```
   Section 1 is a steel pipe pile
   Length of section                                   =    56.000000 ft
```

```
   Pile diameter                                           =     9.625000 in
   Shear capacity of section                               =       0.0000 lbs



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

Ground Slope Angle                                         =        0.000 degrees
                                                           =        0.000 radians

Pile Batter Angle                                          =        0.000 degrees
                                                           =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 5 layers

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

   Distance from top of pile to top of layer               =       0.0000 ft
   Distance from top of pile to bottom of layer            =     3.000000 ft
   Effective unit weight at top of layer                   =   123.000000 pcf
   Effective unit weight at bottom of layer                =   123.000000 pcf
   Friction angle at top of layer                          =    32.000000 deg.
   Friction angle at bottom of layer                       =    32.000000 deg.
   Subgrade k at top of layer                              =    90.000000 pci
   Subgrade k at bottom of layer                           =    90.000000 pci


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

   Distance from top of pile to top of layer               =     3.000000 ft
   Distance from top of pile to bottom of layer            =    34.000000 ft
   Effective unit weight at top of layer                   =    47.600000 pcf
   Effective unit weight at bottom of layer                =    47.600000 pcf
   Friction angle at top of layer                          =    28.300000 deg.
   Friction angle at bottom of layer                       =    28.300000 deg.
   Subgrade k at top of layer                              =    20.000000 pci
   Subgrade k at bottom of layer                           =    20.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer               =    34.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    44.000000 ft
   Effective unit weight at top of layer               =    44.600000 pcf
   Effective unit weight at bottom of layer            =    44.600000 pcf
   Undrained cohesion at top of layer                  =   360.000000 psf
   Undrained cohesion at bottom of layer               =   360.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


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

   Distance from top of pile to top of layer           =    44.000000 ft
   Distance from top of pile to bottom of layer        =    55.000000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Friction angle at top of layer                      =    29.200000 deg.
   Friction angle at bottom of layer                   =    29.200000 deg.
   Subgrade k at top of layer                          =    45.000000 pci
   Subgrade k at bottom of layer                       =    45.000000 pci


Layer 5 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    55.000000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    87.600000 pcf
   Effective unit weight at bottom of layer            =    87.600000 pcf
   Uniaxial compressive strength at top of layer       =   500.000000 psi
   Uniaxial compressive strength at bottom of layer    =   500.000000 psi
   Initial modulus of rock at top of layer             =     1500000. psi
   Initial modulus of rock at bottom of layer          =     1500000. psi
   RQD of rock at top of layer                         =    78.000000 %
   RQD of rock at bottom of layer                      =    78.000000 %
   k rm of rock at top of layer                        =    0.0001000
   k rm of rock at bottom of layer                     =    0.0001000


 (Depth of the lowest soil layer extends 9.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective    Undrained    Angle of
Uniaxial                     E50                   Rock Mass
Layer           Name             Depth       Unit Wt.    Cohesion     Friction
 qu          RQD %         or           kpy        Modulus
 Num.     (p-y Curve Type)        ft           pcf          psf          deg.
```

```
 psi                       krm          pci          psi
-----   -------------------   ----------   ----------   ----------   ----------
----------   ----------   ----------   ----------   ----------
  1            Sand                 0.00     123.0000       --          32.0000
 --           --            --           90.0000       --
          (Reese, et al.)        3.0000     123.0000       --          32.0000
 --           --            --           90.0000       --
  2            Sand              3.0000      47.6000       --          28.3000
 --           --            --           20.0000       --
          (Reese, et al.)       34.0000      47.6000       --          28.3000
 --           --            --           20.0000       --
  3            Soft             34.0000      44.6000     360.0000       --
 --           --           0.02000       --            --
               Clay             44.0000      44.6000     360.0000       --
 --           --           0.02000       --            --
  4            Sand             44.0000      52.6000       --          29.2000
 --           --            --           45.0000       --
          (Reese, et al.)       55.0000      52.6000       --          29.2000
 --           --            --           45.0000       --
  5            Weak             55.0000      87.6000       --           --
500.0000      78.0000     1.00E-04       --         1500000.
               Rock             65.0000      87.6000       --           --
500.0000      78.0000     1.00E-04       --         1500000.
```

```
--------------------------------------------------------------------------------
                               Static Loading Type
--------------------------------------------------------------------------------
```

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

```
--------------------------------------------------------------------------------
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------
```

Number of loads specified = 1

```
Load    Load         Condition                Condition            Axial Thrust
Compute Top y     Run Analysis
 No.    Type             1                        2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       14200. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel Pipe Pile:

Length of Section	=	56.000000 ft
Outer Diameter of Pipe	=	9.625000 in
Pipe Wall Thickness	=	0.500000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	14.333516 sq. in.
Moment of Inertia	=	149.634073 in^4
Elastic Bending Stiffness	=	4339388. kip-in^2
Plastic Modulus, Z	=	41.674479in^3
Plastic Moment Capacity = Fy Z	=	1500.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	516.007 kips
Nominal Axial Tensile Capacity	=	-516.007 kips

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

Number	Axial Thrust Force kips
1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	1489.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	4675.
2	3.0000	3.4420	Yes	No	4675.	552682.
3	34.0000	217.0551	No	No	557358.	25987.
4	44.0000	34.6935	No	No	583345.	522052.
5	55.0000	55.0000	No	Yes	N.A.	N.A.

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

```
--------------------------------------------------------------------------------
            Summary of Pile-head Responses for Conventional Analyses
--------------------------------------------------------------------------------

Definitions of Pile-head Loading Conditions:

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


Load Load                Load                  Axial    Pile-head  Pile-head  Max
Shear Max Moment
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in
Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  1  V, lb     14200.  M, in-lb        0.00  1000.0000     1.0018   -0.01373
14200.    605846.


Maximum pile-head deflection = 1.0017912292 inches
Maximum pile-head rotation   = -0.0137331052 radians = -0.786849 deg.

The analysis ended normally.
```

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

                    LPile for Windows, Version 2019-11.006

                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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park
Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation
Package\

Name of input data file:
Floodwal 2050-2300 pipe pile 0.545inch Wall.lp11d

Name of output report file:
Floodwal 2050-2300 pipe pile 0.545inch Wall.lp11o

Name of plot output file:
Floodwal 2050-2300 pipe pile 0.545inch Wall.lp11p

Name of runtime message file:
Floodwal 2050-2300 pipe pile 0.545inch Wall.lp11r


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

Date: February 23, 2021   Time: 16:08:57

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

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

Analysis Control Options:
 - Maximum number of iterations allowed = 500
 - Deflection tolerance for convergence = 1.0000E-05 in
 - Maximum allowable deflection = 100.0000 in
 - Number of pile increments = 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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 56.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	9.6250
2	56.000	9.6250

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a steel pipe pile
Length of section = 56.000000 ft

```
   Pile diameter                                          =     9.625000 in
   Shear capacity of section                              =       0.0000 lbs
```

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

```
Ground Slope Angle                                        =        0.000 degrees
                                                          =        0.000 radians

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

```
--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------
```

```
The soil profile is modelled using 5 layers

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

   Distance from top of pile to top of layer              =       0.0000 ft
   Distance from top of pile to bottom of layer           =     3.000000 ft
   Effective unit weight at top of layer                  =   123.000000 pcf
   Effective unit weight at bottom of layer               =   123.000000 pcf
   Friction angle at top of layer                         =    32.000000 deg.
   Friction angle at bottom of layer                      =    32.000000 deg.
   Subgrade k at top of layer                             =    90.000000 pci
   Subgrade k at bottom of layer                          =    90.000000 pci


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

   Distance from top of pile to top of layer              =     3.000000 ft
   Distance from top of pile to bottom of layer           =    34.000000 ft
   Effective unit weight at top of layer                  =    47.600000 pcf
   Effective unit weight at bottom of layer               =    47.600000 pcf
   Friction angle at top of layer                         =    28.300000 deg.
   Friction angle at bottom of layer                      =    28.300000 deg.
   Subgrade k at top of layer                             =    20.000000 pci
   Subgrade k at bottom of layer                          =    20.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer              =    34.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    44.000000 ft
   Effective unit weight at top of layer               =    44.600000 pcf
   Effective unit weight at bottom of layer            =    44.600000 pcf
   Undrained cohesion at top of layer                  =   360.000000 psf
   Undrained cohesion at bottom of layer               =   360.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


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

   Distance from top of pile to top of layer           =    44.000000 ft
   Distance from top of pile to bottom of layer        =    55.000000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Friction angle at top of layer                      =    29.200000 deg.
   Friction angle at bottom of layer                   =    29.200000 deg.
   Subgrade k at top of layer                          =    45.000000 pci
   Subgrade k at bottom of layer                       =    45.000000 pci


Layer 5 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    55.000000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    87.600000 pcf
   Effective unit weight at bottom of layer            =    87.600000 pcf
   Uniaxial compressive strength at top of layer       =   500.000000 psi
   Uniaxial compressive strength at bottom of layer    =   500.000000 psi
   Initial modulus of rock at top of layer             =     1500000. psi
   Initial modulus of rock at bottom of layer          =     1500000. psi
   RQD of rock at top of layer                         =    78.000000 %
   RQD of rock at bottom of layer                      =    78.000000 %
   k rm of rock at top of layer                        =    0.0001000
   k rm of rock at bottom of layer                     =    0.0001000


 (Depth of the lowest soil layer extends 9.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective    Undrained    Angle of
Uniaxial                     E50                   Rock Mass
Layer           Name             Depth       Unit Wt.    Cohesion     Friction
 qu          RQD %         or            kpy        Modulus
 Num.     (p-y Curve Type)        ft           pcf          psf          deg.
```

```
 psi                       krm          pci          psi
-----   -------------------   ----------   ----------   ----------   ----------
----------   ----------   ----------   ----------   ----------
  1            Sand                 0.00     123.0000       --          32.0000
 --           --            --           90.0000       --
          (Reese, et al.)        3.0000     123.0000       --          32.0000
 --           --            --           90.0000       --
  2            Sand               3.0000      47.6000       --          28.3000
 --           --            --           20.0000       --
          (Reese, et al.)       34.0000      47.6000       --          28.3000
 --           --            --           20.0000       --
  3            Soft              34.0000      44.6000     360.0000       --
 --           --          0.02000       --            --
               Clay              44.0000      44.6000     360.0000       --
 --           --          0.02000       --            --
  4            Sand              44.0000      52.6000       --          29.2000
 --           --            --           45.0000       --
          (Reese, et al.)       55.0000      52.6000       --          29.2000
 --           --            --           45.0000       --
  5            Weak              55.0000      87.6000       --           --
500.0000      78.0000     1.00E-04       --         1500000.
               Rock              65.0000      87.6000       --           --
500.0000      78.0000     1.00E-04       --         1500000.
```

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition               Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                       2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   ----------------------   ----------------
---------------    ------------
   1     1     V =       14600. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel Pipe Pile:

Length of Section	=	56.000000 ft
Outer Diameter of Pipe	=	9.625000 in
Pipe Wall Thickness	=	0.545000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	15.546485 sq. in.
Moment of Inertia	=	160.796181 in^4
Elastic Bending Stiffness	=	4663089. kip-in^2
Plastic Modulus, Z	=	44.987248in^3
Plastic Moment Capacity = Fy Z	=	1620.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	559.673 kips
Nominal Axial Tensile Capacity	=	-559.673 kips

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

Number	Axial Thrust Force kips
1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	1608.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	4675.
2	3.0000	3.4420	Yes	No	4675.	552682.
3	34.0000	217.0551	No	No	557358.	25987.
4	44.0000	34.6935	No	No	583345.	522052.
5	55.0000	55.0000	No	Yes	N.A.	N.A.

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

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	14600.	M, in-lb	0.00	1000.0000	1.0005	-0.01352	14600.	631956.

Maximum pile-head deflection = 1.0004726137 inches
Maximum pile-head rotation = -0.0135203219 radians = -0.774657 deg.

The analysis ended normally.

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Floodwal 2300-2850 HP12X53.lp11d

Name of output report file:
Floodwal 2300-2850 HP12X53.lp11o

Name of plot output file:
Floodwal 2300-2850 HP12X53.lp11p

Name of runtime message file:
Floodwal 2300-2850 HP12X53.lp11r

Date and Time of Analysis

Date: February 23, 2021   Time: 16:32:09

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
 - Conventional Analysis

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500	
- Deflection tolerance for convergence	=	1.0000E-05	in
- Maximum allowable deflection	=	100.0000	in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 41.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.0000
2	41.000	12.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a H strong axis steel pile
Length of section = 41.000000 ft

```
   Pile width                                            =    12.000000 in
   Shear capacity of section                             =       0.0000 lbs
```

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

Ground Slope Angle                                       =        0.000 degrees
                                                         =        0.000 radians

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

```
--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 4 layers

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

   Distance from top of pile to top of layer             =       0.0000 ft
   Distance from top of pile to bottom of layer          =     8.000000 ft
   Effective unit weight at top of layer                 =   122.000000 pcf
   Effective unit weight at bottom of layer              =   122.000000 pcf
   Friction angle at top of layer                        =    30.300000 deg.
   Friction angle at bottom of layer                     =    30.300000 deg.
   Subgrade k at top of layer                            =    80.000000 pci
   Subgrade k at bottom of layer                         =    80.000000 pci


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

   Distance from top of pile to top of layer             =     8.000000 ft
   Distance from top of pile to bottom of layer          =    27.000000 ft
   Effective unit weight at top of layer                 =    60.500000 pcf
   Effective unit weight at bottom of layer              =    60.500000 pcf
   Friction angle at top of layer                        =    31.500000 deg.
   Friction angle at bottom of layer                     =    31.500000 deg.
   Subgrade k at top of layer                            =    60.000000 pci
   Subgrade k at bottom of layer                         =    60.000000 pci


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

   Distance from top of pile to top of layer             =    27.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    40.000000 ft
   Effective unit weight at top of layer               =    60.500000 pcf
   Effective unit weight at bottom of layer            =    60.500000 pcf
   Friction angle at top of layer                      =    30.500000 deg.
   Friction angle at bottom of layer                   =    30.500000 deg.
   Subgrade k at top of layer                          =    55.000000 pci
   Subgrade k at bottom of layer                       =    55.000000 pci
```

Layer 4 is weak rock, p-y criteria by Reese, 1997

```
   Distance from top of pile to top of layer           =    40.000000 ft
   Distance from top of pile to bottom of layer        =    55.000000 ft
   Effective unit weight at top of layer               =    87.600000 pcf
   Effective unit weight at bottom of layer            =    87.600000 pcf
   Uniaxial compressive strength at top of layer       =   500.000000 psi
   Uniaxial compressive strength at bottom of layer    =   500.000000 psi
   Initial modulus of rock at top of layer             =     1500000. psi
   Initial modulus of rock at bottom of layer          =     1500000. psi
   RQD of rock at top of layer                         =    52.500000 %
   RQD of rock at bottom of layer                      =    52.500000 %
   k rm of rock at top of layer                        =    0.0001000
   k rm of rock at bottom of layer                     =    0.0001000
```

(Depth of the lowest soil layer extends 14.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name or (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	122.0000	30.3000	--	--	--	80.0000	--
	(Reese, et al.)	8.0000	122.0000	30.3000	--	--	--	80.0000	--
2	Sand	8.0000	60.5000	31.5000	--	--	--	60.0000	--
	(Reese, et al.)	27.0000	60.5000	31.5000	--	--	--	60.0000	--
3	Sand	27.0000	60.5000	30.5000	--				

```
 --          --          55.0000       --
        (Reese, et al.)        40.0000      60.5000      30.5000       --
 --          --          55.0000       --
  4           Weak              40.0000      87.6000       --         500.0000
52.5000    1.00E-04       --         1500000.
              Rock              55.0000      87.6000       --         500.0000
52.5000    1.00E-04       --         1500000.
```

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition              Condition            Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                       2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       24500. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel H Strong Axis:

Length of Section	=	41.000000 ft
Flange Width	=	12.000000 in
Section Depth	=	11.800000 in
Flange Thickness	=	0.435000 in
Web Thickness	=	0.435000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	15.194550 sq. in.
Moment of Inertia	=	384.614130 in^4
Elastic Bending Stiffness	=	11153810. kip-in^2
Plastic Modulus, Z	=	72.317108in^3
Plastic Moment Capacity = Fy Z	=	2603.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	547.004 kips
Nominal Axial Tensile Capacity	=	-547.004 kips

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

Number	Axial Thrust Force kips
1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	2595.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	47506.
2	8.0000	7.7173	Yes	No	47506.	842121.
3	27.0000	29.9619	Yes	No	889627.	880974.
4	40.0000	40.0000	No	Yes	N.A.	N.A.

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

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

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

Load Load Load Axial Pile-head Pile-head Max
Shear Max Moment

```
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in
Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  1  V, lb     24500.  M, in-lb        0.00  1000.0000     1.0028   -0.01227
24500.   1287889.


Maximum pile-head deflection = 1.0028218901 inches
Maximum pile-head rotation   = -0.0122748265 radians = -0.703296 deg.

The analysis ended normally.
```

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

                      LPile for Windows, Version 2019-11.006

                  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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park
Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation
Package\

Name of input data file:
Floodwal 2300-2850 HP12X63.lp11d

Name of output report file:
Floodwal 2300-2850 HP12X63.lp11o

Name of plot output file:
Floodwal 2300-2850 HP12X63.lp11p

Name of runtime message file:
Floodwal 2300-2850 HP12X63.lp11r


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

```
--------------------------------------------------------------------------------

               Date:  February 23, 2021          Time:  16:30:44


--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: South Battery Park City Resiliency



Job Number: 17-NY165-01



Client: AECOM



Engineer: SG



Description:





--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

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

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 41.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.1000
2	41.000	12.1000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a H strong axis steel pile
Length of section = 41.000000 ft

```
   Pile width                                                =    12.100000 in
   Shear capacity of section                                 =       0.0000 lbs
```

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

Ground Slope Angle                                           =        0.000 degrees
                                                             =        0.000 radians

Pile Batter Angle                                            =        0.000 degrees
                                                             =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 4 layers

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

   Distance from top of pile to top of layer                 =       0.0000 ft
   Distance from top of pile to bottom of layer              =     8.000000 ft
   Effective unit weight at top of layer                     =   122.000000 pcf
   Effective unit weight at bottom of layer                  =   122.000000 pcf
   Friction angle at top of layer                            =    30.300000 deg.
   Friction angle at bottom of layer                         =    30.300000 deg.
   Subgrade k at top of layer                                =    80.000000 pci
   Subgrade k at bottom of layer                             =    80.000000 pci


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

   Distance from top of pile to top of layer                 =     8.000000 ft
   Distance from top of pile to bottom of layer              =    27.000000 ft
   Effective unit weight at top of layer                     =    60.500000 pcf
   Effective unit weight at bottom of layer                  =    60.500000 pcf
   Friction angle at top of layer                            =    31.500000 deg.
   Friction angle at bottom of layer                         =    31.500000 deg.
   Subgrade k at top of layer                                =    60.000000 pci
   Subgrade k at bottom of layer                             =    60.000000 pci


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

   Distance from top of pile to top of layer                 =    27.000000 ft
```

Distance from top of pile to bottom of layer = 40.000000 ft
Effective unit weight at top of layer = 60.500000 pcf
Effective unit weight at bottom of layer = 60.500000 pcf
Friction angle at top of layer = 30.500000 deg.
Friction angle at bottom of layer = 30.500000 deg.
Subgrade k at top of layer = 55.000000 pci
Subgrade k at bottom of layer = 55.000000 pci

Layer 4 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer = 40.000000 ft
Distance from top of pile to bottom of layer = 55.000000 ft
Effective unit weight at top of layer = 87.600000 pcf
Effective unit weight at bottom of layer = 87.600000 pcf
Uniaxial compressive strength at top of layer = 500.000000 psi
Uniaxial compressive strength at bottom of layer = 500.000000 psi
Initial modulus of rock at top of layer = 1500000. psi
Initial modulus of rock at bottom of layer = 1500000. psi
RQD of rock at top of layer = 52.500000 %
RQD of rock at bottom of layer = 52.500000 %
k rm of rock at top of layer = 0.0001000
k rm of rock at bottom of layer = 0.0001000

(Depth of the lowest soil layer extends 14.000 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.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	122.0000	30.3000	--	--	--	80.0000	--
	(Reese, et al.)	8.0000	122.0000	30.3000	--	--	--	80.0000	--
2	Sand	8.0000	60.5000	31.5000	--	--	--	60.0000	--
	(Reese, et al.)	27.0000	60.5000	31.5000	--	--	--	60.0000	--
3	Sand	27.0000	60.5000	30.5000	--				

```
 --          --          55.0000       --
         (Reese, et al.)        40.0000      60.5000      30.5000       --
 --          --          55.0000       --
  4            Weak              40.0000      87.6000       --         500.0000
52.5000     1.00E-04       --         1500000.
               Rock              55.0000      87.6000       --         500.0000
52.5000     1.00E-04       --         1500000.
```

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition               Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type             1                       2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       26500. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel H Strong Axis:

Length of Section	=	41.000000 ft
Flange Width	=	12.100000 in
Section Depth	=	11.900000 in
Flange Thickness	=	0.515000 in
Web Thickness	=	0.515000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	18.061050 sq. in.
Moment of Inertia	=	459.254129 in^4
Elastic Bending Stiffness	=	13318370. kip-in^2
Plastic Modulus, Z	=	86.158328in^3
Plastic Moment Capacity = Fy Z	=	3102.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	650.198 kips
Nominal Axial Tensile Capacity	=	-650.198 kips

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

Number	Axial Thrust Force kips
1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	3092.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	47639.
2	8.0000	7.7170	Yes	No	47639.	847589.
3	27.0000	29.9497	Yes	No	895227.	888316.
4	40.0000	40.0000	No	Yes	N.A.	N.A.

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

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

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

Load Load Load Axial Pile-head Pile-head Max
Shear Max Moment

```
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in
Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  1  V, lb     26500.  M, in-lb        0.00  1000.0000     1.0003   -0.01186
26500.   1441070.
```

```
Maximum pile-head deflection = 1.0002636686 inches
Maximum pile-head rotation   = -0.0118605343 radians = -0.679559 deg.
```

The analysis ended normally.

==

LPile for Windows, Version 2019-11.006

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

==

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Serial Number of Security Device: 225625906

Files Used for Analysis

Path to file locations:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Floodwal 2300-2850 HP12X74.lp11d

Name of output report file:
Floodwal 2300-2850 HP12X74.lp11o

Name of plot output file:
Floodwal 2300-2850 HP12X74.lp11p

Name of runtime message file:
Floodwal 2300-2850 HP12X74.lp11r

Date and Time of Analysis

Date: February 23, 2021   Time: 16:28:38

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
 - Conventional Analysis

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500	
- Deflection tolerance for convergence	=	1.0000E-05	in
- Maximum allowable deflection	=	100.0000	in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 41.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.2000
2	41.000	12.2000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a H strong axis steel pile
Length of section = 41.000000 ft

```
   Pile width                                              =    12.200000 in
   Shear capacity of section                               =       0.0000 lbs



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

Ground Slope Angle                                         =        0.000 degrees
                                                           =        0.000 radians

Pile Batter Angle                                          =        0.000 degrees
                                                           =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 4 layers

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

   Distance from top of pile to top of layer               =       0.0000 ft
   Distance from top of pile to bottom of layer            =     8.000000 ft
   Effective unit weight at top of layer                   =   122.000000 pcf
   Effective unit weight at bottom of layer                =   122.000000 pcf
   Friction angle at top of layer                          =    30.300000 deg.
   Friction angle at bottom of layer                       =    30.300000 deg.
   Subgrade k at top of layer                              =    80.000000 pci
   Subgrade k at bottom of layer                           =    80.000000 pci


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

   Distance from top of pile to top of layer               =     8.000000 ft
   Distance from top of pile to bottom of layer            =    27.000000 ft
   Effective unit weight at top of layer                   =    60.500000 pcf
   Effective unit weight at bottom of layer                =    60.500000 pcf
   Friction angle at top of layer                          =    31.500000 deg.
   Friction angle at bottom of layer                       =    31.500000 deg.
   Subgrade k at top of layer                              =    60.000000 pci
   Subgrade k at bottom of layer                           =    60.000000 pci


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

   Distance from top of pile to top of layer               =    27.000000 ft
```

Distance from top of pile to bottom of layer = 40.000000 ft
Effective unit weight at top of layer = 60.500000 pcf
Effective unit weight at bottom of layer = 60.500000 pcf
Friction angle at top of layer = 30.500000 deg.
Friction angle at bottom of layer = 30.500000 deg.
Subgrade k at top of layer = 55.000000 pci
Subgrade k at bottom of layer = 55.000000 pci

Layer 4 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer = 40.000000 ft
Distance from top of pile to bottom of layer = 55.000000 ft
Effective unit weight at top of layer = 87.600000 pcf
Effective unit weight at bottom of layer = 87.600000 pcf
Uniaxial compressive strength at top of layer = 500.000000 psi
Uniaxial compressive strength at bottom of layer = 500.000000 psi
Initial modulus of rock at top of layer = 1500000. psi
Initial modulus of rock at bottom of layer = 1500000. psi
RQD of rock at top of layer = 52.500000 %
RQD of rock at bottom of layer = 52.500000 %
k rm of rock at top of layer = 0.0001000
k rm of rock at bottom of layer = 0.0001000

(Depth of the lowest soil layer extends 14.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name or (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	Layer RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	122.0000	30.3000	--	--	--	80.0000	--
	(Reese, et al.)	8.0000	122.0000	30.3000	--	--	--	80.0000	--
2	Sand	8.0000	60.5000	31.5000	--	--	--	60.0000	--
	(Reese, et al.)	27.0000	60.5000	31.5000	--	--	--	60.0000	--
3	Sand	27.0000	60.5000	30.5000	--				

```
 --          --          55.0000       --
         (Reese, et al.)        40.0000      60.5000      30.5000       --
 --          --          55.0000       --
  4            Weak              40.0000      87.6000       --         500.0000
52.5000     1.00E-04       --         1500000.
               Rock              55.0000      87.6000       --         500.0000
52.5000     1.00E-04       --         1500000.
```

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition              Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                       2                Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       28900. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel H Strong Axis:

Length of Section	=	41.000000 ft
Flange Width	=	12.200000 in
Section Depth	=	12.100000 in
Flange Thickness	=	0.610000 in
Web Thickness	=	0.605000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	21.466400 sq. in.
Moment of Inertia	=	556.640624 in^4
Elastic Bending Stiffness	=	16142578. kip-in^2
Plastic Modulus, Z	=	103.412708in^3
Plastic Moment Capacity = Fy Z	=	3723.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	772.790 kips
Nominal Axial Tensile Capacity	=	-772.790 kips

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

Number	Axial Thrust Force kips
1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	3712.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	47775.
2	8.0000	7.7168	Yes	No	47775.	853025.
3	27.0000	29.9376	Yes	No	900800.	895657.
4	40.0000	40.0000	No	Yes	N.A.	N.A.

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

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

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

Load Load Load Axial Pile-head Pile-head Max
Shear Max Moment

```
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in
Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  1  V, lb     28900.  M, in-lb        0.00  1000.0000     1.0005   -0.01145
28900.   1629160.


Maximum pile-head deflection = 1.0004623757 inches
Maximum pile-head rotation   = -0.0114544146 radians = -0.656290 deg.

The analysis ended normally.
```

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Floodwal 2300-2850 HP12X84.lp11d

Name of output report file:
Floodwal 2300-2850 HP12X84.lp11o

Name of plot output file:
Floodwal 2300-2850 HP12X84.lp11p

Name of runtime message file:
Floodwal 2300-2850 HP12X84.lp11r

Date and Time of Analysis

```
--------------------------------------------------------------------------------

               Date:  February 23, 2021          Time:  16:25:05


--------------------------------------------------------------------------------
                                 Problem Title
--------------------------------------------------------------------------------

Project Name: South Battery Park City Resiliency



Job Number: 17-NY165-01



Client: AECOM



Engineer: SG



Description:






--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

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

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          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)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Input of side resistance moment along pile 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.
 - Report only summary tables of pile-head deflection, maximum bending moment,
   and maximum shear force in output report file.
 - 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                                   =       41.000 ft
Depth of ground surface below top of pile              =       0.0000 ft

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

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

            Depth Below          Pile
Point        Pile Head         Diameter
 No.           feet             inches
-----     -------------     -------------
  1            0.000           12.3000
  2           41.000           12.3000


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a H strong axis steel pile
   Length of section                                   =    41.000000 ft
```

```
   Pile width                                              =    12.300000 in
   Shear capacity of section                               =       0.0000 lbs



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

Ground Slope Angle                                         =        0.000 degrees
                                                           =        0.000 radians

Pile Batter Angle                                          =        0.000 degrees
                                                           =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 4 layers

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

   Distance from top of pile to top of layer               =       0.0000 ft
   Distance from top of pile to bottom of layer            =     8.000000 ft
   Effective unit weight at top of layer                   =   122.000000 pcf
   Effective unit weight at bottom of layer                =   122.000000 pcf
   Friction angle at top of layer                          =    30.300000 deg.
   Friction angle at bottom of layer                       =    30.300000 deg.
   Subgrade k at top of layer                              =    80.000000 pci
   Subgrade k at bottom of layer                           =    80.000000 pci


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

   Distance from top of pile to top of layer               =     8.000000 ft
   Distance from top of pile to bottom of layer            =    27.000000 ft
   Effective unit weight at top of layer                   =    60.500000 pcf
   Effective unit weight at bottom of layer                =    60.500000 pcf
   Friction angle at top of layer                          =    31.500000 deg.
   Friction angle at bottom of layer                       =    31.500000 deg.
   Subgrade k at top of layer                              =    60.000000 pci
   Subgrade k at bottom of layer                           =    60.000000 pci


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

   Distance from top of pile to top of layer               =    27.000000 ft
```

Distance from top of pile to bottom of layer = 40.000000 ft
Effective unit weight at top of layer = 60.500000 pcf
Effective unit weight at bottom of layer = 60.500000 pcf
Friction angle at top of layer = 30.500000 deg.
Friction angle at bottom of layer = 30.500000 deg.
Subgrade k at top of layer = 55.000000 pci
Subgrade k at bottom of layer = 55.000000 pci

Layer 4 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer = 40.000000 ft
Distance from top of pile to bottom of layer = 55.000000 ft
Effective unit weight at top of layer = 87.600000 pcf
Effective unit weight at bottom of layer = 87.600000 pcf
Uniaxial compressive strength at top of layer = 500.000000 psi
Uniaxial compressive strength at bottom of layer = 500.000000 psi
Initial modulus of rock at top of layer = 1500000. psi
Initial modulus of rock at bottom of layer = 1500000. psi
RQD of rock at top of layer = 52.500000 %
RQD of rock at bottom of layer = 52.500000 %
k rm of rock at top of layer = 0.0001000
k rm of rock at bottom of layer = 0.0001000

(Depth of the lowest soil layer extends 14.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name or (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	Layer RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	122.0000	30.3000	--	--	--	80.0000	--
	(Reese, et al.)	8.0000	122.0000	30.3000	--	--	--	80.0000	--
2	Sand	8.0000	60.5000	31.5000	--	--	--	60.0000	--
	(Reese, et al.)	27.0000	60.5000	31.5000	--	--	--	60.0000	--
3	Sand	27.0000	60.5000	30.5000	--				

```
 --           --          55.0000       --
         (Reese, et al.)        40.0000      60.5000      30.5000       --
 --           --          55.0000       --
  4            Weak             40.0000      87.6000       --         500.0000
52.5000     1.00E-04       --         1500000.
               Rock             55.0000      87.6000       --         500.0000
52.5000     1.00E-04       --         1500000.
```

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition               Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                       2                 Force, lbs
vs. Pile Length
-----   ----  --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       30800. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel H Strong Axis:

Length of Section	=	41.000000 ft
Flange Width	=	12.300000 in
Section Depth	=	12.300000 in
Flange Thickness	=	0.685000 in
Web Thickness	=	0.685000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	24.338050 sq. in.
Moment of Inertia	=	643.530174 in^4
Elastic Bending Stiffness	=	18662375. kip-in^2
Plastic Modulus, Z	=	118.320547in^3
Plastic Moment Capacity = Fy Z	=	4260.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	876.170 kips
Nominal Axial Tensile Capacity	=	-876.170 kips

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

Number	Axial Thrust Force kips
1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	4246.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	47909.
2	8.0000	7.7165	Yes	No	47909.	858407.
3	27.0000	29.9251	Yes	No	906315.	902999.
4	40.0000	40.0000	No	Yes	N.A.	N.A.

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

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

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

Load Load Load Axial Pile-head Pile-head Max
Shear Max Moment

```
Case Type   Pile-head    Type      Pile-head   Loading  Deflection  Rotation    in
Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  1  V, lb     30800.  M, in-lb        0.00  1000.0000     0.9983   -0.01114
30800.   1784917.
```

Maximum pile-head deflection = 0.9982735069 inches
Maximum pile-head rotation   = -0.0111355807 radians = -0.638022 deg.

The analysis ended normally.

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

                LPile for Windows, Version 2019-11.006

             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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park
Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation
Package\

Name of input data file:
Floodwal 2300-2850 micropile 9.625inch OD 0.5inch Wall.lp11d

Name of output report file:
Floodwal 2300-2850 micropile 9.625inch OD 0.5inch Wall.lp11o

Name of plot output file:
Floodwal 2300-2850 micropile 9.625inch OD 0.5inch Wall.lp11p

Name of runtime message file:
Floodwal 2300-2850 micropile 9.625inch OD 0.5inch Wall.lp11r


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

Date: February 23, 2021   Time: 16:36:48

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 41.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	9.6250
2	41.000	9.6250

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a drilled shaft with permanent casing
Length of section = 41.000000 ft

```
   Casing outside diameter                              =     9.625000 in
   Shear capacity of section                            =       0.0000 lbs



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

Ground Slope Angle                                      =        0.000 degrees
                                                        =        0.000 radians

Pile Batter Angle                                       =        0.000 degrees
                                                        =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 4 layers

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

   Distance from top of pile to top of layer            =       0.0000 ft
   Distance from top of pile to bottom of layer         =     8.000000 ft
   Effective unit weight at top of layer                =   122.000000 pcf
   Effective unit weight at bottom of layer             =   122.000000 pcf
   Friction angle at top of layer                       =    30.300000 deg.
   Friction angle at bottom of layer                    =    30.300000 deg.
   Subgrade k at top of layer                           =    80.000000 pci
   Subgrade k at bottom of layer                        =    80.000000 pci


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

   Distance from top of pile to top of layer            =     8.000000 ft
   Distance from top of pile to bottom of layer         =    27.000000 ft
   Effective unit weight at top of layer                =    60.500000 pcf
   Effective unit weight at bottom of layer             =    60.500000 pcf
   Friction angle at top of layer                       =    31.500000 deg.
   Friction angle at bottom of layer                    =    31.500000 deg.
   Subgrade k at top of layer                           =    60.000000 pci
   Subgrade k at bottom of layer                        =    60.000000 pci


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

   Distance from top of pile to top of layer            =    27.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    40.000000 ft
   Effective unit weight at top of layer               =    60.500000 pcf
   Effective unit weight at bottom of layer            =    60.500000 pcf
   Friction angle at top of layer                      =    30.500000 deg.
   Friction angle at bottom of layer                   =    30.500000 deg.
   Subgrade k at top of layer                          =    55.000000 pci
   Subgrade k at bottom of layer                       =    55.000000 pci


Layer 4 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    40.000000 ft
   Distance from top of pile to bottom of layer        =    55.000000 ft
   Effective unit weight at top of layer               =    87.600000 pcf
   Effective unit weight at bottom of layer            =    87.600000 pcf
   Uniaxial compressive strength at top of layer       =   500.000000 psi
   Uniaxial compressive strength at bottom of layer    =   500.000000 psi
   Initial modulus of rock at top of layer             =     1500000. psi
   Initial modulus of rock at bottom of layer          =     1500000. psi
   RQD of rock at top of layer                         =    52.500000 %
   RQD of rock at bottom of layer                      =    52.500000 %
   k rm of rock at top of layer                        =    0.0001000
   k rm of rock at bottom of layer                     =    0.0001000


 (Depth of the lowest soil layer extends 14.000 ft below the pile tip)



--------------------------------------------------------------------------------
                        Summary of Input Soil Properties
--------------------------------------------------------------------------------

Layer         Soil Type          Layer      Effective    Angle of     Uniaxial
              E50                    Rock Mass
Layer           Name             Depth       Unit Wt.    Friction        qu
RQD %         or            kpy        Modulus
 Num.     (p-y Curve Type)        ft           pcf          deg.         psi
              krm           pci          psi
-----   ------------------   ----------   ----------   ----------   ----------
----------   ----------   ----------   ----------
  1             Sand               0.00     122.0000      30.3000       --
 --           --           80.0000        --
          (Reese, et al.)        8.0000     122.0000      30.3000       --
 --           --           80.0000        --
  2             Sand             8.0000      60.5000      31.5000       --
 --           --           60.0000        --
          (Reese, et al.)       27.0000      60.5000      31.5000       --
 --           --           60.0000        --
  3             Sand            27.0000      60.5000      30.5000       --
```

```
 --          --          55.0000       --
         (Reese, et al.)        40.0000      60.5000      30.5000       --
 --          --          55.0000       --
  4          Weak               40.0000      87.6000       --         500.0000
52.5000    1.00E-04       --         1500000.
             Rock               55.0000      87.6000       --         500.0000
52.5000    1.00E-04       --         1500000.
```

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition              Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                       2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       16300. lbs   M =       0.0000 in-lbs    1000.000000000
    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) with Permanent Casing:

Length of Section	=	41.000000	ft
Outer Diameter of Casing	=	9.625000	in
Casing Wall Thickness	=	0.500000	in
Moment of Inertia of Steel Casing	=	149.634073	in^4
Yield Stress of Casing	=	36000.	psi
Elastic Modulus of Casing	=	29000000.	psi
Number of Reinforcing Bars	=	0	bars
Area of Single Reinforcing Bar	=	0.0000	sq. in.
Offset of Center of Rebar Cage from Center of Pile	=	0.0000	in
Yield Stress of Reinforcing Bars	=	0.0000	psi
Modulus of Elasticity of Reinforcing Bars	=	0.0000	psi
Gross Area of Pile	=	72.759777	sq. in.
Area of Concrete	=	58.426260	sq. in.
Cross-sectional Area of Steel Casing	=	14.333516	sq. in.
Area of All Steel (Casing and Bars)	=	14.333516	sq. in.
Area Ratio of All Steel to Gross Area of Pile	=	19.70	percent

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	714.656	kips
Tensile Load for Cracking of Concrete	=	-72.256	kips
Nominal Axial Tensile Capacity	=	-516.007	kips

Concrete Properties:

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

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

Number	Axial Thrust Force kips
1	1.000

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
1	1.000	1603.382	0.00300000

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

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

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

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

Axial 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	1.000000	1603.	0.650000	1042.	4756825.
1	0.75	1.000000	1603.	0.750000	1203.	4731957.
1	0.90	1.000000	1603.	0.900000	1443.	4060476.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	44595.
2	8.0000	7.7219	Yes	No	44595.	700924.
3	27.0000	30.2463	Yes	No	745519.	706615.
4	40.0000	40.0000	No	Yes	N.A.	N.A.

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

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	16300.	M, in-lb	0.00	1000.0000	0.9949	-0.01423	16300.	759278.

Maximum pile-head deflection = 0.9949296609 inches
Maximum pile-head rotation = -0.0142285698 radians = -0.815237 deg.

The analysis ended normally.

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Floodwal 2300-2850 micropile 9.625inch OD 0.545inch Wall.lp11d

Name of output report file:
Floodwal 2300-2850 micropile 9.625inch OD 0.545inch Wall.lp11o

Name of plot output file:
Floodwal 2300-2850 micropile 9.625inch OD 0.545inch Wall.lp11p

Name of runtime message file:
Floodwal 2300-2850 micropile 9.625inch OD 0.545inch Wall.lp11r

----
Date and Time of Analysis

Date: February 23, 2021   Time: 16:37:53

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
 - Conventional Analysis

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

Analysis Control Options:

```
 - Maximum number of iterations allowed          =          500
 - Deflection tolerance for convergence          =   1.0000E-05 in
 - Maximum allowable deflection                  =     100.0000 in
 - Number of pile increments                     =          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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 41.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	9.6250
2	41.000	9.6250

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a drilled shaft with permanent casing
Length of section = 41.000000 ft

```
   Casing outside diameter                                =     9.625000 in
   Shear capacity of section                              =       0.0000 lbs



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

Ground Slope Angle                                        =        0.000 degrees
                                                          =        0.000 radians

Pile Batter Angle                                         =        0.000 degrees
                                                          =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 4 layers

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

   Distance from top of pile to top of layer              =       0.0000 ft
   Distance from top of pile to bottom of layer           =     8.000000 ft
   Effective unit weight at top of layer                  =   122.000000 pcf
   Effective unit weight at bottom of layer               =   122.000000 pcf
   Friction angle at top of layer                         =    30.300000 deg.
   Friction angle at bottom of layer                      =    30.300000 deg.
   Subgrade k at top of layer                             =    80.000000 pci
   Subgrade k at bottom of layer                          =    80.000000 pci


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

   Distance from top of pile to top of layer              =     8.000000 ft
   Distance from top of pile to bottom of layer           =    27.000000 ft
   Effective unit weight at top of layer                  =    60.500000 pcf
   Effective unit weight at bottom of layer               =    60.500000 pcf
   Friction angle at top of layer                         =    31.500000 deg.
   Friction angle at bottom of layer                      =    31.500000 deg.
   Subgrade k at top of layer                             =    60.000000 pci
   Subgrade k at bottom of layer                          =    60.000000 pci


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

   Distance from top of pile to top of layer              =    27.000000 ft
```

Distance from top of pile to bottom of layer = 40.000000 ft
Effective unit weight at top of layer = 60.500000 pcf
Effective unit weight at bottom of layer = 60.500000 pcf
Friction angle at top of layer = 30.500000 deg.
Friction angle at bottom of layer = 30.500000 deg.
Subgrade k at top of layer = 55.000000 pci
Subgrade k at bottom of layer = 55.000000 pci

Layer 4 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer = 40.000000 ft
Distance from top of pile to bottom of layer = 55.000000 ft
Effective unit weight at top of layer = 87.600000 pcf
Effective unit weight at bottom of layer = 87.600000 pcf
Uniaxial compressive strength at top of layer = 500.000000 psi
Uniaxial compressive strength at bottom of layer = 500.000000 psi
Initial modulus of rock at top of layer = 1500000. psi
Initial modulus of rock at bottom of layer = 1500000. psi
RQD of rock at top of layer = 52.500000 %
RQD of rock at bottom of layer = 52.500000 %
k rm of rock at top of layer = 0.0001000
k rm of rock at bottom of layer = 0.0001000

(Depth of the lowest soil layer extends 14.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name or (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	122.0000	30.3000	--	--	--	80.0000	--
	(Reese, et al.)	8.0000	122.0000	30.3000	--	--	--	80.0000	--
2	Sand	8.0000	60.5000	31.5000	--	--	--	60.0000	--
	(Reese, et al.)	27.0000	60.5000	31.5000	--	--	--	60.0000	--
3	Sand	27.0000	60.5000	30.5000	--				

```
 --          --          55.0000       --
         (Reese, et al.)        40.0000      60.5000      30.5000       --
 --          --          55.0000       --
  4           Weak              40.0000      87.6000       --         500.0000
52.5000    1.00E-04       --         1500000.
              Rock              55.0000      87.6000       --         500.0000
52.5000    1.00E-04       --         1500000.
```

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load        Condition              Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                      2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       16800. lbs   M =       0.0000 in-lbs    1000.000000000
    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) with Permanent Casing:
------------------------------------------------------------------------------

Length of Section                                          =    41.000000 ft
Outer Diameter of Casing                                   =     9.625000 in
Casing Wall Thickness                                      =     0.545000 in
Moment of Inertia of Steel Casing                          =   160.796181 in^4
Yield Stress of Casing                                     =       36000. psi
Elastic Modulus of Casing                                  =    29000000. psi
Number of Reinforcing Bars                                 =            0 bars
Area of Single Reinforcing Bar                             =       0.0000 sq. in.
Offset of Center of Rebar Cage from Center of Pile         =       0.0000 in
Yield Stress of Reinforcing Bars                           =       0.0000 psi
Modulus of Elasticity of Reinforcing Bars                  =       0.0000 psi
Gross Area of Pile                                         =    72.759777 sq. in.
Area of Concrete                                           =    57.213291 sq. in.
Cross-sectional Area of Steel Casing                       =    15.546485 sq. in.
Area of All Steel (Casing and Bars)                        =    15.546485 sq. in.
Area Ratio of All Steel to Gross Area of Pile              =        21.37 percent

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As        =      754.199 kips
Tensile Load for Cracking of Concrete                      =      -75.810 kips
Nominal Axial Tensile Capacity                             =     -559.673 kips



Concrete Properties:
--------------------

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


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

   Number     Axial Thrust Force
                   kips
   ------     ------------------
      1              1.000
```

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
1	1.000	1717.222	0.00300000

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

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

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

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

Axial 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	1.000000	1717.	0.650000	1116.	5068721.
1	0.75	1.000000	1717.	0.750000	1288.	5045921.
1	0.90	1.000000	1717.	0.900000	1546.	4354491.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	44595.
2	8.0000	7.7219	Yes	No	44595.	700924.
3	27.0000	30.2463	Yes	No	745519.	706615.
4	40.0000	40.0000	No	Yes	N.A.	N.A.

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

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	16800.	M, in-lb	0.00	1000.0000	0.9980	-0.01411	16800.	792385.

Maximum pile-head deflection = 0.9979878526 inches
Maximum pile-head rotation = -0.0141057691 radians = -0.808201 deg.

The analysis ended normally.

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Floodwal 2300-2850 micropile 11.875 inch OD 0.582inch Wall.lp11d

Name of output report file:
Floodwal 2300-2850 micropile 11.875 inch OD 0.582inch Wall.lp11o

Name of plot output file:
Floodwal 2300-2850 micropile 11.875 inch OD 0.582inch Wall.lp11p

Name of runtime message file:
Floodwal 2300-2850 micropile 11.875 inch OD 0.582inch Wall.lp11r

----
Date and Time of Analysis

Date: February 23, 2021   Time: 16:42:21

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 41.000 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	11.8750
2	41.000	11.8750

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a steel pipe pile
Length of section = 41.000000 ft

```
   Pile diameter                                          =    11.875000 in
   Shear capacity of section                              =       0.0000 lbs
```

Ground Slope and Pile Batter Angles

```
Ground Slope Angle                                        =        0.000 degrees
                                                          =        0.000 radians

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

Soil and Rock Layering Information

The soil profile is modelled using 4 layers

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

```
   Distance from top of pile to top of layer              =       0.0000 ft
   Distance from top of pile to bottom of layer           =     8.000000 ft
   Effective unit weight at top of layer                  =   122.000000 pcf
   Effective unit weight at bottom of layer               =   122.000000 pcf
   Friction angle at top of layer                         =    30.300000 deg.
   Friction angle at bottom of layer                      =    30.300000 deg.
   Subgrade k at top of layer                             =    80.000000 pci
   Subgrade k at bottom of layer                          =    80.000000 pci
```

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

```
   Distance from top of pile to top of layer              =     8.000000 ft
   Distance from top of pile to bottom of layer           =    27.000000 ft
   Effective unit weight at top of layer                  =    60.500000 pcf
   Effective unit weight at bottom of layer               =    60.500000 pcf
   Friction angle at top of layer                         =    31.500000 deg.
   Friction angle at bottom of layer                      =    31.500000 deg.
   Subgrade k at top of layer                             =    60.000000 pci
   Subgrade k at bottom of layer                          =    60.000000 pci
```

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

```
   Distance from top of pile to top of layer              =    27.000000 ft
```

Distance from top of pile to bottom of layer = 40.000000 ft
Effective unit weight at top of layer = 60.500000 pcf
Effective unit weight at bottom of layer = 60.500000 pcf
Friction angle at top of layer = 30.500000 deg.
Friction angle at bottom of layer = 30.500000 deg.
Subgrade k at top of layer = 55.000000 pci
Subgrade k at bottom of layer = 55.000000 pci

Layer 4 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer = 40.000000 ft
Distance from top of pile to bottom of layer = 55.000000 ft
Effective unit weight at top of layer = 87.600000 pcf
Effective unit weight at bottom of layer = 87.600000 pcf
Uniaxial compressive strength at top of layer = 500.000000 psi
Uniaxial compressive strength at bottom of layer = 500.000000 psi
Initial modulus of rock at top of layer = 1500000. psi
Initial modulus of rock at bottom of layer = 1500000. psi
RQD of rock at top of layer = 52.500000 %
RQD of rock at bottom of layer = 52.500000 %
k rm of rock at top of layer = 0.0001000
k rm of rock at bottom of layer = 0.0001000

(Depth of the lowest soil layer extends 14.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name or (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	Layer RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	122.0000	30.3000	--	--	--	80.0000	--
	(Reese, et al.)	8.0000	122.0000	30.3000	--	--	--	80.0000	--
2	Sand	8.0000	60.5000	31.5000	--	--	--	60.0000	--
	(Reese, et al.)	27.0000	60.5000	31.5000	--	--	--	60.0000	--
3	Sand	27.0000	60.5000	30.5000	--				

```
 --           --          55.0000       --
         (Reese, et al.)        40.0000      60.5000      30.5000       --
 --           --          55.0000       --
  4           Weak              40.0000      87.6000       --         500.0000
52.5000     1.00E-04       --         1500000.
              Rock              55.0000      87.6000       --         500.0000
52.5000     1.00E-04       --         1500000.
```

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition               Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                       2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       22900. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel Pipe Pile:

Length of Section	=	41.000000 ft
Outer Diameter of Pipe	=	11.875000 in
Pipe Wall Thickness	=	0.582000 in
Yield Stress of Pipe	=	80.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	20.648199 sq. in.
Moment of Inertia	=	330.037136 in^4
Elastic Bending Stiffness	=	9571077. kip-in^2
Plastic Modulus, Z	=	74.289249in^3
Plastic Moment Capacity = Fy Z	=	5943.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	1651.856 kips
Nominal Axial Tensile Capacity	=	-1651.856 kips

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

Number	Axial Thrust Force kips
1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	5900.

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

The value of the strength reduction factor depends on the provisions of the

LRFD code being followed.

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	47341.
2	8.0000	7.7176	Yes	No	47341.	835232.
3	27.0000	29.9773	Yes	No	882572.	871798.
4	40.0000	40.0000	No	Yes	N.A.	N.A.

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

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

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

Load Case	Load Type	Pile-head	Load Type	Pile-head	Axial Loading	Pile-head Deflection	Pile-head Rotation	Max Shear in Pile	Max Moment in Pile

```
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  1  V, lb     22900.  M, in-lb        0.00  1000.0000     1.0048   -0.01264
22900.   1171701.
```

Maximum pile-head deflection = 1.0047779372 inches
Maximum pile-head rotation   = -0.0126399502 radians = -0.724216 deg.

The analysis ended normally.

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

                   LPile for Windows, Version 2019-11.006

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

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--------------------------------------------------------------------------------
                            Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park
Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation
Package\

Name of input data file:
Pavilion HP12X53.lp11d

Name of output report file:
Pavilion HP12X53.lp11o

Name of plot output file:
Pavilion HP12X53.lp11p

Name of runtime message file:
Pavilion HP12X53.lp11r


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

```
--------------------------------------------------------------------------------

               Date:  February 23, 2021          Time:  15:50:30


--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: South Battery Park City Resiliency


Job Number: 17-NY165-01


Client: AECOM


Engineer: SG


Description:




--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

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

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 52.500 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.0000
2	52.500	12.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a H strong axis steel pile
Length of section = 52.500000 ft

```
   Pile width                                                =    12.000000 in
   Shear capacity of section                                 =       0.0000 lbs
```

Ground Slope and Pile Batter Angles

```
Ground Slope Angle                                           =        0.000 degrees
                                                             =        0.000 radians

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

Soil and Rock Layering Information

The soil profile is modelled using 6 layers

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

```
   Distance from top of pile to top of layer                 =       0.0000 ft
   Distance from top of pile to bottom of layer              =    10.000000 ft
   Effective unit weight at top of layer                     =   125.000000 pcf
   Effective unit weight at bottom of layer                  =   125.000000 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                                =   125.000000 pci
   Subgrade k at bottom of layer                             =   125.000000 pci
```

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

```
   Distance from top of pile to top of layer                 =    10.000000 ft
   Distance from top of pile to bottom of layer              =    15.000000 ft
   Effective unit weight at top of layer                     =    55.600000 pcf
   Effective unit weight at bottom of layer                  =    55.600000 pcf
   Friction angle at top of layer                            =    30.000000 deg.
   Friction angle at bottom of layer                         =    30.000000 deg.
   Subgrade k at top of layer                                =    50.000000 pci
   Subgrade k at bottom of layer                             =    50.000000 pci
```

Layer 3 is soft clay, p-y criteria by Matlock, 1970

```
   Distance from top of pile to top of layer                 =    15.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    32.500000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Undrained cohesion at top of layer                  =   159.000000 psf
   Undrained cohesion at bottom of layer               =   159.000000 psf
   Epsilon-50 at top of layer                          =     0.050000
   Epsilon-50 at bottom of layer                       =     0.050000


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

   Distance from top of pile to top of layer           =    32.500000 ft
   Distance from top of pile to bottom of layer        =    42.000000 ft
   Effective unit weight at top of layer               =    55.600000 pcf
   Effective unit weight at bottom of layer            =    55.600000 pcf
   Friction angle at top of layer                      =    31.000000 deg.
   Friction angle at bottom of layer                   =    31.000000 deg.
   Subgrade k at top of layer                          =    60.000000 pci
   Subgrade k at bottom of layer                       =    60.000000 pci


Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer           =    42.000000 ft
   Distance from top of pile to bottom of layer        =    51.500000 ft
   Effective unit weight at top of layer               =    42.600000 pcf
   Effective unit weight at bottom of layer            =    42.600000 pcf
   Undrained cohesion at top of layer                  =   300.000000 psf
   Undrained cohesion at bottom of layer               =   300.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


Layer 6 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    51.500000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    85.000000 pcf
   Effective unit weight at bottom of layer            =    85.000000 pcf
   Uniaxial compressive strength at top of layer       =   100.000000 psi
   Uniaxial compressive strength at bottom of layer    =   100.000000 psi
   Initial modulus of rock at top of layer             =       10000. psi
   Initial modulus of rock at bottom of layer          =       10000. psi
   RQD of rock at top of layer                         =    70.000000 %
   RQD of rock at bottom of layer                      =    70.000000 %
   k rm of rock at top of layer                        =    0.0005000
   k rm of rock at bottom of layer                     =    0.0005000


 (Depth of the lowest soil layer extends 12.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	34.0000	--	--	--	125.0000	--
	(Reese, et al.)	10.0000	125.0000	--	34.0000	--	--	--	125.0000	--
2	Sand	10.0000	55.6000	--	30.0000	--	--	--	50.0000	--
	(Reese, et al.)	15.0000	55.6000	--	30.0000	--	--	--	50.0000	--
3	Soft	15.0000	52.6000	159.0000	--	--	--	0.05000	--	--
	Clay	32.5000	52.6000	159.0000	--	--	--	0.05000	--	--
4	Sand	32.5000	55.6000	--	31.0000	--	--	--	60.0000	--
	(Reese, et al.)	42.0000	55.6000	--	31.0000	--	--	--	60.0000	--
5	Soft	42.0000	42.6000	300.0000	--	--	--	0.02000	--	--
	Clay	51.5000	42.6000	300.0000	--	--	--	0.02000	--	--
6	Weak	51.5000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.
	Rock	65.0000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 28500. lbs	M = 0.0000 in-lbs	1000.000000000	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 Steel H Strong Axis:

Length of Section	=	52.500000 ft
Flange Width	=	12.000000 in
Section Depth	=	11.800000 in
Flange Thickness	=	0.435000 in
Web Thickness	=	0.435000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	15.194550 sq. in.
Moment of Inertia	=	384.614130 in^4
Elastic Bending Stiffness	=	11153810. kip-in^2
Plastic Modulus, Z	=	72.317108in^3

Plastic Moment Capacity = Fy Z = 2603.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As = 547.004 kips
Nominal Axial Tensile Capacity = -547.004 kips

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

Number	Axial Thrust Force kips
1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	2595.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Top of Layer	Equivalent Top Depth	Same Layer	Layer is	F0	F1

Layer No.	Below Pile Head ft	Below Grnd Surf ft	Type As Layer Above	Rock or is Below Rock Layer	Integral for Layer lbs	Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	120429.
2	10.0000	11.2447	Yes	No	120429.	175026.
3	15.0000	208.2212	No	No	295455.	25043.
4	32.5000	18.4010	No	No	320498.	684104.
5	42.0000	374.7913	No	No	1004602.	27702.
6	51.5000	51.5000	No	Yes	N.A.	N.A.

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

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	28500.	M, in-lb	0.00	1000.0000	0.9925	-0.01287	28500.	1400444.

Maximum pile-head deflection = 0.9925406993 inches
Maximum pile-head rotation = -0.0128736237 radians = -0.737604 deg.

The analysis ended normally.

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Pavilion HP12X63.lp11d

Name of output report file:
Pavilion HP12X63.lp11o

Name of plot output file:
Pavilion HP12X63.lp11p

Name of runtime message file:
Pavilion HP12X63.lp11r

Date and Time of Analysis

Date: February 23, 2021   Time: 15:52:15

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 52.500 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.1000
2	52.500	12.1000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a H strong axis steel pile
Length of section = 52.500000 ft

```
   Pile width                                              =    12.100000 in
   Shear capacity of section                               =       0.0000 lbs



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

Ground Slope Angle                                         =        0.000 degrees
                                                           =        0.000 radians

Pile Batter Angle                                          =        0.000 degrees
                                                           =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 6 layers

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

   Distance from top of pile to top of layer               =       0.0000 ft
   Distance from top of pile to bottom of layer            =    10.000000 ft
   Effective unit weight at top of layer                   =   125.000000 pcf
   Effective unit weight at bottom of layer                =   125.000000 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                              =   125.000000 pci
   Subgrade k at bottom of layer                           =   125.000000 pci


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

   Distance from top of pile to top of layer               =    10.000000 ft
   Distance from top of pile to bottom of layer            =    15.000000 ft
   Effective unit weight at top of layer                   =    55.600000 pcf
   Effective unit weight at bottom of layer                =    55.600000 pcf
   Friction angle at top of layer                          =    30.000000 deg.
   Friction angle at bottom of layer                       =    30.000000 deg.
   Subgrade k at top of layer                              =    50.000000 pci
   Subgrade k at bottom of layer                           =    50.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer               =    15.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    32.500000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Undrained cohesion at top of layer                  =   159.000000 psf
   Undrained cohesion at bottom of layer               =   159.000000 psf
   Epsilon-50 at top of layer                          =     0.050000
   Epsilon-50 at bottom of layer                       =     0.050000


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

   Distance from top of pile to top of layer           =    32.500000 ft
   Distance from top of pile to bottom of layer        =    42.000000 ft
   Effective unit weight at top of layer               =    55.600000 pcf
   Effective unit weight at bottom of layer            =    55.600000 pcf
   Friction angle at top of layer                      =    31.000000 deg.
   Friction angle at bottom of layer                   =    31.000000 deg.
   Subgrade k at top of layer                          =    60.000000 pci
   Subgrade k at bottom of layer                       =    60.000000 pci


Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer           =    42.000000 ft
   Distance from top of pile to bottom of layer        =    51.500000 ft
   Effective unit weight at top of layer               =    42.600000 pcf
   Effective unit weight at bottom of layer            =    42.600000 pcf
   Undrained cohesion at top of layer                  =   300.000000 psf
   Undrained cohesion at bottom of layer               =   300.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


Layer 6 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    51.500000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    85.000000 pcf
   Effective unit weight at bottom of layer            =    85.000000 pcf
   Uniaxial compressive strength at top of layer       =   100.000000 psi
   Uniaxial compressive strength at bottom of layer    =   100.000000 psi
   Initial modulus of rock at top of layer             =       10000. psi
   Initial modulus of rock at bottom of layer          =       10000. psi
   RQD of rock at top of layer                         =    70.000000 %
   RQD of rock at bottom of layer                      =    70.000000 %
   k rm of rock at top of layer                        =    0.0005000
   k rm of rock at bottom of layer                     =    0.0005000


 (Depth of the lowest soil layer extends 12.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	34.0000	--	--	--	125.0000	--
	(Reese, et al.)	10.0000	125.0000	--	34.0000	--	--	--	125.0000	--
2	Sand	10.0000	55.6000	--	30.0000	--	--	--	50.0000	--
	(Reese, et al.)	15.0000	55.6000	--	30.0000	--	--	--	50.0000	--
3	Soft	15.0000	52.6000	159.0000	--	--	--	0.05000	--	--
	Clay	32.5000	52.6000	159.0000	--	--	--	0.05000	--	--
4	Sand	32.5000	55.6000	--	31.0000	--	--	--	60.0000	--
	(Reese, et al.)	42.0000	55.6000	--	31.0000	--	--	--	60.0000	--
5	Soft	42.0000	42.6000	300.0000	--	--	--	0.02000	--	--
	Clay	51.5000	42.6000	300.0000	--	--	--	0.02000	--	--
6	Weak	51.5000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.
	Rock	65.0000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition              Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                        2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   ----------------------   ----------------
---------------    ------------
   1     1     V =       31000. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel H Strong Axis:

Length of Section	=	52.500000 ft
Flange Width	=	12.100000 in
Section Depth	=	11.900000 in
Flange Thickness	=	0.515000 in
Web Thickness	=	0.515000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	18.061050 sq. in.
Moment of Inertia	=	459.254129 in^4
Elastic Bending Stiffness	=	13318370. kip-in^2
Plastic Modulus, Z	=	86.158328in^3

Plastic Moment Capacity = Fy Z = 3102.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As = 650.198 kips
Nominal Axial Tensile Capacity = -650.198 kips

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

Number	Axial Thrust Force kips
1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	3092.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Top of Layer	Equivalent Top Depth	Same Layer	Layer is	F0	F1

Layer No.	Below Pile Head ft	Below Grnd Surf ft	Type As Layer Above	Rock or is Below Rock Layer	Integral for Layer lbs	Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	120650.
2	10.0000	11.2451	Yes	No	120650.	176273.
3	15.0000	207.5383	No	No	296923.	25251.
4	32.5000	18.4284	No	No	322174.	688042.
5	42.0000	373.7937	No	No	1010216.	27933.
6	51.5000	51.5000	No	Yes	N.A.	N.A.

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

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	31000.	M, in-lb	0.00	1000.0000	1.0080	-0.01263	31000.	1575209.

Maximum pile-head deflection = 1.0080240268 inches
Maximum pile-head rotation = -0.0126309569 radians = -0.723701 deg.

The analysis ended normally.

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Pavilion HP12X74.lp11d

Name of output report file:
Pavilion HP12X74.lp11o

Name of plot output file:
Pavilion HP12X74.lp11p

Name of runtime message file:
Pavilion HP12X74.lp11r

Date and Time of Analysis

Date: February 23, 2021   Time: 15:57:09

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:
- Maximum number of iterations allowed = 500
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 100.0000 in
- Number of pile increments = 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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 52.500 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.2000
2	52.500	12.2000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a H strong axis steel pile
Length of section = 52.500000 ft

```
   Pile width                                             =    12.200000 in
   Shear capacity of section                              =       0.0000 lbs



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

Ground Slope Angle                                        =        0.000 degrees
                                                          =        0.000 radians

Pile Batter Angle                                         =        0.000 degrees
                                                          =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 6 layers

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

   Distance from top of pile to top of layer              =       0.0000 ft
   Distance from top of pile to bottom of layer           =    10.000000 ft
   Effective unit weight at top of layer                  =   125.000000 pcf
   Effective unit weight at bottom of layer               =   125.000000 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                             =   125.000000 pci
   Subgrade k at bottom of layer                          =   125.000000 pci


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

   Distance from top of pile to top of layer              =    10.000000 ft
   Distance from top of pile to bottom of layer           =    15.000000 ft
   Effective unit weight at top of layer                  =    55.600000 pcf
   Effective unit weight at bottom of layer               =    55.600000 pcf
   Friction angle at top of layer                         =    30.000000 deg.
   Friction angle at bottom of layer                      =    30.000000 deg.
   Subgrade k at top of layer                             =    50.000000 pci
   Subgrade k at bottom of layer                          =    50.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer              =    15.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    32.500000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Undrained cohesion at top of layer                  =   159.000000 psf
   Undrained cohesion at bottom of layer               =   159.000000 psf
   Epsilon-50 at top of layer                          =     0.050000
   Epsilon-50 at bottom of layer                       =     0.050000


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

   Distance from top of pile to top of layer           =    32.500000 ft
   Distance from top of pile to bottom of layer        =    42.000000 ft
   Effective unit weight at top of layer               =    55.600000 pcf
   Effective unit weight at bottom of layer            =    55.600000 pcf
   Friction angle at top of layer                      =    31.000000 deg.
   Friction angle at bottom of layer                   =    31.000000 deg.
   Subgrade k at top of layer                          =    60.000000 pci
   Subgrade k at bottom of layer                       =    60.000000 pci


Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer           =    42.000000 ft
   Distance from top of pile to bottom of layer        =    51.500000 ft
   Effective unit weight at top of layer               =    42.600000 pcf
   Effective unit weight at bottom of layer            =    42.600000 pcf
   Undrained cohesion at top of layer                  =   300.000000 psf
   Undrained cohesion at bottom of layer               =   300.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


Layer 6 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    51.500000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    85.000000 pcf
   Effective unit weight at bottom of layer            =    85.000000 pcf
   Uniaxial compressive strength at top of layer       =   100.000000 psi
   Uniaxial compressive strength at bottom of layer    =   100.000000 psi
   Initial modulus of rock at top of layer             =       10000. psi
   Initial modulus of rock at bottom of layer          =       10000. psi
   RQD of rock at top of layer                         =    70.000000 %
   RQD of rock at bottom of layer                      =    70.000000 %
   k rm of rock at top of layer                        =    0.0005000
   k rm of rock at bottom of layer                     =    0.0005000


 (Depth of the lowest soil layer extends 12.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	34.0000	--	--	--	125.0000	--
	(Reese, et al.)	10.0000	125.0000	--	34.0000	--	--	--	125.0000	--
2	Sand	10.0000	55.6000	--	30.0000	--	--	--	50.0000	--
	(Reese, et al.)	15.0000	55.6000	--	30.0000	--	--	--	50.0000	--
3	Soft	15.0000	52.6000	159.0000	--	--	--	0.05000	--	--
	Clay	32.5000	52.6000	159.0000	--	--	--	0.05000	--	--
4	Sand	32.5000	55.6000	--	31.0000	--	--	--	60.0000	--
	(Reese, et al.)	42.0000	55.6000	--	31.0000	--	--	--	60.0000	--
5	Soft	42.0000	42.6000	300.0000	--	--	--	0.02000	--	--
	Clay	51.5000	42.6000	300.0000	--	--	--	0.02000	--	--
6	Weak	51.5000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.
	Rock	65.0000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition                Condition            Axial Thrust
Compute Top y     Run Analysis
 No.    Type           1                        2                  Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       33500. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel H Strong Axis:

Length of Section	=	52.500000 ft
Flange Width	=	12.200000 in
Section Depth	=	12.100000 in
Flange Thickness	=	0.610000 in
Web Thickness	=	0.605000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	21.466400 sq. in.
Moment of Inertia	=	556.640624 in^4
Elastic Bending Stiffness	=	16142578. kip-in^2
Plastic Modulus, Z	=	103.412708in^3

```
Plastic Moment Capacity = Fy Z                            =        3723.in-kip

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = Fy As                    =      772.790 kips
Nominal Axial Tensile Capacity                            =     -772.790 kips



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

   Number     Axial Thrust Force
                   kips
   ------     ------------------
      1              1.000


--------------------------------------------------------------------------------
   Summary of Results for Nominal Moment Capacity for Section 1
--------------------------------------------------------------------------------

                                            Nominal
Load               Axial                    Moment
 No.              Thrust                   Capacity
                   kips                     in-kips
----         ----------------          ----------------
  1             1.0000000000                     3712.
```

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

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

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

```
--------------------------------------------------------------------------------
           Layering Correction Equivalent Depths of Soil & Rock Layers
--------------------------------------------------------------------------------

         Top of    Equivalent
          Layer     Top Depth  Same Layer  Layer is        F0          F1
```

Layer No.	Below Pile Head ft	Below Grnd Surf ft	Type As Layer Above	Rock or is Below Rock Layer	Integral for Layer lbs	Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	120874.
2	10.0000	11.2455	Yes	No	120874.	177492.
3	15.0000	206.8495	No	No	298366.	25460.
4	32.5000	18.4551	No	No	323825.	691910.
5	42.0000	372.7782	No	No	1015735.	28164.
6	51.5000	51.5000	No	Yes	N.A.	N.A.

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

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	33500.	M, in-lb	0.00	1000.0000	1.0044	-0.01215	33500.	1759707.

Maximum pile-head deflection = 1.0044032367 inches
Maximum pile-head rotation = -0.0121465137 radians = -0.695944 deg.

The analysis ended normally.

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Pavilion HP12X84.lp11d

Name of output report file:
Pavilion HP12X84.lp11o

Name of plot output file:
Pavilion HP12X84.lp11p

Name of runtime message file:
Pavilion HP12X84.lp11r

Date and Time of Analysis

Date: February 23, 2021   Time: 15:56:28

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 52.500 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.3000
2	52.500	12.3000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a H strong axis steel pile
Length of section = 52.500000 ft

```
   Pile width                                              =    12.300000 in
   Shear capacity of section                               =       0.0000 lbs
```

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

Ground Slope Angle                                         =        0.000 degrees
                                                           =        0.000 radians

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

```
--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 6 layers

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

   Distance from top of pile to top of layer               =       0.0000 ft
   Distance from top of pile to bottom of layer            =    10.000000 ft
   Effective unit weight at top of layer                   =   125.000000 pcf
   Effective unit weight at bottom of layer                =   125.000000 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                              =   125.000000 pci
   Subgrade k at bottom of layer                           =   125.000000 pci


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

   Distance from top of pile to top of layer               =    10.000000 ft
   Distance from top of pile to bottom of layer            =    15.000000 ft
   Effective unit weight at top of layer                   =    55.600000 pcf
   Effective unit weight at bottom of layer                =    55.600000 pcf
   Friction angle at top of layer                          =    30.000000 deg.
   Friction angle at bottom of layer                       =    30.000000 deg.
   Subgrade k at top of layer                              =    50.000000 pci
   Subgrade k at bottom of layer                           =    50.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer               =    15.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    32.500000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Undrained cohesion at top of layer                  =   159.000000 psf
   Undrained cohesion at bottom of layer               =   159.000000 psf
   Epsilon-50 at top of layer                          =     0.050000
   Epsilon-50 at bottom of layer                       =     0.050000


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

   Distance from top of pile to top of layer           =    32.500000 ft
   Distance from top of pile to bottom of layer        =    42.000000 ft
   Effective unit weight at top of layer               =    55.600000 pcf
   Effective unit weight at bottom of layer            =    55.600000 pcf
   Friction angle at top of layer                      =    31.000000 deg.
   Friction angle at bottom of layer                   =    31.000000 deg.
   Subgrade k at top of layer                          =    60.000000 pci
   Subgrade k at bottom of layer                       =    60.000000 pci


Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer           =    42.000000 ft
   Distance from top of pile to bottom of layer        =    51.500000 ft
   Effective unit weight at top of layer               =    42.600000 pcf
   Effective unit weight at bottom of layer            =    42.600000 pcf
   Undrained cohesion at top of layer                  =   300.000000 psf
   Undrained cohesion at bottom of layer               =   300.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


Layer 6 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    51.500000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    85.000000 pcf
   Effective unit weight at bottom of layer            =    85.000000 pcf
   Uniaxial compressive strength at top of layer       =   100.000000 psi
   Uniaxial compressive strength at bottom of layer    =   100.000000 psi
   Initial modulus of rock at top of layer             =       10000. psi
   Initial modulus of rock at bottom of layer          =       10000. psi
   RQD of rock at top of layer                         =    70.000000 %
   RQD of rock at bottom of layer                      =    70.000000 %
   k rm of rock at top of layer                        =    0.0005000
   k rm of rock at bottom of layer                     =    0.0005000


 (Depth of the lowest soil layer extends 12.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	34.0000	--	--	--	125.0000	--
	(Reese, et al.)	10.0000	125.0000	--	34.0000	--	--	--	125.0000	--
2	Sand	10.0000	55.6000	--	30.0000	--	--	--	50.0000	--
	(Reese, et al.)	15.0000	55.6000	--	30.0000	--	--	--	50.0000	--
3	Soft	15.0000	52.6000	159.0000	--	--	--	0.05000	--	--
	Clay	32.5000	52.6000	159.0000	--	--	--	0.05000	--	--
4	Sand	32.5000	55.6000	--	31.0000	--	--	--	60.0000	--
	(Reese, et al.)	42.0000	55.6000	--	31.0000	--	--	--	60.0000	--
5	Soft	42.0000	42.6000	300.0000	--	--	--	0.02000	--	--
	Clay	51.5000	42.6000	300.0000	--	--	--	0.02000	--	--
6	Weak	51.5000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.
	Rock	65.0000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 35500. lbs	M = 0.0000 in-lbs	1000.000000000	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 Steel H Strong Axis:

Length of Section	=	52.500000 ft
Flange Width	=	12.300000 in
Section Depth	=	12.300000 in
Flange Thickness	=	0.685000 in
Web Thickness	=	0.685000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	24.338050 sq. in.
Moment of Inertia	=	643.530174 in^4
Elastic Bending Stiffness	=	18662375. kip-in^2
Plastic Modulus, Z	=	118.320547in^3

Plastic Moment Capacity = Fy Z = 4260.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As = 876.170 kips
Nominal Axial Tensile Capacity = -876.170 kips

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

Number	Axial Thrust Force kips
1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	4246.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Top of Layer	Equivalent Top Depth	Same Layer	Layer is	F0	F1

Layer No.	Below Pile Head ft	Below Grnd Surf ft	Type As Layer Above	Rock or is Below Rock Layer	Integral for Layer lbs	Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	121101.
2	10.0000	11.2460	Yes	No	121101.	178684.
3	15.0000	206.1558	No	No	299785.	25669.
4	32.5000	18.4812	No	No	325453.	695723.
5	42.0000	371.7508	No	No	1021176.	28395.
6	51.5000	51.5000	No	Yes	N.A.	N.A.

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

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	35500.	M, in-lb	0.00	1000.0000	1.0020	-0.01180	35500.	1910706.

Maximum pile-head deflection = 1.0019722392 inches
Maximum pile-head rotation = -0.0118012343 radians = -0.676161 deg.

The analysis ended normally.

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

                   LPile for Windows, Version 2019-11.006

               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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park
Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation
Package\

Name of input data file:
Pavilion Micropile9.625 inch OD- 0.5 inch Wall.lp11d

Name of output report file:
Pavilion Micropile9.625 inch OD- 0.5 inch Wall.lp11o

Name of plot output file:
Pavilion Micropile9.625 inch OD- 0.5 inch Wall.lp11p

Name of runtime message file:
Pavilion Micropile9.625 inch OD- 0.5 inch Wall.lp11r


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

Date: February 23, 2021   Time: 16:00:45

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 52.500 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	9.6250
2	52.500	9.6250

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a drilled shaft with permanent casing
Length of section = 52.500000 ft

```
   Casing outside diameter                              =     9.625000 in
   Shear capacity of section                            =       0.0000 lbs



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

Ground Slope Angle                                      =        0.000 degrees
                                                        =        0.000 radians

Pile Batter Angle                                       =        0.000 degrees
                                                        =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 6 layers

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

   Distance from top of pile to top of layer            =       0.0000 ft
   Distance from top of pile to bottom of layer         =    10.000000 ft
   Effective unit weight at top of layer                =   125.000000 pcf
   Effective unit weight at bottom of layer             =   125.000000 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                           =   125.000000 pci
   Subgrade k at bottom of layer                        =   125.000000 pci


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

   Distance from top of pile to top of layer            =    10.000000 ft
   Distance from top of pile to bottom of layer         =    15.000000 ft
   Effective unit weight at top of layer                =    55.600000 pcf
   Effective unit weight at bottom of layer             =    55.600000 pcf
   Friction angle at top of layer                       =    30.000000 deg.
   Friction angle at bottom of layer                    =    30.000000 deg.
   Subgrade k at top of layer                           =    50.000000 pci
   Subgrade k at bottom of layer                        =    50.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer            =    15.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    32.500000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Undrained cohesion at top of layer                  =   159.000000 psf
   Undrained cohesion at bottom of layer               =   159.000000 psf
   Epsilon-50 at top of layer                          =     0.050000
   Epsilon-50 at bottom of layer                       =     0.050000


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

   Distance from top of pile to top of layer           =    32.500000 ft
   Distance from top of pile to bottom of layer        =    42.000000 ft
   Effective unit weight at top of layer               =    55.600000 pcf
   Effective unit weight at bottom of layer            =    55.600000 pcf
   Friction angle at top of layer                      =    31.000000 deg.
   Friction angle at bottom of layer                   =    31.000000 deg.
   Subgrade k at top of layer                          =    60.000000 pci
   Subgrade k at bottom of layer                       =    60.000000 pci


Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer           =    42.000000 ft
   Distance from top of pile to bottom of layer        =    51.500000 ft
   Effective unit weight at top of layer               =    42.600000 pcf
   Effective unit weight at bottom of layer            =    42.600000 pcf
   Undrained cohesion at top of layer                  =   300.000000 psf
   Undrained cohesion at bottom of layer               =   300.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


Layer 6 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    51.500000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    85.000000 pcf
   Effective unit weight at bottom of layer            =    85.000000 pcf
   Uniaxial compressive strength at top of layer       =   100.000000 psi
   Uniaxial compressive strength at bottom of layer    =   100.000000 psi
   Initial modulus of rock at top of layer             =       10000. psi
   Initial modulus of rock at bottom of layer          =       10000. psi
   RQD of rock at top of layer                         =    70.000000 %
   RQD of rock at bottom of layer                      =    70.000000 %
   k rm of rock at top of layer                        =    0.0005000
   k rm of rock at bottom of layer                     =    0.0005000


 (Depth of the lowest soil layer extends 12.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	34.0000	--	--	--	125.0000	--
	(Reese, et al.)	10.0000	125.0000	--	34.0000	--	--	--	125.0000	--
2	Sand	10.0000	55.6000	--	30.0000	--	--	--	50.0000	--
	(Reese, et al.)	15.0000	55.6000	--	30.0000	--	--	--	50.0000	--
3	Soft	15.0000	52.6000	159.0000	--	--	--	0.05000	--	--
	Clay	32.5000	52.6000	159.0000	--	--	--	0.05000	--	--
4	Sand	32.5000	55.6000	--	31.0000	--	--	--	60.0000	--
	(Reese, et al.)	42.0000	55.6000	--	31.0000	--	--	--	60.0000	--
5	Soft	42.0000	42.6000	300.0000	--	--	--	0.02000	--	--
	Clay	51.5000	42.6000	300.0000	--	--	--	0.02000	--	--
6	Weak	51.5000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.
	Rock	65.0000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.

Static Loading Type

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

```
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------

Number of loads specified = 1

Load    Load         Condition                Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                        2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       19300. lbs   M =       0.0000 in-lbs    1000.000000000
    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) with Permanent Casing:
------------------------------------------------------------------------------

Length of Section                                       =    52.500000 ft
Outer Diameter of Casing                                =     9.625000 in
Concrete Cover Thickness Inside Casing                  =     3.000000 in
Casing Wall Thickness                                   =     0.500000 in
Moment of Inertia of Steel Casing                       =   149.634073 in^4
Yield Stress of Casing                                  =       45000. psi
Elastic Modulus of Casing                               =    29000000. psi
Number of Reinforcing Bars                              =            1 bar
Area of Single Reinforcing Bar                          =     0.440000 sq. in.
Edge-to-Edge Bar Spacing                                =    -0.750000 in
Maximum Concrete Aggregate Size                         =     0.750000 in
```

```
Ratio of Bar Spacing to Aggregate Size                     =        -1.00
Offset of Center of Rebar Cage from Center of Pile         =       0.0000 in
Yield Stress of Reinforcing Bars                           =       60000. psi
Modulus of Elasticity of Reinforcing Bars                  =    29000000. psi
Gross Area of Pile                                         =    72.759777 sq. in.
Area of Concrete                                           =    57.986260 sq. in.
Cross-sectional Area of Steel Casing                       =    14.333516 sq. in.
Area of All Steel (Casing and Bars)                        =    14.773516 sq. in.
Area Ratio of All Steel to Gross Area of Pile              =        20.30 percent
```

Axial Structural Capacities:

```
Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As        =      843.917 kips
Tensile Load for Cracking of Concrete                      =      -72.150 kips
Nominal Axial Tensile Capacity                             =     -671.408 kips
```

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	0.750000	0.440000	0.00000	0.00000

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

Concrete Properties:

```
Compressive Strength of Concrete                           =        3500. psi
Modulus of Elasticity of Concrete                          =     3372165. psi
Modulus of Rupture of Concrete                             =  -443.705984 psi
Compression Strain at Peak Stress                          =     0.001764
Tensile Strain at Fracture of Concrete                     =   -0.0001156
Maximum Coarse Aggregate Size                              =     0.750000 in
```

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

Number	Axial Thrust Force kips
1	1.000

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
1	1.000	1935.389	0.00300000

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

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

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

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

Axial 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	1.000000	1935.	0.650000	1258.	4714973.
1	0.75	1.000000	1935.	0.750000	1452.	4700121.
1	0.90	1.000000	1935.	0.900000	1742.	4251521.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer	Top of Layer Below	Equivalent Top Depth Below	Same Layer Type As	Layer is Rock or	F0 Integral	F1 Integral

No.	Pile Head ft	Grnd Surf ft	Layer Above	is Below Rock Layer	for Layer lbs	for Layer lbs
1	0.00	0.00	N.A.	No	0.00	115457.
2	10.0000	11.2405	Yes	No	115457.	141028.
3	15.0000	225.0438	No	No	256485.	20086.
4	32.5000	17.7289	No	No	276571.	577492.
5	42.0000	396.6993	No	No	854063.	22219.
6	51.5000	51.5000	No	Yes	N.A.	N.A.

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

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	19300.	M, in-lb	0.00	1000.0000	1.0022	-0.01516	19300.	846003.

Maximum pile-head deflection = 1.0022094667 inches
Maximum pile-head rotation = -0.0151596688 radians = -0.868585 deg.

The analysis ended normally.

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\

Name of input data file:
Pavilion Micropile9.625 inch OD- 0.545 inch Wall.lp11d

Name of output report file:
Pavilion Micropile9.625 inch OD- 0.545 inch Wall.lp11o

Name of plot output file:
Pavilion Micropile9.625 inch OD- 0.545 inch Wall.lp11p

Name of runtime message file:
Pavilion Micropile9.625 inch OD- 0.545 inch Wall.lp11r

Date and Time of Analysis

```
--------------------------------------------------------------------------------

               Date:  February 23, 2021          Time:  16:03:15


--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: South Battery Park City Resiliency



Job Number: 17-NY165-01



Client: AECOM



Engineer: SG



Description:





--------------------------------------------------------------------------------
                          Program Options and Settings
--------------------------------------------------------------------------------

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

Analysis Control Options:
 - Maximum number of iterations allowed                =          500
 - Deflection tolerance for convergence                =   1.0000E-05 in
 - Maximum allowable deflection                        =     100.0000 in
 - Number of pile increments                           =          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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 52.500 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	9.6250
2	52.500	9.6250

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a drilled shaft with permanent casing
Length of section = 52.500000 ft

```
   Casing outside diameter                                =     9.625000 in
   Shear capacity of section                              =       0.0000 lbs



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

Ground Slope Angle                                        =        0.000 degrees
                                                          =        0.000 radians

Pile Batter Angle                                         =        0.000 degrees
                                                          =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 6 layers

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

   Distance from top of pile to top of layer              =       0.0000 ft
   Distance from top of pile to bottom of layer           =    10.000000 ft
   Effective unit weight at top of layer                  =   125.000000 pcf
   Effective unit weight at bottom of layer               =   125.000000 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                             =   125.000000 pci
   Subgrade k at bottom of layer                          =   125.000000 pci


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

   Distance from top of pile to top of layer              =    10.000000 ft
   Distance from top of pile to bottom of layer           =    15.000000 ft
   Effective unit weight at top of layer                  =    55.600000 pcf
   Effective unit weight at bottom of layer               =    55.600000 pcf
   Friction angle at top of layer                         =    30.000000 deg.
   Friction angle at bottom of layer                      =    30.000000 deg.
   Subgrade k at top of layer                             =    50.000000 pci
   Subgrade k at bottom of layer                          =    50.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer              =    15.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    32.500000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Undrained cohesion at top of layer                  =   159.000000 psf
   Undrained cohesion at bottom of layer               =   159.000000 psf
   Epsilon-50 at top of layer                          =     0.050000
   Epsilon-50 at bottom of layer                       =     0.050000


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

   Distance from top of pile to top of layer           =    32.500000 ft
   Distance from top of pile to bottom of layer        =    42.000000 ft
   Effective unit weight at top of layer               =    55.600000 pcf
   Effective unit weight at bottom of layer            =    55.600000 pcf
   Friction angle at top of layer                      =    31.000000 deg.
   Friction angle at bottom of layer                   =    31.000000 deg.
   Subgrade k at top of layer                          =    60.000000 pci
   Subgrade k at bottom of layer                       =    60.000000 pci


Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer           =    42.000000 ft
   Distance from top of pile to bottom of layer        =    51.500000 ft
   Effective unit weight at top of layer               =    42.600000 pcf
   Effective unit weight at bottom of layer            =    42.600000 pcf
   Undrained cohesion at top of layer                  =   300.000000 psf
   Undrained cohesion at bottom of layer               =   300.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


Layer 6 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    51.500000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    85.000000 pcf
   Effective unit weight at bottom of layer            =    85.000000 pcf
   Uniaxial compressive strength at top of layer       =   100.000000 psi
   Uniaxial compressive strength at bottom of layer    =   100.000000 psi
   Initial modulus of rock at top of layer             =       10000. psi
   Initial modulus of rock at bottom of layer          =       10000. psi
   RQD of rock at top of layer                         =    70.000000 %
   RQD of rock at bottom of layer                      =    70.000000 %
   k rm of rock at top of layer                        =    0.0005000
   k rm of rock at bottom of layer                     =    0.0005000


 (Depth of the lowest soil layer extends 12.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	34.0000	--	--	--	125.0000	--
	(Reese, et al.)	10.0000	125.0000	--	34.0000	--	--	--	125.0000	--
2	Sand	10.0000	55.6000	--	30.0000	--	--	--	50.0000	--
	(Reese, et al.)	15.0000	55.6000	--	30.0000	--	--	--	50.0000	--
3	Soft	15.0000	52.6000	159.0000	--	--	--	0.05000	--	--
	Clay	32.5000	52.6000	159.0000	--	--	--	0.05000	--	--
4	Sand	32.5000	55.6000	--	31.0000	--	--	--	60.0000	--
	(Reese, et al.)	42.0000	55.6000	--	31.0000	--	--	--	60.0000	--
5	Soft	42.0000	42.6000	300.0000	--	--	--	0.02000	--	--
	Clay	51.5000	42.6000	300.0000	--	--	--	0.02000	--	--
6	Weak	51.5000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.
	Rock	65.0000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.

Static Loading Type

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

```
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------

Number of loads specified = 1

Load    Load         Condition               Condition            Axial Thrust
Compute Top y     Run Analysis
 No.    Type           1                         2                  Force, lbs
vs. Pile Length
-----   ----   --------------------   ----------------------   ----------------
---------------    ------------
   1     1     V =       20000. lbs   M =       0.0000 in-lbs    1000.000000000
    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) with Permanent Casing:
------------------------------------------------------------------------------

Length of Section                                        =    52.500000 ft
Outer Diameter of Casing                                 =     9.625000 in
Concrete Cover Thickness Inside Casing                   =     3.000000 in
Casing Wall Thickness                                    =     0.545000 in
Moment of Inertia of Steel Casing                        =   160.796181 in^4
Yield Stress of Casing                                   =       45000. psi
Elastic Modulus of Casing                                =    29000000. psi
Number of Reinforcing Bars                               =            1 bar
Area of Single Reinforcing Bar                           =     0.440000 sq. in.
Edge-to-Edge Bar Spacing                                 =    -0.750000 in
Maximum Concrete Aggregate Size                          =     0.750000 in
```

```
Ratio of Bar Spacing to Aggregate Size                      =        -1.00
Offset of Center of Rebar Cage from Center of Pile          =       0.0000 in
Yield Stress of Reinforcing Bars                            =       60000. psi
Modulus of Elasticity of Reinforcing Bars                   =    29000000. psi
Gross Area of Pile                                          =    72.759777 sq. in.
Area of Concrete                                            =    56.773291 sq. in.
Cross-sectional Area of Steel Casing                        =    15.546485 sq. in.
Area of All Steel (Casing and Bars)                         =    15.986485 sq. in.
Area Ratio of All Steel to Gross Area of Pile               =        21.97 percent
```

Axial Structural Capacities:

```
Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As         =      894.892 kips
Tensile Load for Cracking of Concrete                       =      -75.745 kips
Nominal Axial Tensile Capacity                              =     -725.992 kips
```

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	0.750000	0.440000	0.00000	0.00000

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

Concrete Properties:

```
Compressive Strength of Concrete                            =        3500. psi
Modulus of Elasticity of Concrete                           =     3372165. psi
Modulus of Rupture of Concrete                              =  -443.705984 psi
Compression Strain at Peak Stress                           =     0.001764
Tensile Strain at Fracture of Concrete                      =   -0.0001156
Maximum Coarse Aggregate Size                               =     0.750000 in
```

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

Number	Axial Thrust Force kips
1	1.000

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
1	1.000	2073.238	0.00300000

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

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

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

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

Axial 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	1.000000	2073.	0.650000	1348.	5027489.
1	0.75	1.000000	2073.	0.750000	1555.	5012696.
1	0.90	1.000000	2073.	0.900000	1866.	4557862.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer	Top of Layer Below	Equivalent Top Depth Below	Same Layer Type As	Layer is Rock or	F0 Integral	F1 Integral

No.	Pile Head ft	Grnd Surf ft	Layer Above	is Below Rock Layer	for Layer lbs	for Layer lbs
1	0.00	0.00	N.A.	No	0.00	115457.
2	10.0000	11.2405	Yes	No	115457.	141028.
3	15.0000	225.0438	No	No	256485.	20086.
4	32.5000	17.7289	No	No	276571.	577492.
5	42.0000	396.6993	No	No	854063.	22219.
6	51.5000	51.5000	No	Yes	N.A.	N.A.

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

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	20000.	M, in-lb	0.00	1000.0000	1.0143	-0.01515	20000.	889070.

Maximum pile-head deflection = 1.0143043260 inches
Maximum pile-head rotation = -0.0151540645 radians = -0.868264 deg.

The analysis ended normally.

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

                    LPile for Windows, Version 2019-11.006

                  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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park
Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation
Package\

Name of input data file:
Pavilion Micropile 11.875 inch OD 0.582inch Wall.lp11d

Name of output report file:
Pavilion Micropile 11.875 inch OD 0.582inch Wall.lp11o

Name of plot output file:
Pavilion Micropile 11.875 inch OD 0.582inch Wall.lp11p

Name of runtime message file:
Pavilion Micropile 11.875 inch OD 0.582inch Wall.lp11r


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

Date: February 23, 2021   Time: 16:04:36

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
 - Conventional Analysis

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 52.500 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	11.8750
2	52.500	11.8750

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a drilled shaft with permanent casing
Length of section = 52.500000 ft

```
   Casing outside diameter                               =    11.875000 in
   Shear capacity of section                             =       0.0000 lbs



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

Ground Slope Angle                                       =        0.000 degrees
                                                         =        0.000 radians

Pile Batter Angle                                        =        0.000 degrees
                                                         =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 6 layers

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

   Distance from top of pile to top of layer             =       0.0000 ft
   Distance from top of pile to bottom of layer          =    10.000000 ft
   Effective unit weight at top of layer                 =   125.000000 pcf
   Effective unit weight at bottom of layer              =   125.000000 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                            =   125.000000 pci
   Subgrade k at bottom of layer                         =   125.000000 pci


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

   Distance from top of pile to top of layer             =    10.000000 ft
   Distance from top of pile to bottom of layer          =    15.000000 ft
   Effective unit weight at top of layer                 =    55.600000 pcf
   Effective unit weight at bottom of layer              =    55.600000 pcf
   Friction angle at top of layer                        =    30.000000 deg.
   Friction angle at bottom of layer                     =    30.000000 deg.
   Subgrade k at top of layer                            =    50.000000 pci
   Subgrade k at bottom of layer                         =    50.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer             =    15.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    32.500000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Undrained cohesion at top of layer                  =   159.000000 psf
   Undrained cohesion at bottom of layer               =   159.000000 psf
   Epsilon-50 at top of layer                          =     0.050000
   Epsilon-50 at bottom of layer                       =     0.050000


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

   Distance from top of pile to top of layer           =    32.500000 ft
   Distance from top of pile to bottom of layer        =    42.000000 ft
   Effective unit weight at top of layer               =    55.600000 pcf
   Effective unit weight at bottom of layer            =    55.600000 pcf
   Friction angle at top of layer                      =    31.000000 deg.
   Friction angle at bottom of layer                   =    31.000000 deg.
   Subgrade k at top of layer                          =    60.000000 pci
   Subgrade k at bottom of layer                       =    60.000000 pci


Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer           =    42.000000 ft
   Distance from top of pile to bottom of layer        =    51.500000 ft
   Effective unit weight at top of layer               =    42.600000 pcf
   Effective unit weight at bottom of layer            =    42.600000 pcf
   Undrained cohesion at top of layer                  =   300.000000 psf
   Undrained cohesion at bottom of layer               =   300.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


Layer 6 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    51.500000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    85.000000 pcf
   Effective unit weight at bottom of layer            =    85.000000 pcf
   Uniaxial compressive strength at top of layer       =   100.000000 psi
   Uniaxial compressive strength at bottom of layer    =   100.000000 psi
   Initial modulus of rock at top of layer             =       10000. psi
   Initial modulus of rock at bottom of layer          =       10000. psi
   RQD of rock at top of layer                         =    70.000000 %
   RQD of rock at bottom of layer                      =    70.000000 %
   k rm of rock at top of layer                        =    0.0005000
   k rm of rock at bottom of layer                     =    0.0005000


 (Depth of the lowest soil layer extends 12.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	34.0000	--	--	--	125.0000	--
	(Reese, et al.)	10.0000	125.0000	--	34.0000	--	--	--	125.0000	--
2	Sand	10.0000	55.6000	--	30.0000	--	--	--	50.0000	--
	(Reese, et al.)	15.0000	55.6000	--	30.0000	--	--	--	50.0000	--
3	Soft	15.0000	52.6000	159.0000	--	--	--	0.05000	--	--
	Clay	32.5000	52.6000	159.0000	--	--	--	0.05000	--	--
4	Sand	32.5000	55.6000	--	31.0000	--	--	--	60.0000	--
	(Reese, et al.)	42.0000	55.6000	--	31.0000	--	--	--	60.0000	--
5	Soft	42.0000	42.6000	300.0000	--	--	--	0.02000	--	--
	Clay	51.5000	42.6000	300.0000	--	--	--	0.02000	--	--
6	Weak	51.5000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.
	Rock	65.0000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

```
Load    Load         Condition              Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                       2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   ----------------------   ----------------
---------------    ------------
   1     1     V =       28000. lbs   M =       0.0000 in-lbs    1000.000000000
    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) with Permanent Casing:

```
Length of Section                                        =    52.500000 ft
Outer Diameter of Casing                                 =    11.875000 in
Concrete Cover Thickness Inside Casing                   =     3.000000 in
Casing Wall Thickness                                    =     0.582000 in
Moment of Inertia of Steel Casing                        =   330.037136 in^4
Yield Stress of Casing                                   =       80000. psi
Elastic Modulus of Casing                                =    29000000. psi
Number of Reinforcing Bars                               =            1 bar
Area of Single Reinforcing Bar                           =     0.440000 sq. in.
Edge-to-Edge Bar Spacing                                 =    -0.750000 in
Maximum Concrete Aggregate Size                          =     0.750000 in
```

```
Ratio of Bar Spacing to Aggregate Size                    =        -1.00
Offset of Center of Rebar Cage from Center of Pile        =       0.0000 in
Yield Stress of Reinforcing Bars                          =       60000. psi
Modulus of Elasticity of Reinforcing Bars                 =    29000000. psi
Gross Area of Pile                                        =   110.753413 sq. in.
Area of Concrete                                          =    89.665213 sq. in.
Cross-sectional Area of Steel Casing                      =    20.648199 sq. in.
Area of All Steel (Casing and Bars)                       =    21.088199 sq. in.
Area Ratio of All Steel to Gross Area of Pile             =        19.04 percent

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As       =     1945.010 kips
Tensile Load for Cracking of Concrete                     =     -105.678 kips
Nominal Axial Tensile Capacity                            =    -1678.256 kips


Reinforcing Bar Dimensions and Positions Used in Computations:

     Bar          Bar Diam.      Bar Area          X              Y
    Number         inches        sq. in.        inches         inches
  ----------     ----------     ----------     ----------     ----------
      1           0.750000       0.440000        0.00000        0.00000


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


Concrete Properties:
--------------------

Compressive Strength of Concrete                          =        3500. psi
Modulus of Elasticity of Concrete                         =     3372165. psi
Modulus of Rupture of Concrete                            =  -443.705984 psi
Compression Strain at Peak Stress                         =     0.001764
Tensile Strain at Fracture of Concrete                    =   -0.0001156
Maximum Coarse Aggregate Size                             =     0.750000 in


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

   Number     Axial Thrust Force
                   kips
   ------     ------------------
      1             1.000


--------------------------------------------------------------------------------
   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
1	1.000	5256.673	0.00300000

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

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

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

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

Axial 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	1.000000	5257.	0.650000	3417.	10345975.
1	0.75	1.000000	5257.	0.750000	3943.	10293710.
1	0.90	1.000000	5257.	0.900000	4731.	10188584.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer	Top of Layer Below	Equivalent Top Depth Below	Same Layer Type As	Layer is Rock or	F0 Integral	F1 Integral

No.	Pile Head ft	Grnd Surf ft	Layer Above	is Below Rock Layer	for Layer lbs	for Layer lbs
1	0.00	0.00	N.A.	No	0.00	120148.
2	10.0000	11.2441	Yes	No	120148.	173426.
3	15.0000	209.0577	No	No	293574.	24782.
4	32.5000	18.3658	No	No	318355.	679098.
5	42.0000	376.0131	No	No	997453.	27413.
6	51.5000	51.5000	No	Yes	N.A.	N.A.

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

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	28000.	M, in-lb	0.00	1000.0000	1.0017	-0.01310	28000.	1367877.

Maximum pile-head deflection = 1.0017324815 inches
Maximum pile-head rotation = -0.0131007874 radians = -0.750620 deg.

The analysis ended normally.

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

                    LPile for Windows, Version 2019-11.006

                 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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park
Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation
Package\

Name of input data file:
Pavilion Pipe Pile-0.5inch Wall.lp11d

Name of output report file:
Pavilion Pipe Pile-0.5inch Wall.lp11o

Name of plot output file:
Pavilion Pipe Pile-0.5inch Wall.lp11p

Name of runtime message file:
Pavilion Pipe Pile-0.5inch Wall.lp11r


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

Date: February 23, 2021   Time: 15:41:27

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
 - Conventional Analysis

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 52.500 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	9.6250
2	52.500	9.6250

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a drilled shaft with permanent casing
Length of section = 52.500000 ft

```
   Casing outside diameter                              =     9.625000 in
   Shear capacity of section                            =       0.0000 lbs
```

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

Ground Slope Angle                                      =        0.000 degrees
                                                        =        0.000 radians

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

```
--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 6 layers

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

   Distance from top of pile to top of layer            =       0.0000 ft
   Distance from top of pile to bottom of layer         =    10.000000 ft
   Effective unit weight at top of layer                =   125.000000 pcf
   Effective unit weight at bottom of layer             =   125.000000 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                           =   125.000000 pci
   Subgrade k at bottom of layer                        =   125.000000 pci


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

   Distance from top of pile to top of layer            =    10.000000 ft
   Distance from top of pile to bottom of layer         =    15.000000 ft
   Effective unit weight at top of layer                =    55.600000 pcf
   Effective unit weight at bottom of layer             =    55.600000 pcf
   Friction angle at top of layer                       =    30.000000 deg.
   Friction angle at bottom of layer                    =    30.000000 deg.
   Subgrade k at top of layer                           =    50.000000 pci
   Subgrade k at bottom of layer                        =    50.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer            =    15.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    32.500000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Undrained cohesion at top of layer                  =   159.000000 psf
   Undrained cohesion at bottom of layer               =   159.000000 psf
   Epsilon-50 at top of layer                          =     0.050000
   Epsilon-50 at bottom of layer                       =     0.050000


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

   Distance from top of pile to top of layer           =    32.500000 ft
   Distance from top of pile to bottom of layer        =    42.000000 ft
   Effective unit weight at top of layer               =    55.600000 pcf
   Effective unit weight at bottom of layer            =    55.600000 pcf
   Friction angle at top of layer                      =    31.000000 deg.
   Friction angle at bottom of layer                   =    31.000000 deg.
   Subgrade k at top of layer                          =    60.000000 pci
   Subgrade k at bottom of layer                       =    60.000000 pci


Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer           =    42.000000 ft
   Distance from top of pile to bottom of layer        =    51.500000 ft
   Effective unit weight at top of layer               =    42.600000 pcf
   Effective unit weight at bottom of layer            =    42.600000 pcf
   Undrained cohesion at top of layer                  =   300.000000 psf
   Undrained cohesion at bottom of layer               =   300.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


Layer 6 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    51.500000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    85.000000 pcf
   Effective unit weight at bottom of layer            =    85.000000 pcf
   Uniaxial compressive strength at top of layer       =   100.000000 psi
   Uniaxial compressive strength at bottom of layer    =   100.000000 psi
   Initial modulus of rock at top of layer             =       10000. psi
   Initial modulus of rock at bottom of layer          =       10000. psi
   RQD of rock at top of layer                         =    70.000000 %
   RQD of rock at bottom of layer                      =    70.000000 %
   k rm of rock at top of layer                        =    0.0005000
   k rm of rock at bottom of layer                     =    0.0005000


 (Depth of the lowest soil layer extends 12.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	34.0000	--	--	--	125.0000	--
	(Reese, et al.)	10.0000	125.0000	--	34.0000	--	--	--	125.0000	--
2	Sand	10.0000	55.6000	--	30.0000	--	--	--	50.0000	--
	(Reese, et al.)	15.0000	55.6000	--	30.0000	--	--	--	50.0000	--
3	Soft	15.0000	52.6000	159.0000	--	--	--	0.05000	--	--
	Clay	32.5000	52.6000	159.0000	--	--	--	0.05000	--	--
4	Sand	32.5000	55.6000	--	31.0000	--	--	--	60.0000	--
	(Reese, et al.)	42.0000	55.6000	--	31.0000	--	--	--	60.0000	--
5	Soft	42.0000	42.6000	300.0000	--	--	--	0.02000	--	--
	Clay	51.5000	42.6000	300.0000	--	--	--	0.02000	--	--
6	Weak	51.5000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.
	Rock	65.0000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.

Static Loading Type

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

```
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------

Number of loads specified = 1

Load    Load         Condition              Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type           1                        2                 Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       19300. lbs   M =       0.0000 in-lbs    1000.000000000
    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) with Permanent Casing:
------------------------------------------------------------------------------

Length of Section                                      =    52.500000 ft
Outer Diameter of Casing                               =     9.625000 in
Casing Wall Thickness                                  =     0.500000 in
Moment of Inertia of Steel Casing                      =   149.634073 in^4
Yield Stress of Casing                                 =       35000. psi
Elastic Modulus of Casing                              =    29000000. psi
Number of Reinforcing Bars                             =            0 bars
Area of Single Reinforcing Bar                         =       0.0000 sq. in.
Offset of Center of Rebar Cage from Center of Pile     =       0.0000 in
Yield Stress of Reinforcing Bars                       =       0.0000 psi
Modulus of Elasticity of Reinforcing Bars              =       0.0000 psi
```

```
Gross Area of Pile                                     =    72.759777 sq. in.
Area of Concrete                                       =    58.426260 sq. in.
Cross-sectional Area of Steel Casing                   =    14.333516 sq. in.
Area of All Steel (Casing and Bars)                    =    14.333516 sq. in.
Area Ratio of All Steel to Gross Area of Pile          =        19.70 percent

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As    =      675.491 kips
Tensile Load for Cracking of Concrete                  =      -70.847 kips
Nominal Axial Tensile Capacity                         =     -501.673 kips



Concrete Properties:
--------------------

Compressive Strength of Concrete                       =        3500. psi
Modulus of Elasticity of Concrete                      =     3372165. psi
Modulus of Rupture of Concrete                         =  -443.705984 psi
Compression Strain at Peak Stress                      =     0.001764
Tensile Strain at Fracture of Concrete                 =   -0.0001156
Maximum Coarse Aggregate Size                          =     0.750000 in


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

   Number     Axial Thrust Force
                   kips
   ------     ------------------
      1              1.000


--------------------------------------------------------------------------------
   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          Axial Thrust       Nominal Mom. Cap.      Max. Comp.
  No.              kips               in-kip               Strain
 ----         ----------------   ------------------     ------------
   1               1.000             1551.123          0.00300000

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

In ACI 318, the value of the strength reduction factor depends on whether
```

the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

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

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

Axial 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	1.000000	1551.	0.650000	1008.	4730556.
1	0.75	1.000000	1551.	0.750000	1163.	4709058.
1	0.90	1.000000	1551.	0.900000	1396.	4051705.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	115457.
2	10.0000	11.2405	Yes	No	115457.	141028.
3	15.0000	225.0438	No	No	256485.	20086.
4	32.5000	17.7289	No	No	276571.	577492.
5	42.0000	396.6993	No	No	854063.	22219.
6	51.5000	51.5000	No	Yes	N.A.	N.A.

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

```
       non-liquefied sands, and cemented c-phi soil.



--------------------------------------------------------------------------------
            Summary of Pile-head Responses for Conventional Analyses
--------------------------------------------------------------------------------

Definitions of Pile-head Loading Conditions:

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


Load Load                Load                  Axial    Pile-head  Pile-head  Max
Shear Max Moment
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in
Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  1  V, lb     19300.  M, in-lb        0.00  1000.0000     1.0025   -0.01516
19300.   845994.


Maximum pile-head deflection = 1.0025053467 inches
Maximum pile-head rotation   = -0.0151647921 radians = -0.868879 deg.

The analysis ended normally.
```

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

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

Path to file locations:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park
Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation
Package\

Name of input data file:
Pavilion Pipe Pile-0.545inch Wall.lp11d

Name of output report file:
Pavilion Pipe Pile-0.545inch Wall.lp11o

Name of plot output file:
Pavilion Pipe Pile-0.545inch Wall.lp11p

Name of runtime message file:
Pavilion Pipe Pile-0.545inch Wall.lp11r


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

Date: February 23, 2021   Time: 15:45:08

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
 - Conventional Analysis

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

Analysis Control Options:
 - Maximum number of iterations allowed = 500
 - Deflection tolerance for convergence = 1.0000E-05 in
 - Maximum allowable deflection = 100.0000 in
 - Number of pile increments = 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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 52.500 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	9.6250
2	52.500	9.6250

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a drilled shaft with permanent casing
Length of section = 52.500000 ft

```
   Casing outside diameter                                =     9.625000 in
   Shear capacity of section                              =       0.0000 lbs



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

Ground Slope Angle                                        =        0.000 degrees
                                                          =        0.000 radians

Pile Batter Angle                                         =        0.000 degrees
                                                          =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 6 layers

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

   Distance from top of pile to top of layer              =       0.0000 ft
   Distance from top of pile to bottom of layer           =    10.000000 ft
   Effective unit weight at top of layer                  =   125.000000 pcf
   Effective unit weight at bottom of layer               =   125.000000 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                             =   125.000000 pci
   Subgrade k at bottom of layer                          =   125.000000 pci


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

   Distance from top of pile to top of layer              =    10.000000 ft
   Distance from top of pile to bottom of layer           =    15.000000 ft
   Effective unit weight at top of layer                  =    55.600000 pcf
   Effective unit weight at bottom of layer               =    55.600000 pcf
   Friction angle at top of layer                         =    30.000000 deg.
   Friction angle at bottom of layer                      =    30.000000 deg.
   Subgrade k at top of layer                             =    50.000000 pci
   Subgrade k at bottom of layer                          =    50.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer              =    15.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    32.500000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Undrained cohesion at top of layer                  =   159.000000 psf
   Undrained cohesion at bottom of layer               =   159.000000 psf
   Epsilon-50 at top of layer                          =     0.050000
   Epsilon-50 at bottom of layer                       =     0.050000


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

   Distance from top of pile to top of layer           =    32.500000 ft
   Distance from top of pile to bottom of layer        =    42.000000 ft
   Effective unit weight at top of layer               =    55.600000 pcf
   Effective unit weight at bottom of layer            =    55.600000 pcf
   Friction angle at top of layer                      =    31.000000 deg.
   Friction angle at bottom of layer                   =    31.000000 deg.
   Subgrade k at top of layer                          =    60.000000 pci
   Subgrade k at bottom of layer                       =    60.000000 pci


Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer           =    42.000000 ft
   Distance from top of pile to bottom of layer        =    51.500000 ft
   Effective unit weight at top of layer               =    42.600000 pcf
   Effective unit weight at bottom of layer            =    42.600000 pcf
   Undrained cohesion at top of layer                  =   300.000000 psf
   Undrained cohesion at bottom of layer               =   300.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


Layer 6 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    51.500000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    85.000000 pcf
   Effective unit weight at bottom of layer            =    85.000000 pcf
   Uniaxial compressive strength at top of layer       =   100.000000 psi
   Uniaxial compressive strength at bottom of layer    =   100.000000 psi
   Initial modulus of rock at top of layer             =       10000. psi
   Initial modulus of rock at bottom of layer          =       10000. psi
   RQD of rock at top of layer                         =    70.000000 %
   RQD of rock at bottom of layer                      =    70.000000 %
   k rm of rock at top of layer                        =    0.0005000
   k rm of rock at bottom of layer                     =    0.0005000


 (Depth of the lowest soil layer extends 12.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	34.0000	--	--	--	125.0000	--
	(Reese, et al.)	10.0000	125.0000	--	34.0000	--	--	--	125.0000	--
2	Sand	10.0000	55.6000	--	30.0000	--	--	--	50.0000	--
	(Reese, et al.)	15.0000	55.6000	--	30.0000	--	--	--	50.0000	--
3	Soft	15.0000	52.6000	159.0000	--	--	--	0.05000	--	--
	Clay	32.5000	52.6000	159.0000	--	--	--	0.05000	--	--
4	Sand	32.5000	55.6000	--	31.0000	--	--	--	60.0000	--
	(Reese, et al.)	42.0000	55.6000	--	31.0000	--	--	--	60.0000	--
5	Soft	42.0000	42.6000	300.0000	--	--	--	0.02000	--	--
	Clay	51.5000	42.6000	300.0000	--	--	--	0.02000	--	--
6	Weak	51.5000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.
	Rock	65.0000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

```
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------

Number of loads specified = 1

Load    Load         Condition                Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type            1                         2                Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       19800. lbs   M =       0.0000 in-lbs    1000.000000000
    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) with Permanent Casing:
------------------------------------------------------------------------------

Length of Section                                      =    52.500000 ft
Outer Diameter of Casing                               =     9.625000 in
Casing Wall Thickness                                  =     0.545000 in
Moment of Inertia of Steel Casing                      =   160.796181 in^4
Yield Stress of Casing                                 =       35000. psi
Elastic Modulus of Casing                              =    29000000. psi
Number of Reinforcing Bars                             =            0 bars
Area of Single Reinforcing Bar                         =       0.0000 sq. in.
Offset of Center of Rebar Cage from Center of Pile     =       0.0000 in
Yield Stress of Reinforcing Bars                       =       0.0000 psi
Modulus of Elasticity of Reinforcing Bars              =       0.0000 psi
```

```
Gross Area of Pile                                     =    72.759777 sq. in.
Area of Concrete                                       =    57.213291 sq. in.
Cross-sectional Area of Steel Casing                   =    15.546485 sq. in.
Area of All Steel (Casing and Bars)                    =    15.546485 sq. in.
Area Ratio of All Steel to Gross Area of Pile          =        21.37 percent

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As    =      714.337 kips
Tensile Load for Cracking of Concrete                  =      -74.441 kips
Nominal Axial Tensile Capacity                         =     -544.127 kips



Concrete Properties:
--------------------

Compressive Strength of Concrete                       =        3500. psi
Modulus of Elasticity of Concrete                      =     3372165. psi
Modulus of Rupture of Concrete                         =  -443.705984 psi
Compression Strain at Peak Stress                      =     0.001764
Tensile Strain at Fracture of Concrete                 =   -0.0001156
Maximum Coarse Aggregate Size                          =     0.750000 in


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

   Number     Axial Thrust Force
                   kips
   ------     ------------------
      1              1.000


--------------------------------------------------------------------------------
   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          Axial Thrust       Nominal Mom. Cap.      Max. Comp.
  No.              kips                in-kip              Strain
 ----         ----------------   ------------------    ------------
   1               1.000             1661.993          0.00300000

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

In ACI 318, the value of the strength reduction factor depends on whether
```

the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

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

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

Axial 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	1.000000	1662.	0.650000	1080.	5042922.
1	0.75	1.000000	1662.	0.750000	1246.	5023270.
1	0.90	1.000000	1662.	0.900000	1496.	4343649.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	115457.
2	10.0000	11.2405	Yes	No	115457.	141028.
3	15.0000	225.0438	No	No	256485.	20086.
4	32.5000	17.7289	No	No	276571.	577492.
5	42.0000	396.6993	No	No	854063.	22219.
6	51.5000	51.5000	No	Yes	N.A.	N.A.

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

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	19800.	M, in-lb	0.00	1000.0000	0.9983	-0.01494	19800.	876862.

Maximum pile-head deflection = 0.9983494399 inches
Maximum pile-head rotation = -0.0149393309 radians = -0.855961 deg.

The analysis ended normally.

APPENDIX I-4

CALCULATIONS OF PILE CAPACITY AND PILE STIFFNESS
I-4: VERTICAL AND LATERAL STIFFNESS OF HP12×63

APPENDIX I4-VERTICAL AND LATERAL STIFFNESS FOR HP12×63

1. VERTICAL STIFFNESS OF A SINGLE PILE/A GROUP OF PILES: K_{eq}

$$\frac{1}{K_{eq}} = \frac{1}{K_{footing}} + \frac{1}{K_{pile}}$$

- **$K_{footing}$**

The vertical stiffness of the $K_{footing}$ is computed in the following manner:

1. Based on the cap geometry, determine the area that include the piles only, call it A.
2. Column load= P
3. Determine the equivalent diameter of the pile group as $B = 2\sqrt{\frac{A}{\pi}}$
4. As all piles are bearing on rock, the compression of the rock is estimated considering spread footing with a diameter B on rock with average loading P/A on rock with modulus of deformation E and Poisson's ratio μ, using the expression for uniform rigid circular footing (DM-7.1-211)

   $\delta_v = q\ B\ \frac{1-\mu^2}{E}(0.74)$

   For μ=0.3, the above expression reduces to

$$\delta_v = q\ B\ \frac{0.67}{E}$$

   And the stiffness K is

$$K_v = \frac{q}{\delta_v} = \frac{1.5\ E}{B}$$

   The units of K_v is ($\frac{F}{L^3}$). In term of total load the units will be in F/L and K

$$K_{footing} = \frac{qA}{\delta_v} = \frac{1.5A\ E}{B}$$

- **K_{pile}**

  Considering 110-ton pile HP12×63, 55 feet long, the elastic shortening is 220(55)(12)/(18.4×29000)=0.272 inch. So, the stiffness is 800 kip/in, which is K_{pile}.

- **K_{eq}**

$$\frac{1}{K_{eq}} = \frac{1}{K_{footing}} + \frac{1}{K_{pile}}$$

$$\Rightarrow K_{eq} = \frac{K_{footing}K_{pile}}{K_{footing}+K_{pile}}$$

$$\Rightarrow K_{eq} = \frac{K_{footing}}{1+\frac{K_{footing}}{K_{pile}}}$$

$$\Rightarrow K_{eq} = \frac{\frac{1.5AE}{B}}{1+\frac{K_{footing}}{K_{pile}}}$$

$$\Rightarrow K_{eq} = \frac{1.5AE}{B+\frac{1.5AE}{K_{pile}}}$$

Assigning E for the rock can be determined using AASHTO methods. A GSI of 45 can be assigned based on AASHTO Fig 10.4.6.4-1. The intact modulus for Schist can vary from a low 860 ksi to mean 4970 ksi (AASHTO Table C10.4.6.5-1). The ratio of the mass modulus to the intact modulus can be derived using AASHTO Table 10.4.6.5-1 as $\frac{1}{100}e^{\frac{GSI}{21.7}}$=0.08. Accordingly, the mass E can vary from 68.8 ksi to 397.6 ksi with an average of 200ksi.

For a single HP12×63 under vertical load of 220 kips: A=18.40in^2, the equivalent diameter B=4.84inches, K_{pile}=800 kips/in, then the calculated K_{eq}=470kips/inch.

2. LATERAL STIFFNESS OF PILE

   Using software L-Pile, the estimated lateral deflections of an HP12×63 under the lateral load of 16kips along its strong axis and weak axis are 0.389" and 0.739", respectively (see attachment). The corresponding lateral stiffness along the strong axis and the weak axis are 41.1kips/inch and 21.6kips/inch, respectively.

PAVILION HP12x63-LATEARL DEFLECTION ALONG STRONG AXIS

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

                    LPile for Windows, Version 2019-11.006

                  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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park
Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation
Package\Stiffness-Pavilion HP12X63\

Name of input data file:
Pavilion HP12X63 Strong Axis.lp11d

Name of output report file:
Pavilion HP12X63 Strong Axis.lp11o

Name of plot output file:
Pavilion HP12X63 Strong Axis.lp11p

Name of runtime message file:
Pavilion HP12X63 Strong Axis.lp11r


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

Date: February 24, 2021 Time: 10:05:26

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

Computational Options:
 - Conventional Analysis

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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 = 52.500 ft
Depth of ground surface below top of pile = 0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.1000
2	52.500	12.1000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a H strong axis steel pile
Length of section = 52.500000 ft

```
   Pile width                                             =    12.100000 in
   Shear capacity of section                              =       0.0000 lbs
```

Ground Slope and Pile Batter Angles

```
Ground Slope Angle                                        =        0.000 degrees
                                                          =        0.000 radians

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

Soil and Rock Layering Information

The soil profile is modelled using 6 layers

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

```
   Distance from top of pile to top of layer              =       0.0000 ft
   Distance from top of pile to bottom of layer           =    10.000000 ft
   Effective unit weight at top of layer                  =   125.000000 pcf
   Effective unit weight at bottom of layer               =   125.000000 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                             =   125.000000 pci
   Subgrade k at bottom of layer                          =   125.000000 pci
```

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

```
   Distance from top of pile to top of layer              =    10.000000 ft
   Distance from top of pile to bottom of layer           =    15.000000 ft
   Effective unit weight at top of layer                  =    55.600000 pcf
   Effective unit weight at bottom of layer               =    55.600000 pcf
   Friction angle at top of layer                         =    30.000000 deg.
   Friction angle at bottom of layer                      =    30.000000 deg.
   Subgrade k at top of layer                             =    50.000000 pci
   Subgrade k at bottom of layer                          =    50.000000 pci
```

Layer 3 is soft clay, p-y criteria by Matlock, 1970

```
   Distance from top of pile to top of layer              =    15.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    32.500000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Undrained cohesion at top of layer                  =   159.000000 psf
   Undrained cohesion at bottom of layer               =   159.000000 psf
   Epsilon-50 at top of layer                          =     0.050000
   Epsilon-50 at bottom of layer                       =     0.050000


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

   Distance from top of pile to top of layer           =    32.500000 ft
   Distance from top of pile to bottom of layer        =    42.000000 ft
   Effective unit weight at top of layer               =    55.600000 pcf
   Effective unit weight at bottom of layer            =    55.600000 pcf
   Friction angle at top of layer                      =    31.000000 deg.
   Friction angle at bottom of layer                   =    31.000000 deg.
   Subgrade k at top of layer                          =    60.000000 pci
   Subgrade k at bottom of layer                       =    60.000000 pci


Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer           =    42.000000 ft
   Distance from top of pile to bottom of layer        =    51.500000 ft
   Effective unit weight at top of layer               =    42.600000 pcf
   Effective unit weight at bottom of layer            =    42.600000 pcf
   Undrained cohesion at top of layer                  =   300.000000 psf
   Undrained cohesion at bottom of layer               =   300.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


Layer 6 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    51.500000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    85.000000 pcf
   Effective unit weight at bottom of layer            =    85.000000 pcf
   Uniaxial compressive strength at top of layer       =   100.000000 psi
   Uniaxial compressive strength at bottom of layer    =   100.000000 psi
   Initial modulus of rock at top of layer             =       10000. psi
   Initial modulus of rock at bottom of layer          =       10000. psi
   RQD of rock at top of layer                         =    70.000000 %
   RQD of rock at bottom of layer                      =    70.000000 %
   k rm of rock at top of layer                        =    0.0005000
   k rm of rock at bottom of layer                     =    0.0005000


 (Depth of the lowest soil layer extends 12.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	34.0000	--	--	--	125.0000	--
	(Reese, et al.)	10.0000	125.0000	--	34.0000	--	--	--	125.0000	--
2	Sand	10.0000	55.6000	--	30.0000	--	--	--	50.0000	--
	(Reese, et al.)	15.0000	55.6000	--	30.0000	--	--	--	50.0000	--
3	Soft	15.0000	52.6000	159.0000	--	--	--	0.05000	--	--
	Clay	32.5000	52.6000	159.0000	--	--	--	0.05000	--	--
4	Sand	32.5000	55.6000	--	31.0000	--	--	--	60.0000	--
	(Reese, et al.)	42.0000	55.6000	--	31.0000	--	--	--	60.0000	--
5	Soft	42.0000	42.6000	300.0000	--	--	--	0.02000	--	--
	Clay	51.5000	42.6000	300.0000	--	--	--	0.02000	--	--
6	Weak	51.5000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.
	Rock	65.0000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.

Static Loading Type

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

```
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------

Number of loads specified = 1

Load    Load         Condition               Condition           Axial Thrust
Compute Top y     Run Analysis
 No.    Type           1                       2                   Force, lbs
vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------
---------------    ------------
   1     1     V =       16000. lbs   M =       0.0000 in-lbs    1000.000000000
    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 Steel H Strong Axis:
---------------------------------------------

Length of Section                                      =    52.500000 ft
Flange Width                                           =    12.100000 in
Section Depth                                          =    11.900000 in
Flange Thickness                                       =     0.515000 in
Web Thickness                                          =     0.515000 in
Yield Stress of Pipe                                   =    36.000000 ksi
Elastic Modulus                                        =       29000. ksi
Cross-sectional Area                                   =    18.061050 sq. in.
Moment of Inertia                                      =   459.254129 in^4
Elastic Bending Stiffness                              =    13318370. kip-in^2
Plastic Modulus, Z                                     =    86.158328in^3
```

Plastic Moment Capacity = Fy Z = 3102.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As = 650.198 kips
Nominal Axial Tensile Capacity = -650.198 kips

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

Number	Axial Thrust Force kips
1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	3092.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Top of Layer	Equivalent Top Depth	Same Layer	Layer is	F0	F1

Layer No.	Below Pile Head ft	Below Grnd Surf ft	Type As Layer Above	Rock or is Below Rock Layer	Integral for Layer lbs	Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	120650.
2	10.0000	11.2451	Yes	No	120650.	176273.
3	15.0000	207.5383	No	No	296923.	25251.
4	32.5000	18.4284	No	No	322174.	688042.
5	42.0000	373.7937	No	No	1010216.	27933.
6	51.5000	51.5000	No	Yes	N.A.	N.A.

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

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	16000.	M, in-lb	0.00	1000.0000	0.3889	-0.00528	16000.	700990.

Maximum pile-head deflection = 0.3888716876 inches
Maximum pile-head rotation = -0.0052789070 radians = -0.302459 deg.

The analysis ended normally.

PAVILION HP12x63-LATERAL DEFLECTION ALONG WEAK AXIS

==

LPile for Windows, Version 2019-11.006

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:
\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\Lateral Resistance of Pile Foundation\Calculation Package\Stiffness-Pavilion HP12X63\

Name of input data file:
Pavilion HP12X63 Weak Axis.lp11d

Name of output report file:
Pavilion HP12X63 Weak Axis.lp11o

Name of plot output file:
Pavilion HP12X63 Weak Axis.lp11p

Name of runtime message file:
Pavilion HP12X63 Weak Axis.lp11r

Date and Time of Analysis

Date: February 24, 2021   Time: 10:05:55

Problem Title

Project Name: South Battery Park City Resiliency

Job Number: 17-NY165-01

Client: AECOM

Engineer: SG

Description:

Program Options and Settings

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

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	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)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Input of side resistance moment along pile 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.
- Report only summary tables of pile-head deflection, maximum bending moment, and maximum shear force in output report file.
- 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                                     =      52.500 ft
Depth of ground surface below top of pile                =      0.0000 ft
```

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.1000
2	52.500	12.1000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

```
   Section 1 is a H weak axis steel pile
   Length of section                                     =    52.500000 ft
```

```
   Pile width                                              =    11.900000 in
   Shear capacity of section                               =       0.0000 lbs



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

Ground Slope Angle                                         =        0.000 degrees
                                                           =        0.000 radians

Pile Batter Angle                                          =        0.000 degrees
                                                           =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 6 layers

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

   Distance from top of pile to top of layer               =       0.0000 ft
   Distance from top of pile to bottom of layer            =    10.000000 ft
   Effective unit weight at top of layer                   =   125.000000 pcf
   Effective unit weight at bottom of layer                =   125.000000 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                              =   125.000000 pci
   Subgrade k at bottom of layer                           =   125.000000 pci


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

   Distance from top of pile to top of layer               =    10.000000 ft
   Distance from top of pile to bottom of layer            =    15.000000 ft
   Effective unit weight at top of layer                   =    55.600000 pcf
   Effective unit weight at bottom of layer                =    55.600000 pcf
   Friction angle at top of layer                          =    30.000000 deg.
   Friction angle at bottom of layer                       =    30.000000 deg.
   Subgrade k at top of layer                              =    50.000000 pci
   Subgrade k at bottom of layer                           =    50.000000 pci


Layer 3 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer               =    15.000000 ft
```

```
   Distance from top of pile to bottom of layer        =    32.500000 ft
   Effective unit weight at top of layer               =    52.600000 pcf
   Effective unit weight at bottom of layer            =    52.600000 pcf
   Undrained cohesion at top of layer                  =   159.000000 psf
   Undrained cohesion at bottom of layer               =   159.000000 psf
   Epsilon-50 at top of layer                          =     0.050000
   Epsilon-50 at bottom of layer                       =     0.050000


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

   Distance from top of pile to top of layer           =    32.500000 ft
   Distance from top of pile to bottom of layer        =    42.000000 ft
   Effective unit weight at top of layer               =    55.600000 pcf
   Effective unit weight at bottom of layer            =    55.600000 pcf
   Friction angle at top of layer                      =    31.000000 deg.
   Friction angle at bottom of layer                   =    31.000000 deg.
   Subgrade k at top of layer                          =    60.000000 pci
   Subgrade k at bottom of layer                       =    60.000000 pci


Layer 5 is soft clay, p-y criteria by Matlock, 1970

   Distance from top of pile to top of layer           =    42.000000 ft
   Distance from top of pile to bottom of layer        =    51.500000 ft
   Effective unit weight at top of layer               =    42.600000 pcf
   Effective unit weight at bottom of layer            =    42.600000 pcf
   Undrained cohesion at top of layer                  =   300.000000 psf
   Undrained cohesion at bottom of layer               =   300.000000 psf
   Epsilon-50 at top of layer                          =     0.020000
   Epsilon-50 at bottom of layer                       =     0.020000


Layer 6 is weak rock, p-y criteria by Reese, 1997

   Distance from top of pile to top of layer           =    51.500000 ft
   Distance from top of pile to bottom of layer        =    65.000000 ft
   Effective unit weight at top of layer               =    85.000000 pcf
   Effective unit weight at bottom of layer            =    85.000000 pcf
   Uniaxial compressive strength at top of layer       =   100.000000 psi
   Uniaxial compressive strength at bottom of layer    =   100.000000 psi
   Initial modulus of rock at top of layer             =       10000. psi
   Initial modulus of rock at bottom of layer          =       10000. psi
   RQD of rock at top of layer                         =    70.000000 %
   RQD of rock at bottom of layer                      =    70.000000 %
   k rm of rock at top of layer                        =    0.0005000
   k rm of rock at bottom of layer                     =    0.0005000


 (Depth of the lowest soil layer extends 12.500 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	Undrained Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 or krm	kpy pci	Rock Mass Modulus psi
1	Sand	0.00	125.0000	--	34.0000	--	--	--	125.0000	--
	(Reese, et al.)	10.0000	125.0000	--	34.0000	--	--	--	125.0000	--
2	Sand	10.0000	55.6000	--	30.0000	--	--	--	50.0000	--
	(Reese, et al.)	15.0000	55.6000	--	30.0000	--	--	--	50.0000	--
3	Soft	15.0000	52.6000	159.0000	--	--	--	0.05000	--	--
	Clay	32.5000	52.6000	159.0000	--	--	--	0.05000	--	--
4	Sand	32.5000	55.6000	--	31.0000	--	--	--	60.0000	--
	(Reese, et al.)	42.0000	55.6000	--	31.0000	--	--	--	60.0000	--
5	Soft	42.0000	42.6000	300.0000	--	--	--	0.02000	--	--
	Clay	51.5000	42.6000	300.0000	--	--	--	0.02000	--	--
6	Weak	51.5000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.
	Rock	65.0000	85.0000	--	--	100.0000	70.0000	5.00E-04	--	10000.

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 16000. lbs	M = 0.0000 in-lbs	1000.000000000	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 Steel H Weak Axis:

Length of Section	=	52.500000 ft
Flange Width	=	12.100000 in
Section Depth	=	11.900000 in
Flange Thickness	=	0.515000 in
Web Thickness	=	0.515000 in
Yield Stress of Pipe	=	36.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	18.061050 sq. in.
Moment of Inertia	=	152.182714 in^4
Elastic Bending Stiffness	=	4413299. kip-in^2
Plastic Modulus, Z	=	38.421324in^3

Plastic Moment Capacity = Fy Z = 1383.in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As = 650.198 kips
Nominal Axial Tensile Capacity = -650.198 kips

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

Number	Axial Thrust Force kips
1	1.000

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	1.0000000000	1344.

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

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

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

Layering Correction Equivalent Depths of Soil & Rock Layers

Top of Layer	Equivalent Top Depth	Same Layer	Layer is	F0	F1

Layer No.	Below Pile Head ft	Below Grnd Surf ft	Type As Layer Above	Rock or is Below Rock Layer	Integral for Layer lbs	Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	120650.
2	10.0000	11.2451	Yes	No	120650.	176273.
3	15.0000	207.5383	No	No	296923.	25251.
4	32.5000	18.4284	No	No	322174.	688042.
5	42.0000	373.7937	No	No	1010216.	27933.
6	51.5000	51.5000	No	Yes	N.A.	N.A.

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

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	16000.	M, in-lb	0.00	1000.0000	0.7394	-0.01169	16000.	614111.

Maximum pile-head deflection = 0.7393916669 inches
Maximum pile-head rotation = -0.0116924387 radians = -0.669927 deg.

The analysis ended normally.

APPENDIX J

SUMMARY OF SEEPAGE ANALYSES

- J-1: Seepage Analyses Results and Model Inputs
- J-2: Sensitivity Analyses of Transient Flow near MJH

APPENDIX J-1

J-1: SEEPAGE ANALYSIS RESULTS AND MODEL INPUTS

Seepage Analysis Results and Factor of Safety against Piping for WP1 to WP7

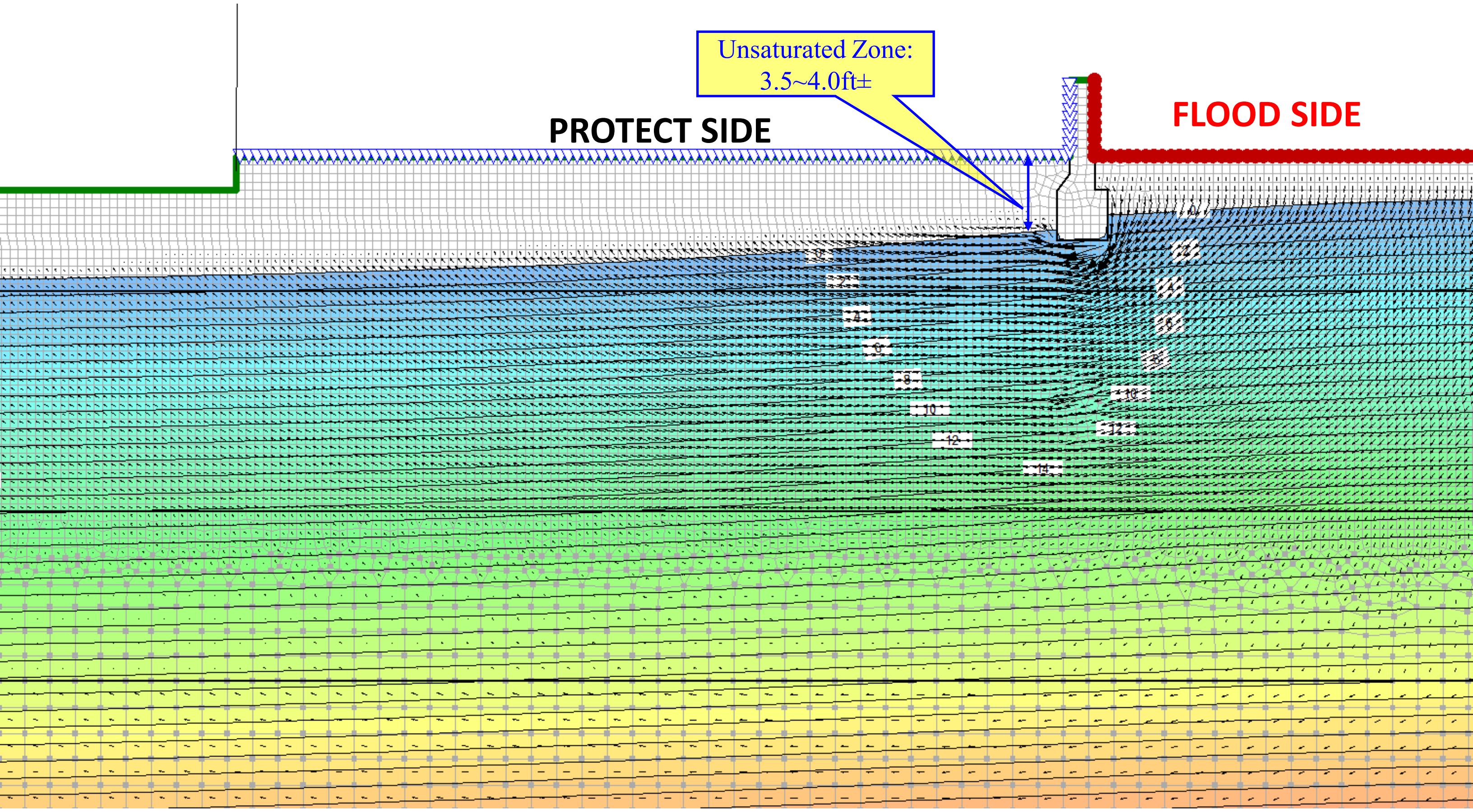
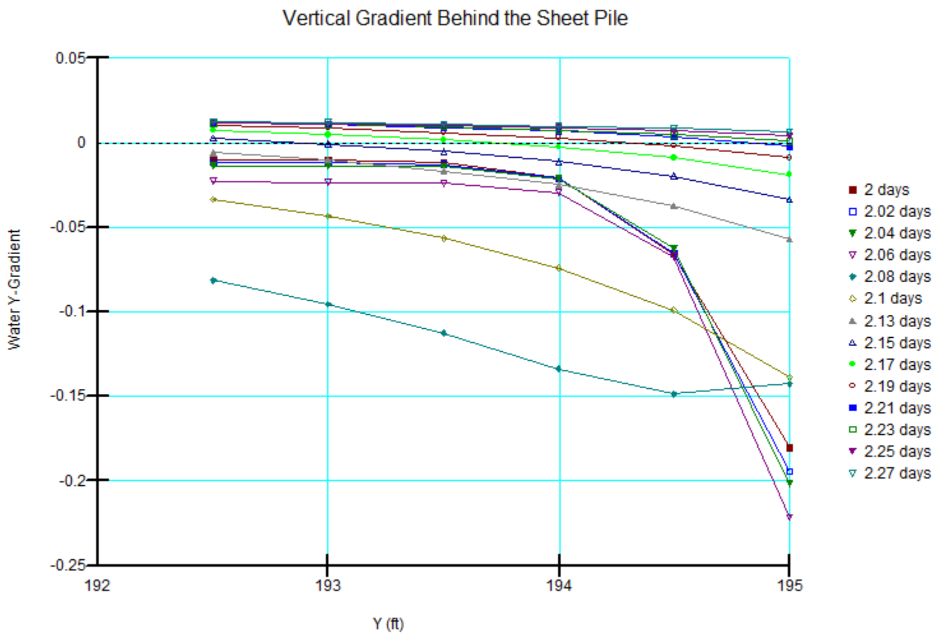


Figure 1: Water Pressure Head Contours for Seepage Barrier with Tip at El.+6.0



On the 2.08th day:
*Flood rises to its peak El. 11.3ft**

*(*reduced 100-Year Storm was used in the seepage analyses per AECOM's request)*

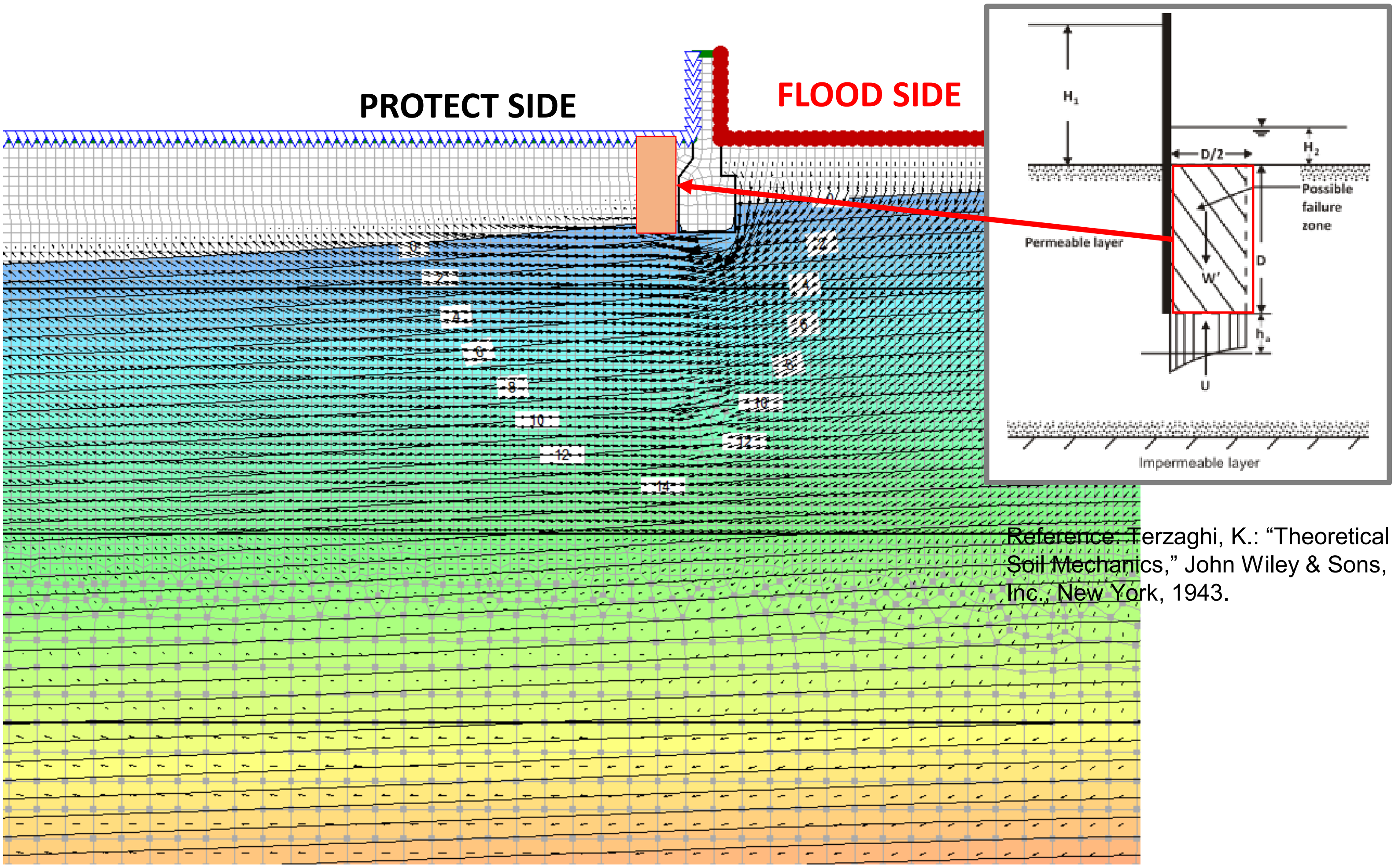
The highest level that water would rise to behind the sheet pile on the protected side: Y=196.8 (El.6.8).

Figure 2: Vertical Gradient behind the Sheet Pile at Peak Flood Elevation

Estimated Factor of safety based on gradient:
FS=1/0.23=4.35 > (FS=4~5 by EM 1110-2-1901, page 4-24), OK

Seepage Analysis Results and Factor of Safety against Piping for for WP1 to WP7

ESITMATING FACTOR OF SAFETY AGAGINST PIPING BY AGAINST PIPING BY TERZAGHI (1943)



Reference: Terzaghi, K.: “Theoretical Soil Mechanics,” John Wiley & Sons, Inc., New York, 1943.

Excess pore pressure at bottom of the possible failure zone: h_a=0.1ft
Height of unsaturated zone on the protected side: 3.5ft
Height of saturated zone above tip of the seepage barrier on the protected side: 0.5ft
Factor of safety against piping due to heave:

FS=[3.5*115+(115-62.4)*0.5]/(0.1*62.4)=68.7 (greater than FS=4~5 recommended by Harr, OK)

Harr (1962, p. 125) suggested that a factor of safety of 4 to 5 with should be sufficient for safe performance of the structure. [Harr, M.: “Groundwater and Seepage,” McGraw-Hill Book Company, 1962.]

Seepage Analysis Results and Factor of Safety against Piping for WP7~WP20 (Sta.10+45 to 14+61) (I)

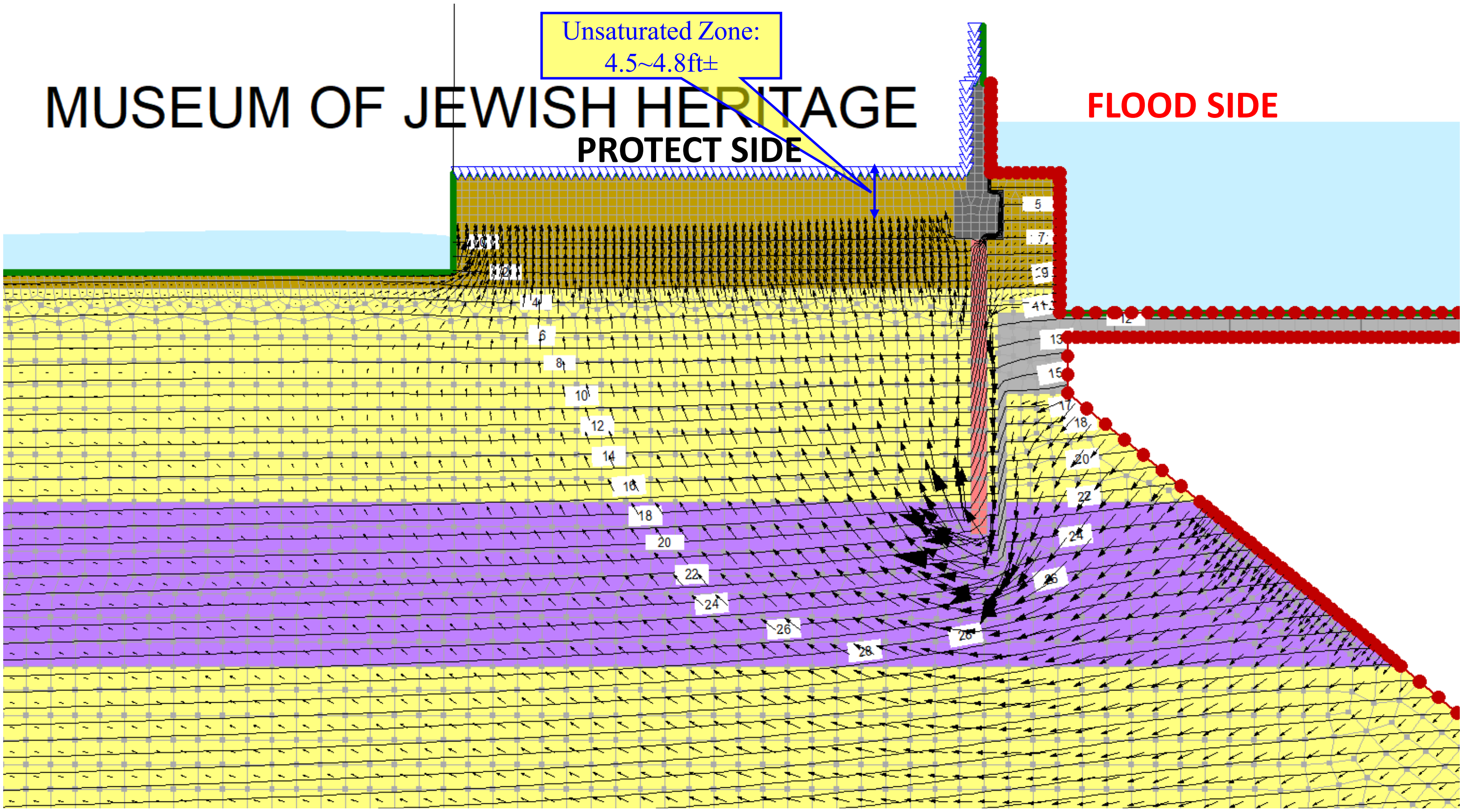
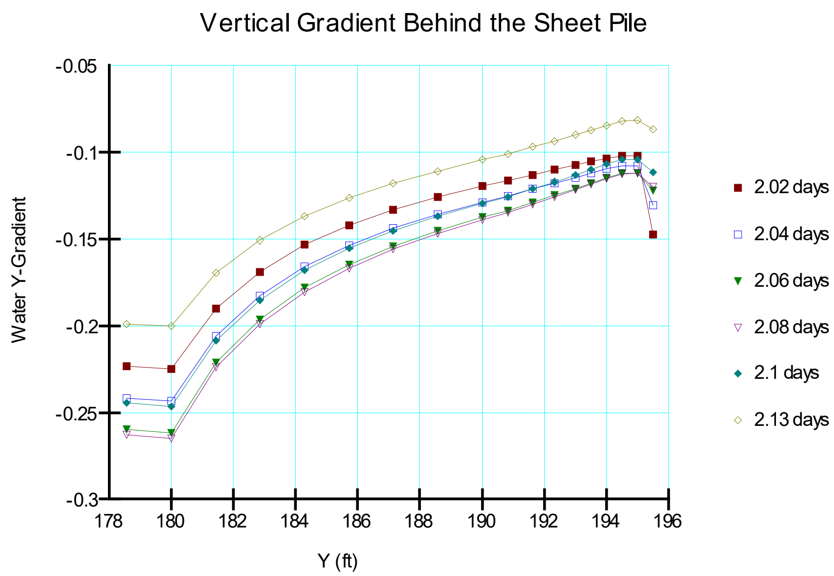


Figure 1: Water Pressure Head Contours for Seepage Barrier with Tip at El.-12.0



On the 2.08th day:
*Flood rises to its peak El. 13.55ft**

*(*insignificant impact on the safety factor against piping using flood elevation of 13.8. See sensitivity analyses performed for Sta.20+50 to 21+50 and Sta.23+00 to 25+00)*

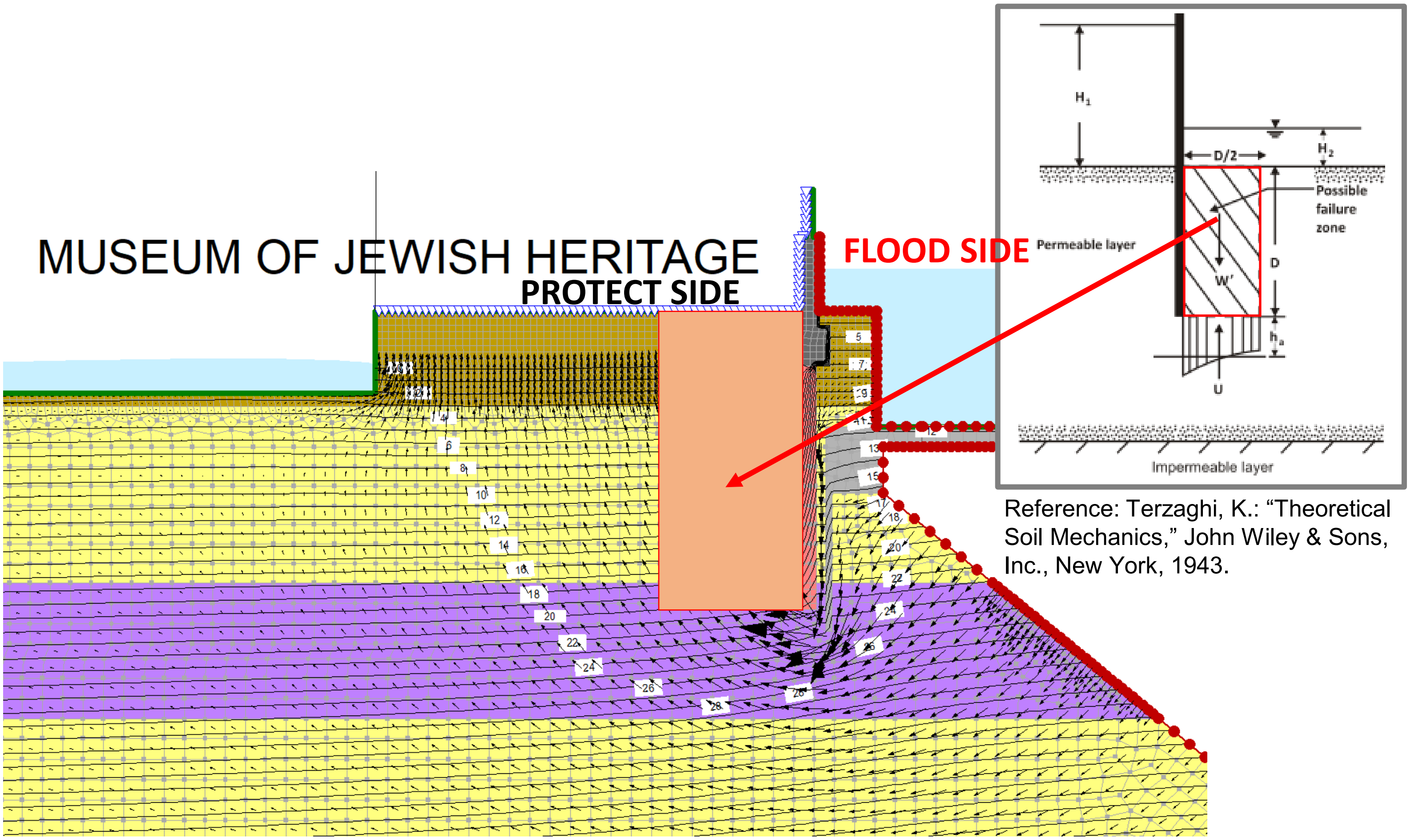
The highest level that water would rise to behind the sheet pile on the protected side: Y=195.2 (El.5.2).

Figure 2: Vertical Gradient behind the Sheet Pile at Peak Flood Elevation

Estimated Factor of safety based on gradient:
FS=1/0.15=6.67 > (FS=4~5 by EM 1110-2-1901, page 4-24), OK

Seepage Analysis Results and Factor of Safety against Piping for WP7~WP20 (Sta.10+45 to 14+61) (II)

ESITMATING FACTOR OF SAFETY AGAGINST PIPING BY AGAINST PIPING BY TERZAGHI (1943)



Reference: Terzaghi, K.: "Theoretical Soil Mechanics," John Wiley & Sons, Inc., New York, 1943.

Excess pore pressure at bottom of the possible failure zone: h_a=3.8ft
Height of unsaturated zone on the protected side: 4.8ft
Height of saturated zone above tip of the seepage barrier on the protected side: 17.2ft
Factor of safety against piping due to heave:

FS=[4.8*115+(115-62.4)*17.2]/(3.8*62.4)=6.14 (greater than FS=4~5 recommended by Harr, OK)

Harr (1962, p. 125) suggested that a factor of safety of 4 to 5 with should be sufficient for safe performance of the structure. [Harr, M.: "Groundwater and Seepage," McGraw-Hill Book Company, 1962.]

Seepage Analysis Results and Factor of Safety against Piping for WP20~WP26 (Sta.14+61 to 20+50) (I)

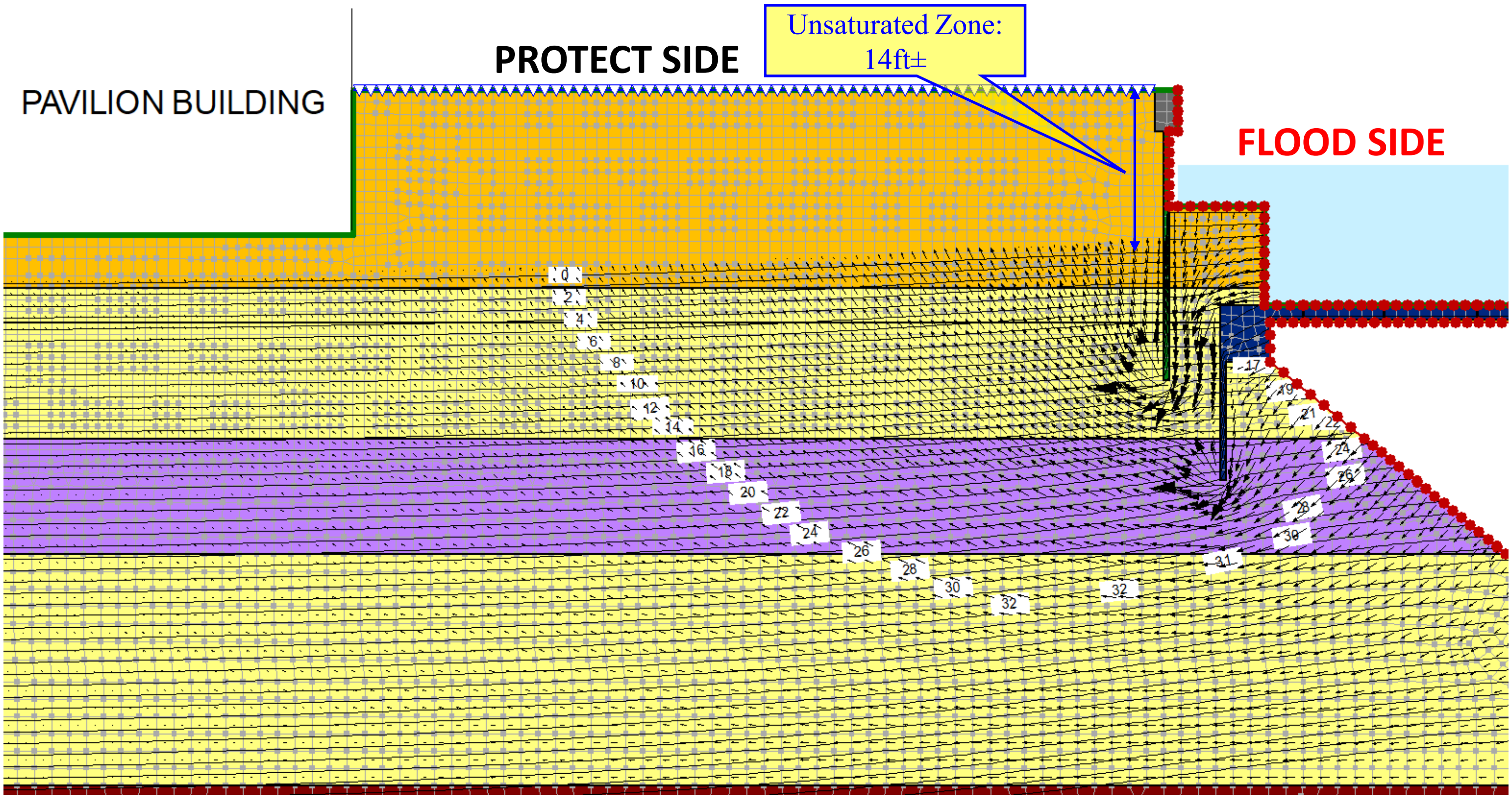
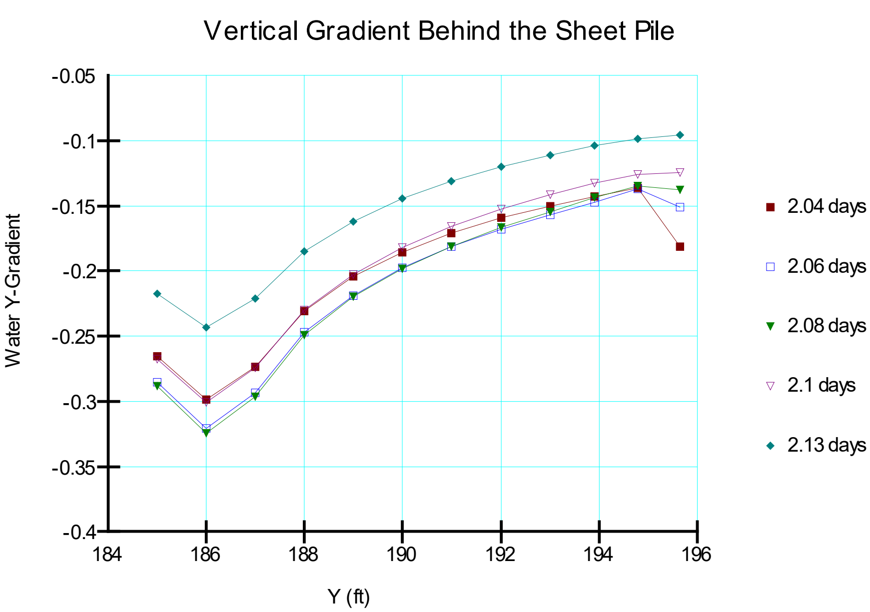


Figure 3: Water Pressure Head Contours for Seepage Barrier with Tip at El.-5.0



On the 2.08th day:
*Flood rises to its peak El. 13.55ft**

*(*insignificant impact on the safety factor against piping using flood elevation of 13.8. See sensitivity analyses performed for Sta.20+50 to 21+50 and Sta.23+00 to 25+00)*

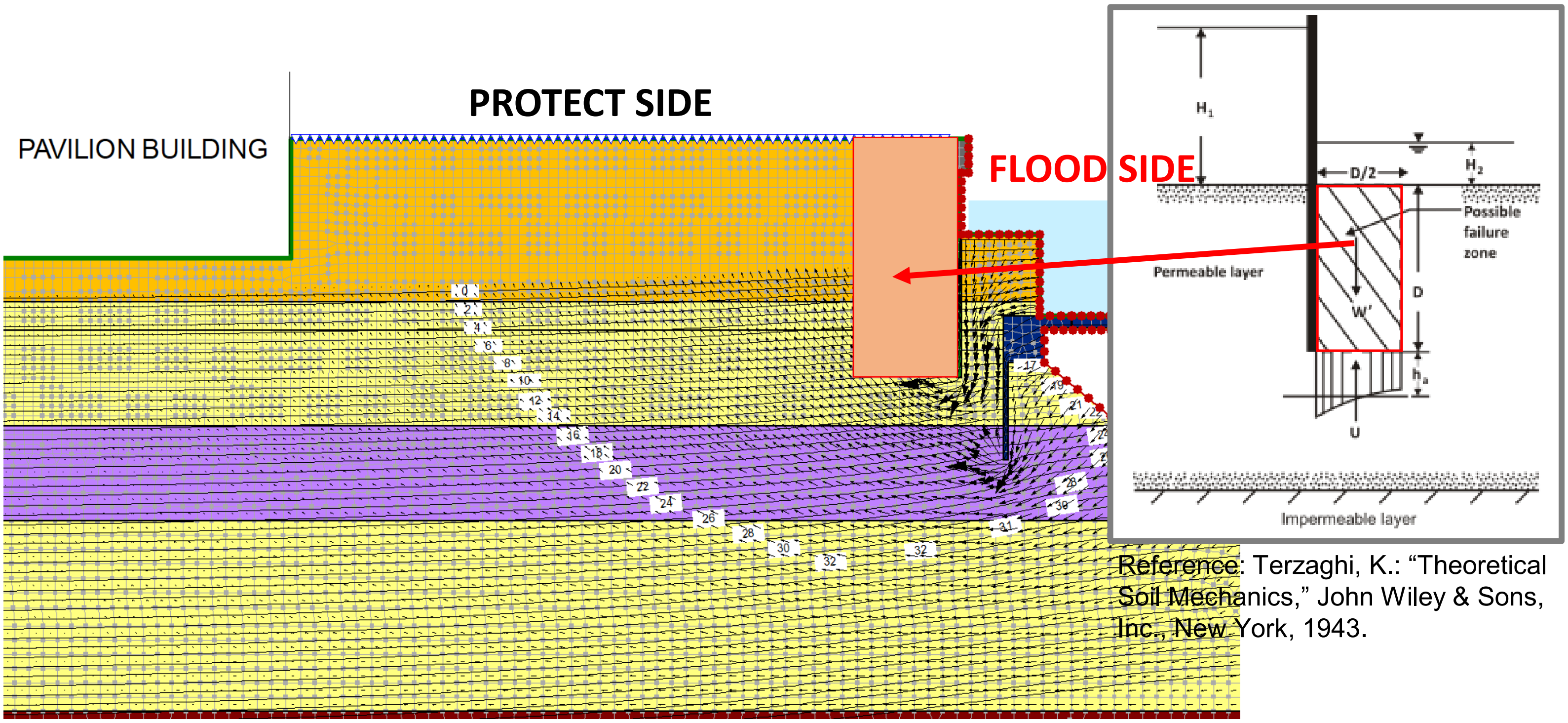
The highest level that water would rise to behind the sheet pile on the protected side: Y=196.0 (El.6.0).

Figure 4: Vertical Gradient behind the Sheet Pile at Peak Flood Elevation

Estimated Factor of safety based on gradient:
FS=1/0.18=5.56 > (FS=4~5 by EM 1110-2-1901, page 4-24), OK

Seepage Analysis Results and Factor of Safety against Piping for WP20~WP26 (Sta.14+61 to 20+50) (II)

ESITMATING FACTOR OF SAFETY AGAGINST PIPING BY AGAINST PIPING BY TERZAGHI (1943)



Reference: Terzaghi, K.: "Theoretical Soil Mechanics," John Wiley & Sons, Inc., New York, 1943.

Excess pore pressure at bottom of the possible failure zone: h_a=2.0ft
Height of unsaturated zone on the protected side : 14ft
Height of saturated zone above tip of the seepage barrier on the protected side : 11ft
Factor of safety against piping due to heave:

FS=[14*115+(115-62.4)*11]/(2*62.4)=17.5 (greater than FS=4~5 recommended by Harr, OK)

Harr (1962, p. 125) suggested that a factor of safety of 4 to 5 with should be sufficient for safe performance of the structure. [Harr, M.: "Groundwater and Seepage," McGraw-Hill Book Company, 1962.]

Seepage Analysis Results and Factor of Safety against Piping for WP26~WP29/30 (Sta.20+50 to 21+50) (Ia)

(Case Ia: with Peak Flood El.13.55)

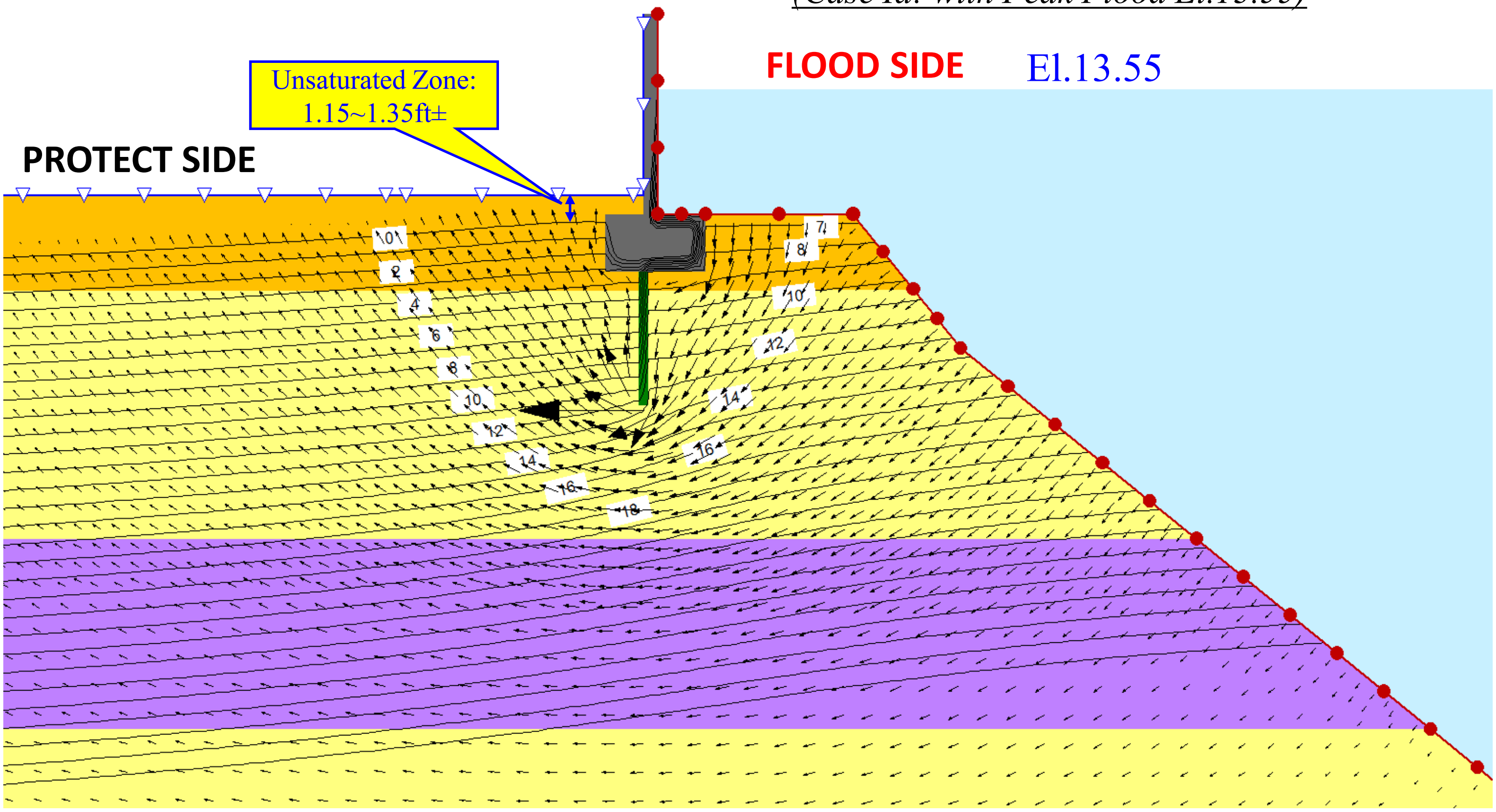
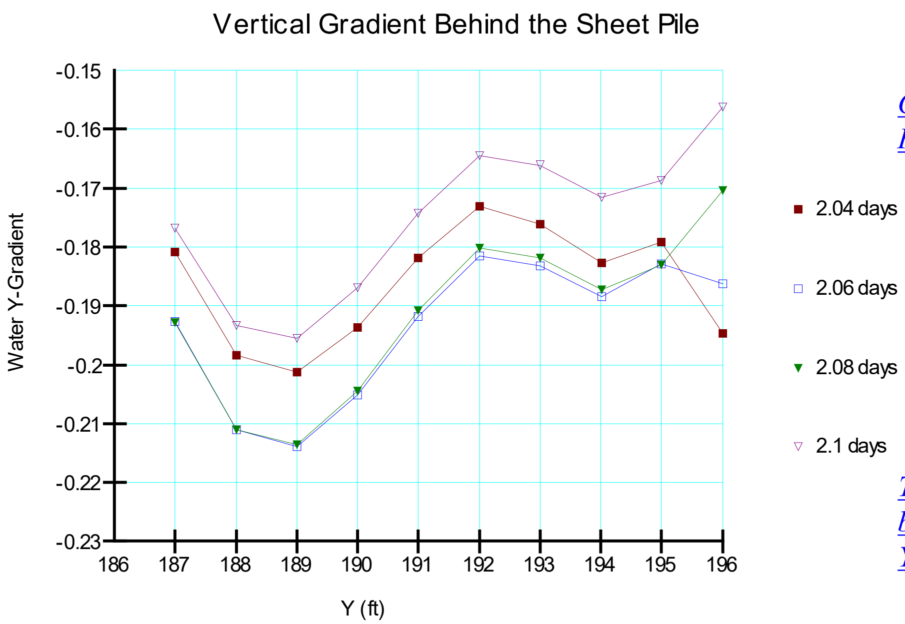


Figure 5: Water Pressure Head Contours for Seepage Barrier with Tip at El.-3.0



On the 2.08th day:
Flood rises to its peak El. 13.55ft

The highest level that water would rise to behind the sheet pile on the protected side: Y=196.7 (El.6.7).

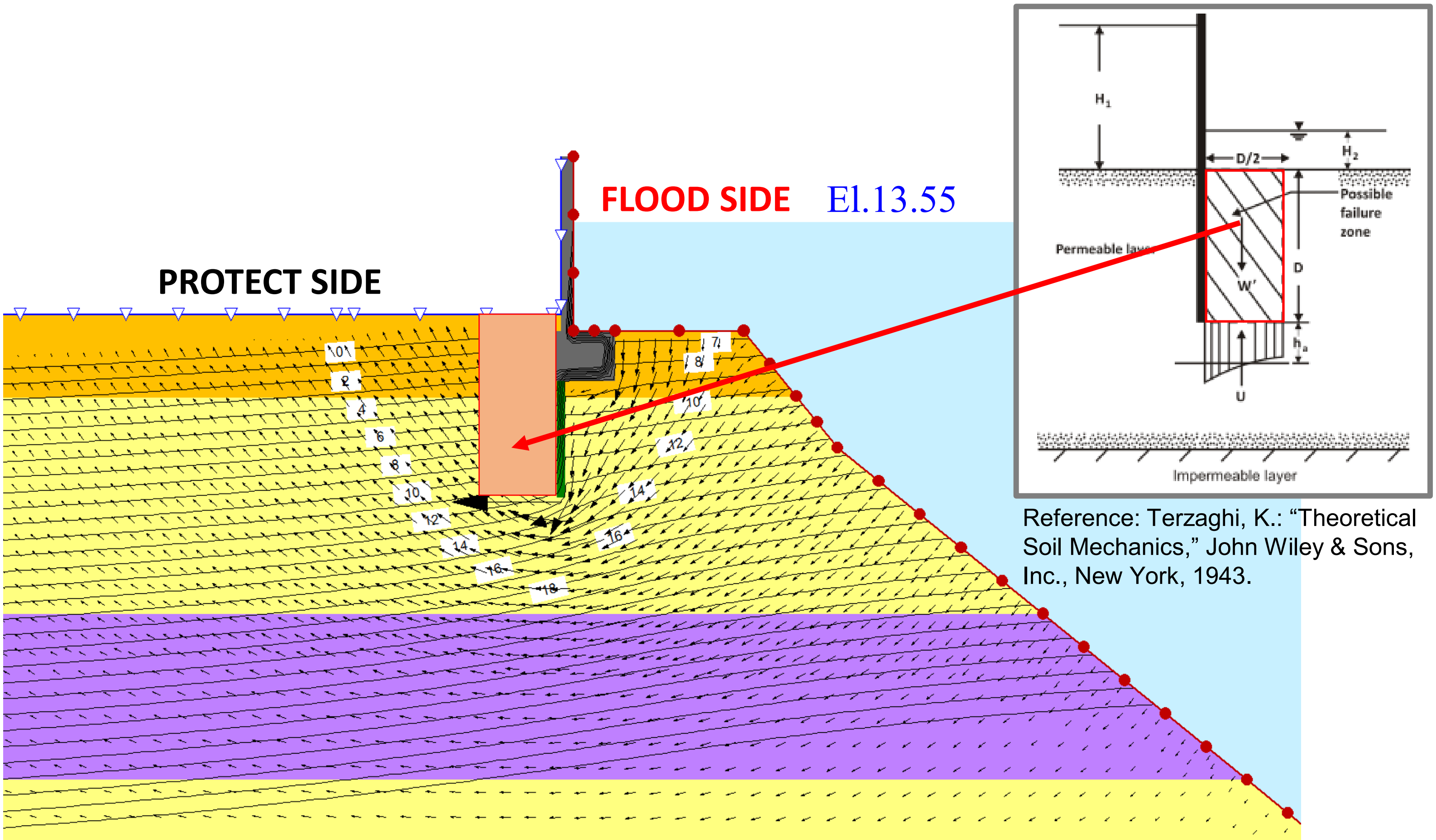
Figure 6: Vertical Gradient behind the Sheet Pile at Peak Flood Elevation

Estimated Factor of safety based on gradient:
FS=1/0.185=5.41 > (FS=4~5 by EM 1110-2-1901, page 4-24), OK

Seepage Analysis Results and Factor of Safety against Piping for WP26~WP29/30 (Sta.20+50 to 21+50) (IIa)

(Case IIa: with Peak Flood El.13.55)

ESITMATING FACTOR OF SAFETY AGAGINST PIPING BY AGAINST PIPING BY TERZAGHI (1943)



Reference: Terzaghi, K.: "Theoretical Soil Mechanics," John Wiley & Sons, Inc., New York, 1943.

Excess pore pressure at bottom of the possible failure zone: h_a=1.857ft

Height of unsaturated zone on the protected side : 1.3ft

Height of saturated zone above tip of the seepage barrier on the protected side : 9.7ft

Factor of safety against piping due to heave:

FS=[1.3*115+(115-62.4)*9.7]/(1.857*62.4)=5.69 (greater than FS=4~5 recommended by Harr, OK)

Harr (1962, p. 125) suggested that a factor of safety of 4 to 5 with should be sufficient for safe performance of the structure. [Harr, M.: "Groundwater and Seepage," McGraw-Hill Book Company, 1962.]

Seepage Analysis Results and Factor of Safety against Piping for WP26~WP29/30 (Sta.20+50 to 21+50) (IIa)

(Case IIa: with Peak Flood El.13.80)

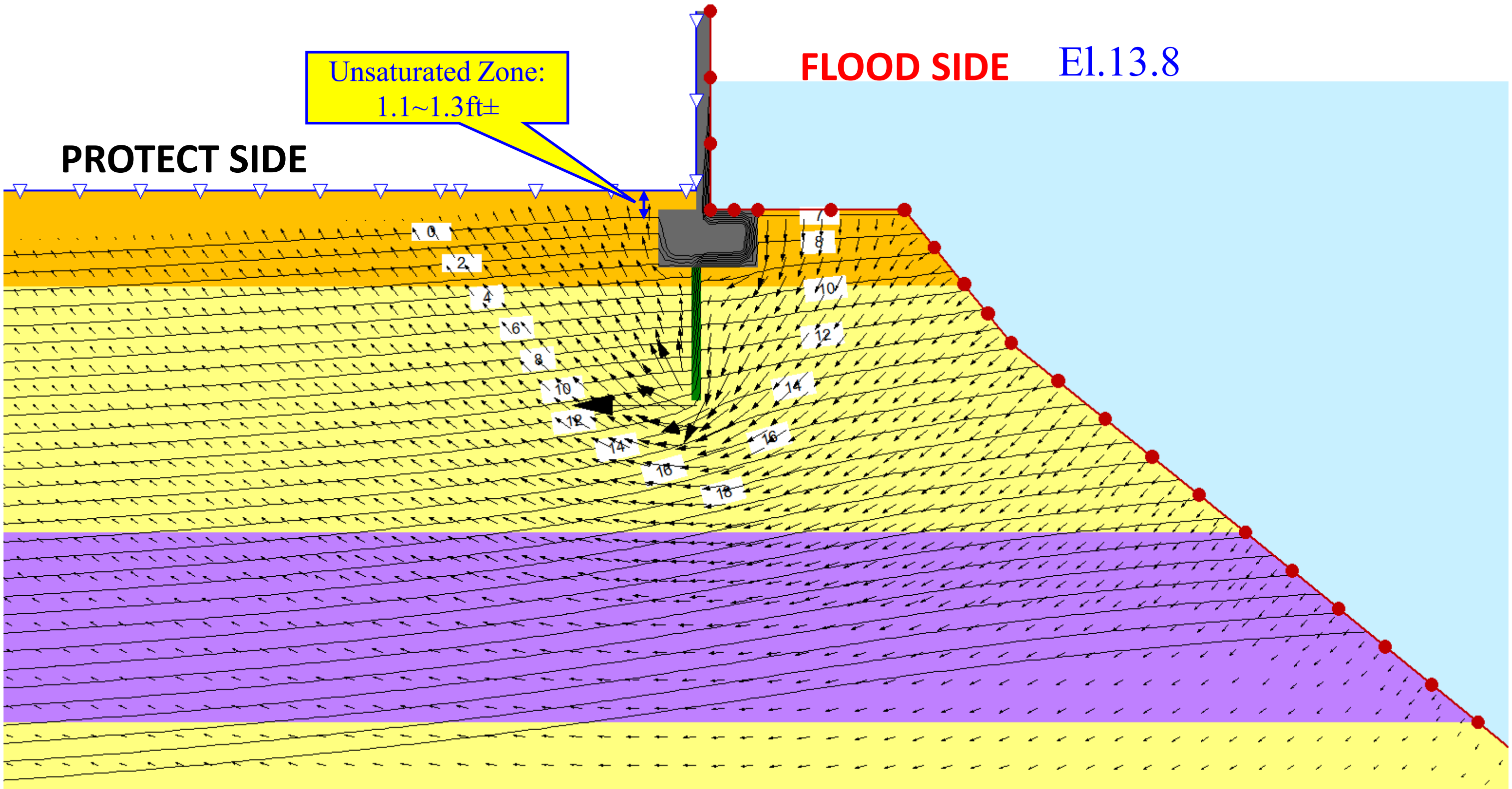


Figure 7: Water Pressure Head Contours for Seepage Barrier with Tip at El.-3.0

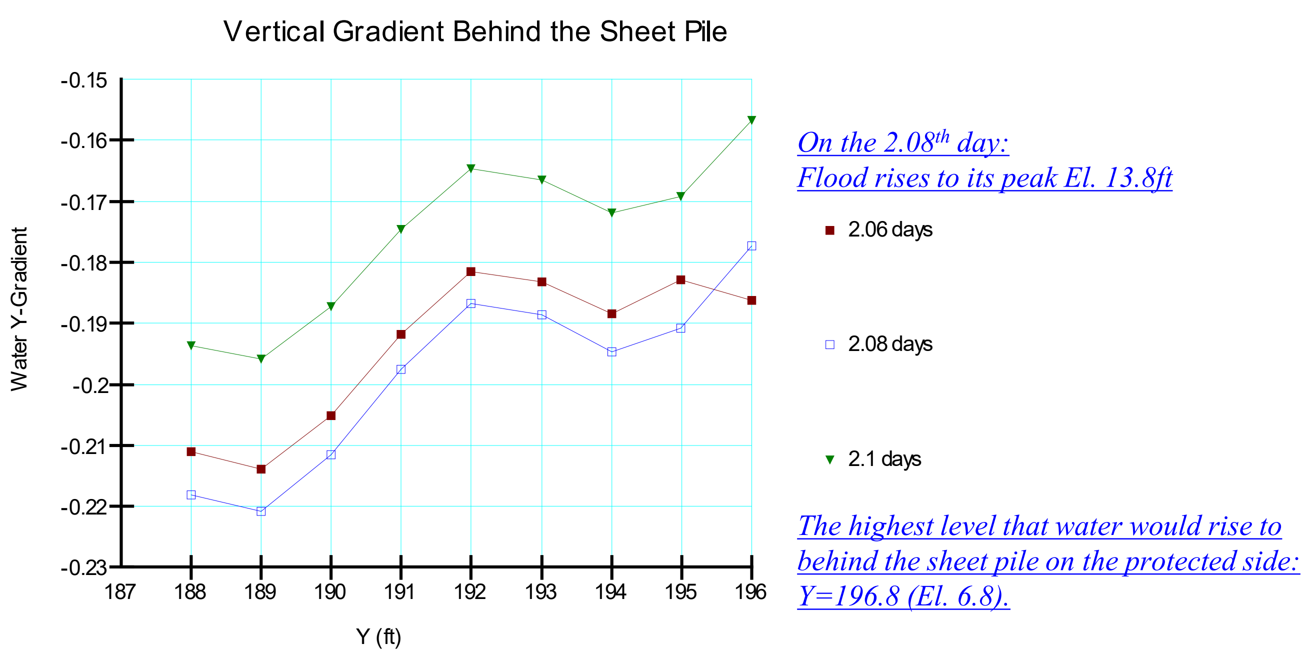


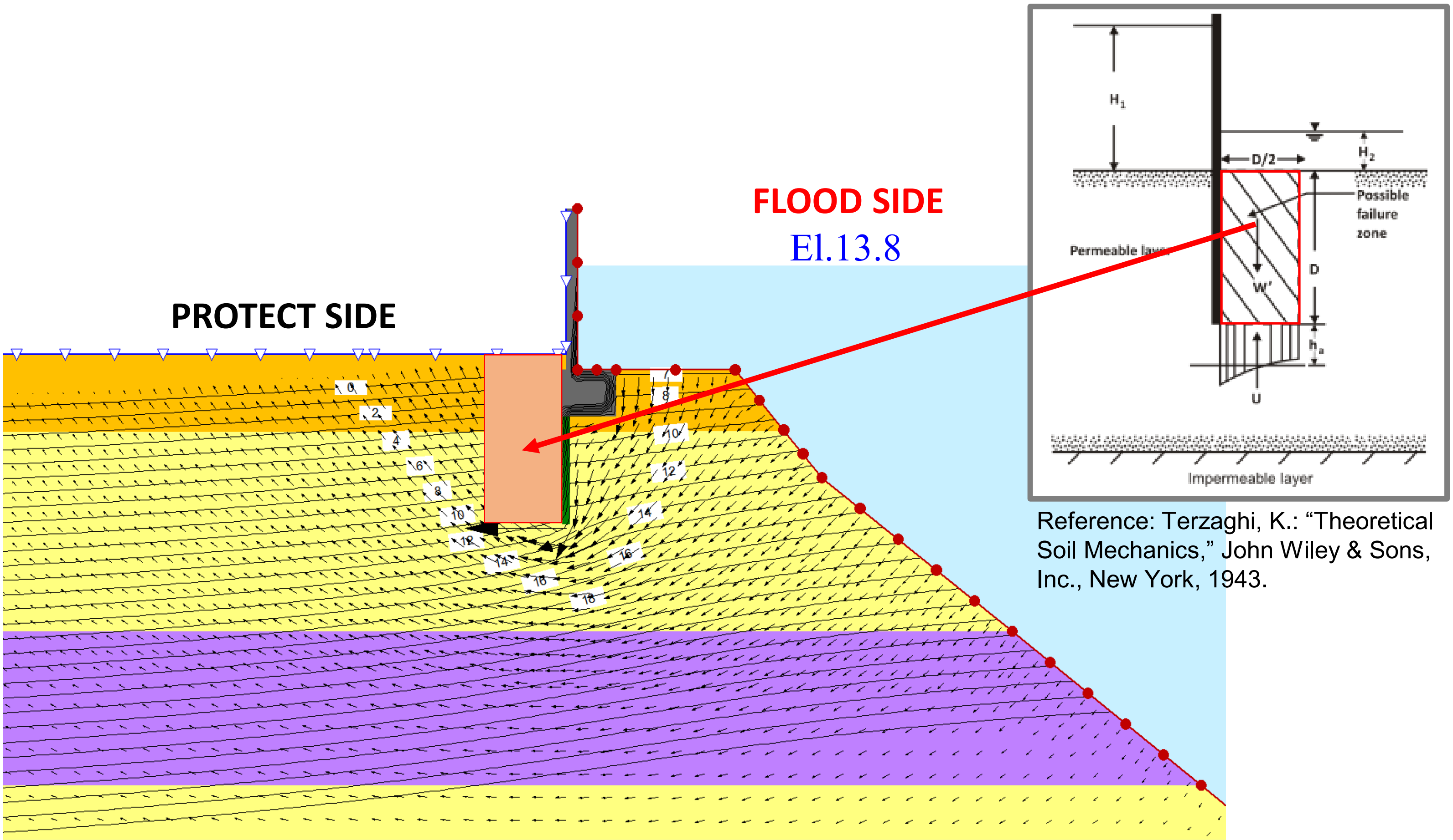
Figure 8: Vertical Gradient behind the Sheet Pile at Peak Flood Elevation

Estimated Factor of safety based on gradient:
FS=1/0.19=5.26 > (FS=4~5 by EM 1110-2-1901, page 4-24), OK

Seepage Analysis Results and Factor of Safety against Piping for WP26~WP29/30 (Sta.20+50 to 21+50) (IIb)

(Case IIb: with Peak Flood El.13.80)

ESITMATING FACTOR OF SAFETY AGAGINST PIPING BY AGAINST PIPING BY TERZAGHI (1943)



Reference: Terzaghi, K.: "Theoretical Soil Mechanics," John Wiley & Sons, Inc., New York, 1943.

Excess pore pressure at bottom of the possible failure zone: h_a=2.0645ft
Height of unsaturated zone on the protected side : 1.3ft
Height of saturated zone above tip of the seepage barrier on the protected side : 9.7ft
Factor of safety against piping due to heave:

FS=[1.3*115+(115-62.4)*9.7]/(2.0645*62.4)=5.12 (greater than FS=4~5 recommended by Harr, OK)

Harr (1962, p. 125) suggested that a factor of safety of 4 to 5 with should be sufficient for safe performance of the structure. [Harr, M.: "Groundwater and Seepage," McGraw-Hill Book Company, 1962.]

Seepage Analysis Results and Factor of Safety against Piping for WP29/30~ WP33 (Sta.21+50 to 23+00) (I)

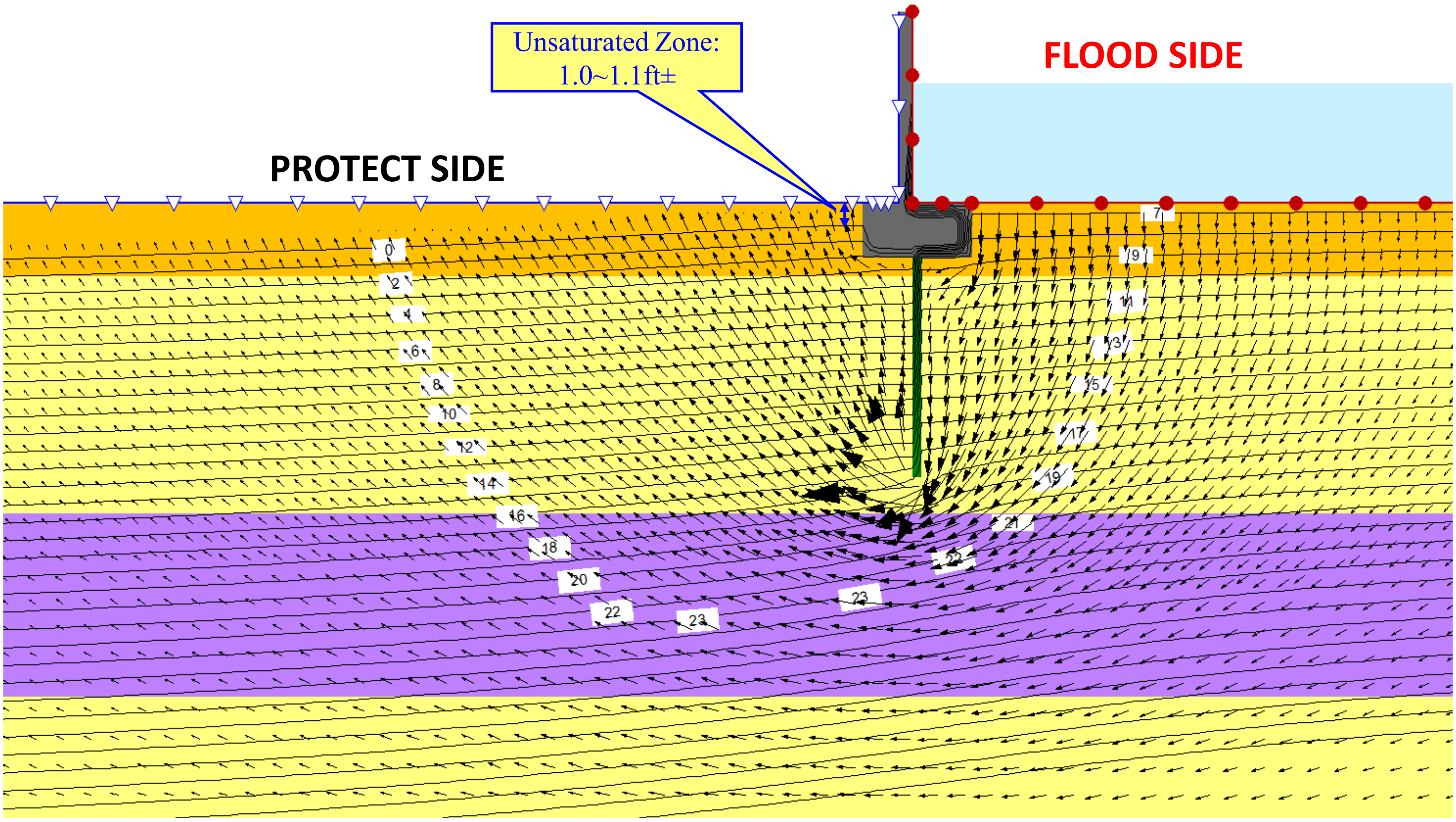
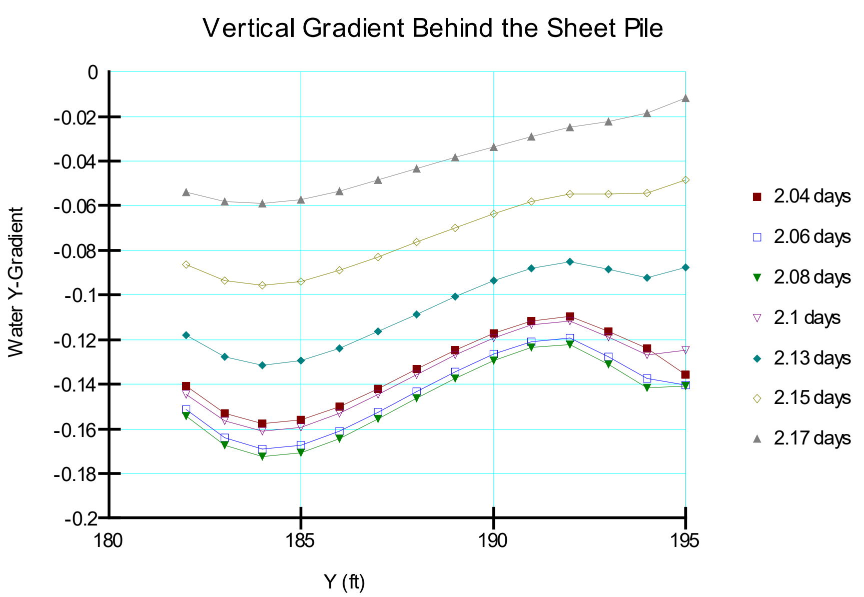


Figure 9: Water Pressure Head Contours for Seepage Barrier with Tip at El.-8.0



On the 2.08th day:
*Flood rises to its peak El. 13.55ft**

*(*insignificant impact on the safety factor against piping using flood elevation of 13.8. See sensitivity analyses performed for Sta.20+50 to 21+50 and Sta.23+00 to 25+00)*

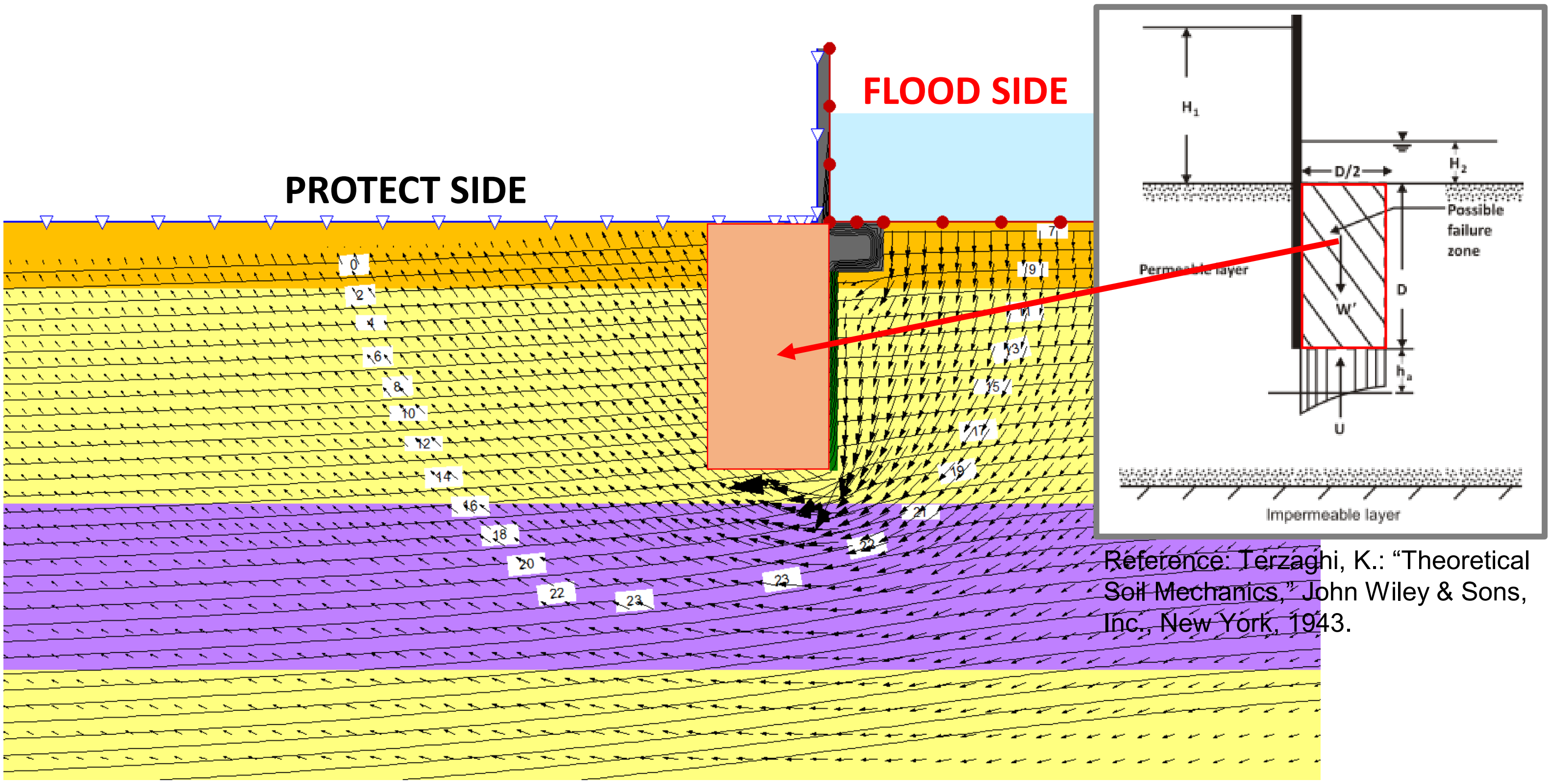
The highest level that water would rise to behind the sheet pile on the protected side: Y=195.9 (El.5.9).

Figure 10: Vertical Gradient behind the Sheet Pile at Peak Flood Elevation

Estimated Factor of safety based on gradient:
FS=1/0.14=7.14 > (FS=4~5 by EM 1110-2-1901, page 4-24), OK

Seepage Analysis Results and Factor of Safety against Piping for WP29/30~WP33 (Sta.21+50 to 23+00) (II)

ESITMATING FACTOR OF SAFETY AGAGINST PIPING BY AGAINST PIPING BY TERZAGHI (1943)



Reference: Terzaghi, K.: “Theoretical Soil Mechanics,” John Wiley & Sons, Inc., New York, 1943.

Excess pore pressure at bottom of the possible failure zone: h_a=2.1ft
Height of unsaturated zone on the protected side : 1.1ft
Height of saturated zone above tip of the seepage barrier on the protected side : 13.9ft
Factor of safety against piping due to heave:

FS=[1.1*115+(115-62.4)*13.9]/(2.1*62.4)=6.54 (greater than FS=4~5 recommended by Harr, OK)

Harr (1962, p. 125) suggested that a factor of safety of 4 to 5 with should be sufficient for safe performance of the structure. [Harr, M.: “Groundwater and Seepage,” McGraw-Hill Book Company, 1962.]

Seepage Analysis Results and Factor of Safety against Piping for WP33~WP40 (Sta.23+00 to 25+00) (Ia)

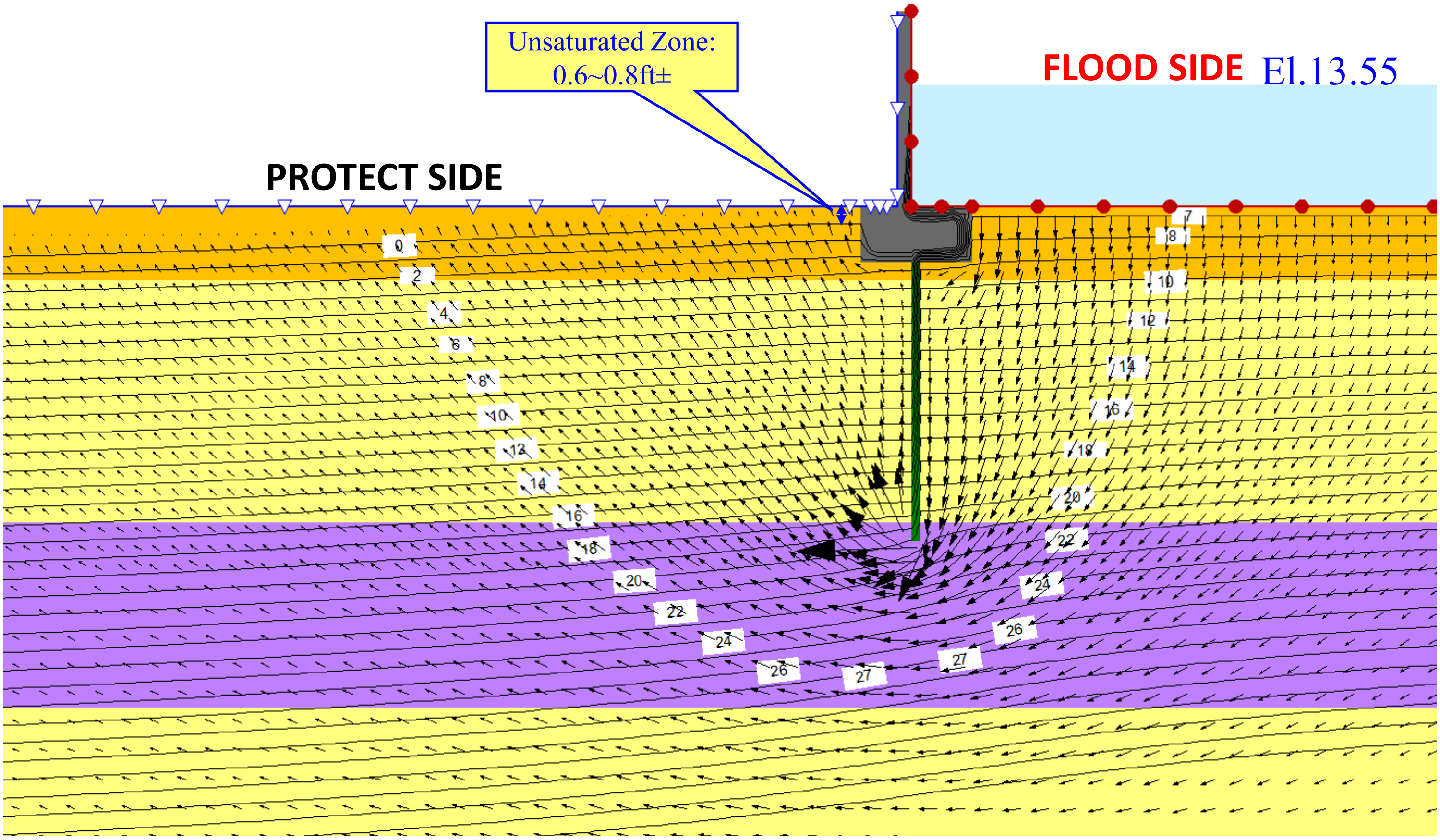
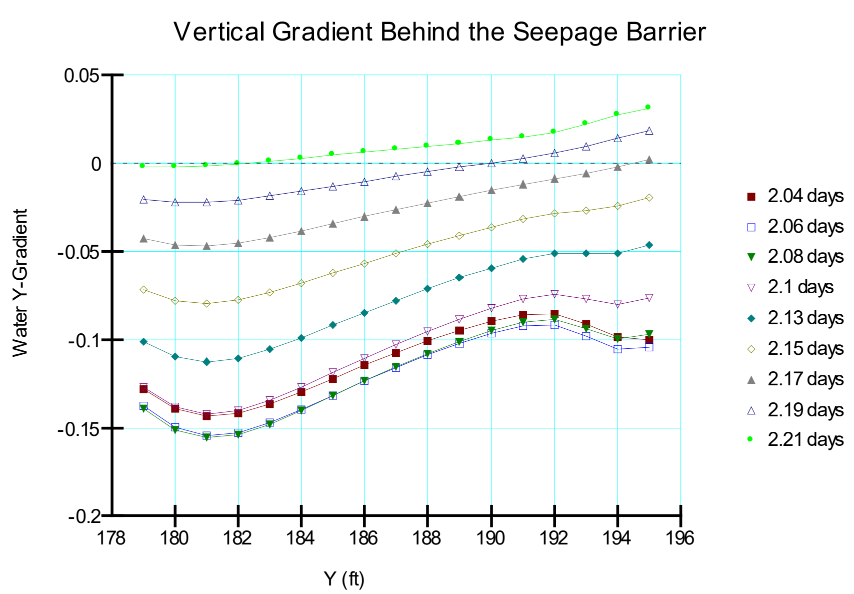


Figure 11: Water Pressure Head Contours for Seepage Barrier with Tip at El.-11.0



On the 2.08th day:
Flood rises to its peak El. 13.55ft

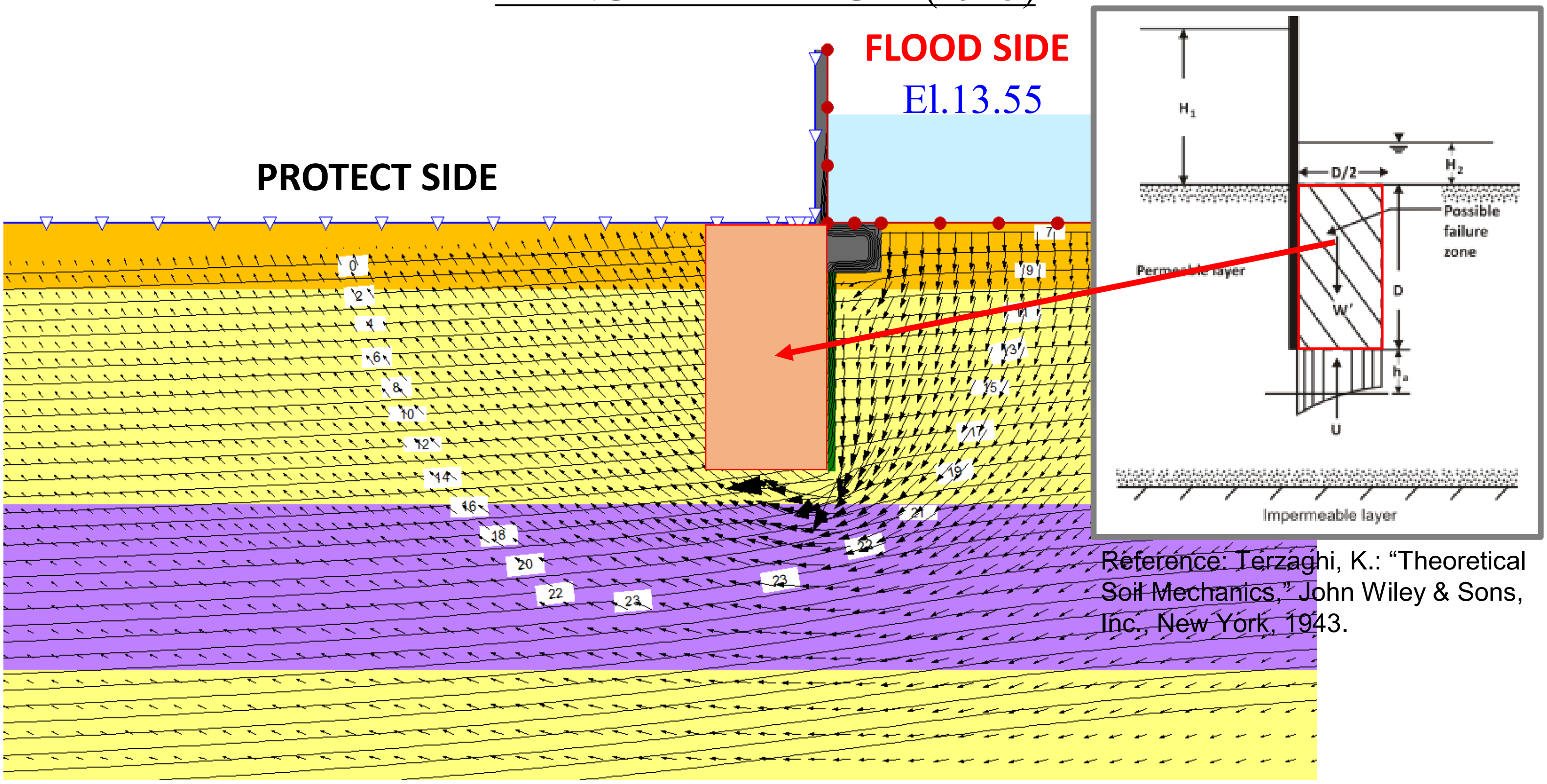
The highest level that water would rise to behind the sheet pile on the protected side: Y=196.2 (El.6.2).

Figure 12: Vertical Gradient behind the Sheet Pile at Peak Flood Elevation

Estimated Factor of safety based on gradient:
FS=1/0.11=9.1 > (FS=4~5 by EM 1110-2-1901, page 4-24), OK

Seepage Analysis Results and Factor of Safety against Piping for WP33~WP40 (Sta.23+00 to 25+00) (IIa)

ESITMATING FACTOR OF SAFETY AGAGINST PIPING BY AGAINST PIPING BY TERZAGHI (1943)



Reference: Terzaghi, K.: "Theoretical Soil Mechanics," John Wiley & Sons, Inc., New York, 1943.

Excess pore pressure at bottom of the possible failure zone: h_a=1.8ft
Height of unsaturated zone on the protected side : 0.8ft
Height of saturated zone above tip of the seepage barrier on the protected side : 17.2ft
Factor of safety against piping due to heave:

FS=[0.8*115+(115-62.4)*17.2]/(1.8*62.4)=8.9 (greater than FS=4~5 recommended by Harr, OK)

Harr (1962, p. 125) suggested that a factor of safety of 4 to 5 with should be sufficient for safe performance of the structure. [Harr, M.: "Groundwater and Seepage," McGraw-Hill Book Company, 1962.]

Seepage Analysis Results and Factor of Safety against Piping for WP33~WP40 (Sta.23+00 to 25+00) (Ib)

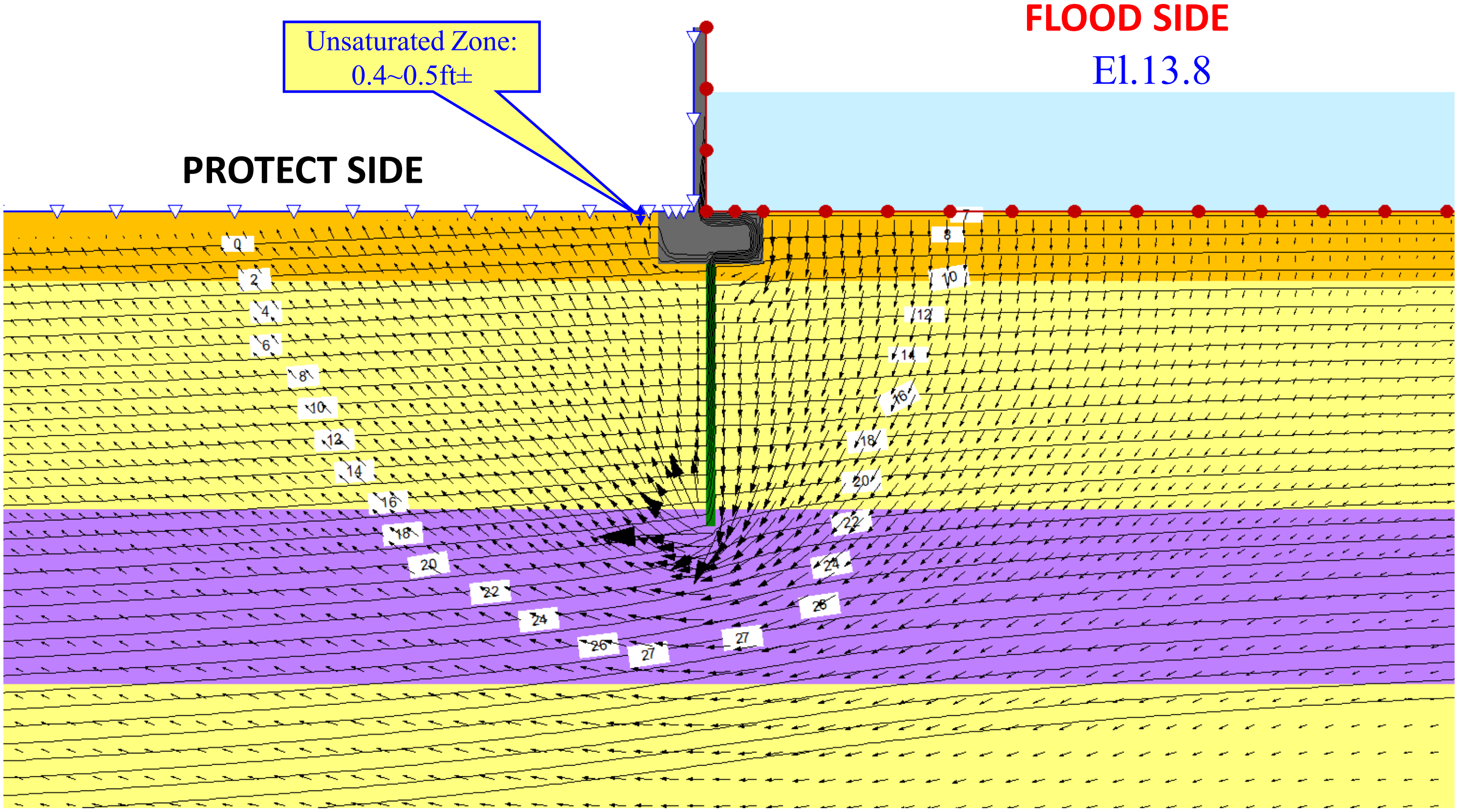
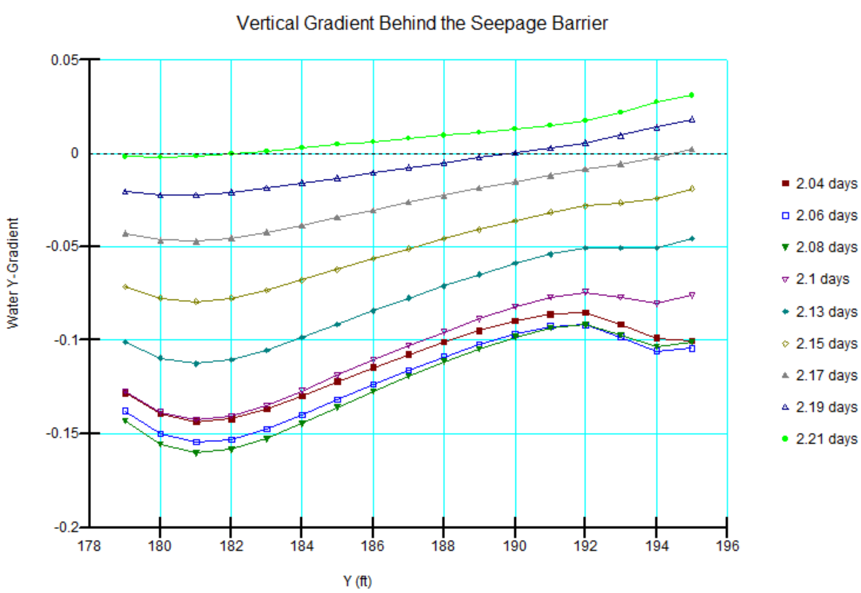


Figure 11: Water Pressure Head Contours for Seepage Barrier with Tip at El.-11.0



On the 2.08th day:
Flood rises to its peak El. 13.8ft

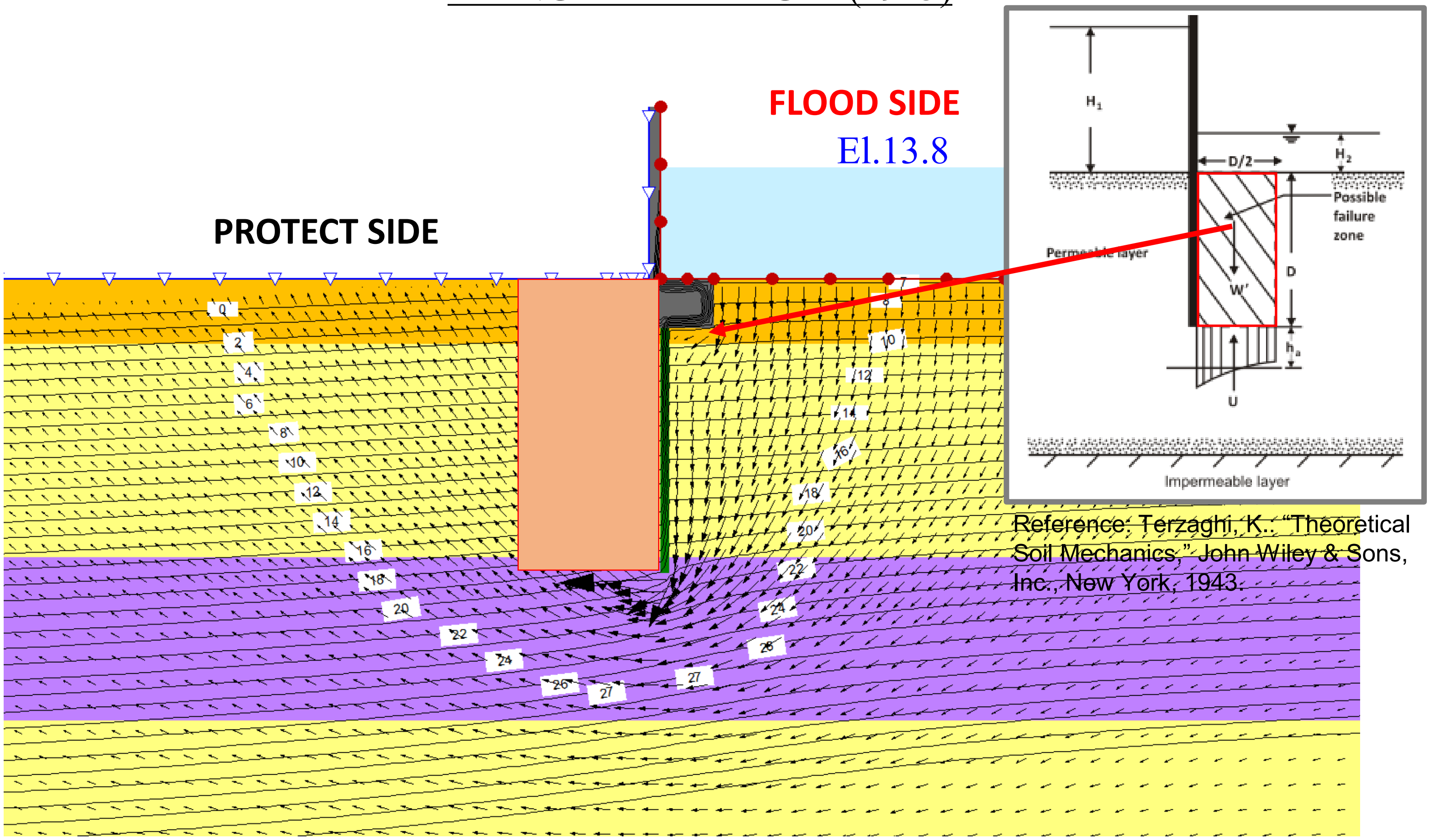
The highest level that water would rise to behind the sheet pile on the protected side: Y=196.5 (El.6.5).

Figure 12: Vertical Gradient behind the Sheet Pile at Peak Flood Elevation

Estimated Factor of safety based on gradient:
FS=1/0.11=9.1 > (FS=4~5 by EM 1110-2-1901, page 4-24), OK

Seepage Analysis Results and Factor of Safety against Piping for WP33~WP40 (Sta.23+00 to 25+00) (IIb)

ESITMATING FACTOR OF SAFETY AGAGINST PIPING BY AGAINST PIPING BY TERZAGHI (1943)



Reference: Terzaghi, K.: "Theoretical Soil Mechanics," John Wiley & Sons, Inc., New York, 1943.

Excess pore pressure at bottom of the possible failure zone: h_a=1.9ft
Height of unsaturated zone on the protected side : 0.5ft
Height of saturated zone above tip of the seepage barrier on the protected side : 17.5ft
Factor of safety against piping due to heave:

FS=[0.5*115+(115-62.4)*17.5]/(1.9*62.4)=8.2 (greater than FS=4~5 recommended by Harr, OK)

Harr (1962, p. 125) suggested that a factor of safety of 4 to 5 with should be sufficient for safe performance of the structure. [Harr, M.: "Groundwater and Seepage," McGraw-Hill Book Company, 1962.]

Seepage Analysis Results and Factor of Safety against Piping for WP40~WP46 (Sta.25+00 to 28+00) (I)

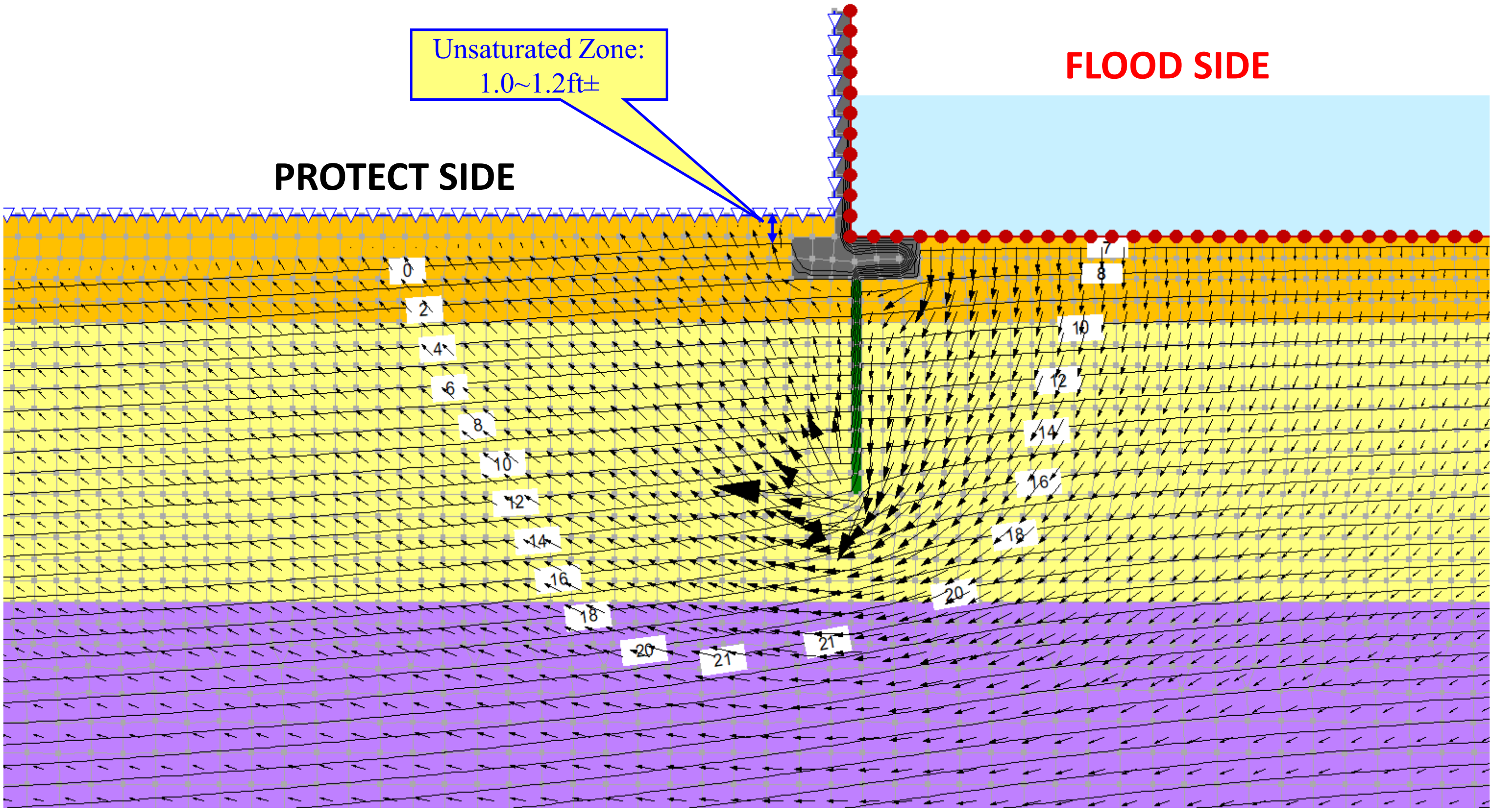
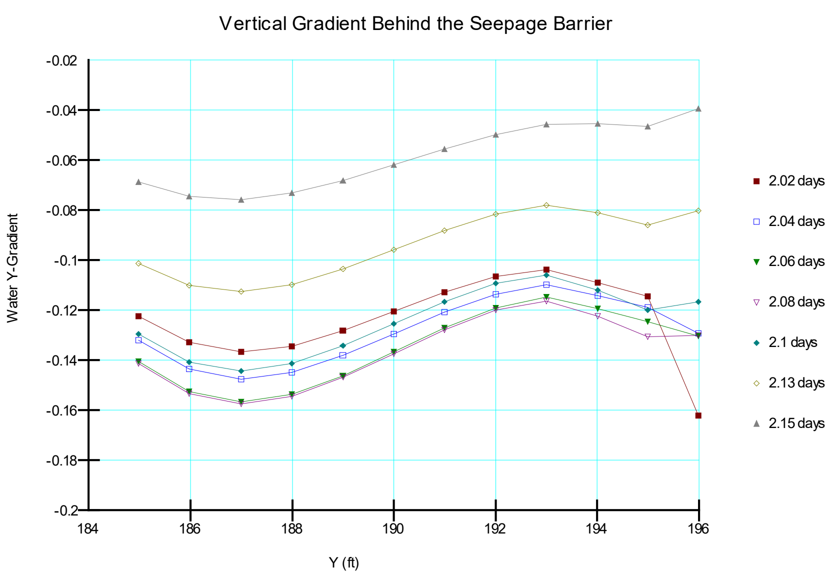


Figure 13: Water Pressure Head Contours for Seepage Barrier with Tip at El.-5.0



On the 2.08th day:
*Flood rises to its peak El. 13.55ft**

*(*insignificant impact on the safety factor against piping using flood elevation of 13.8. See sensitivity analyses performed for Sta.20+50 to 21+50 and Sta.23+00 to 25+00)*

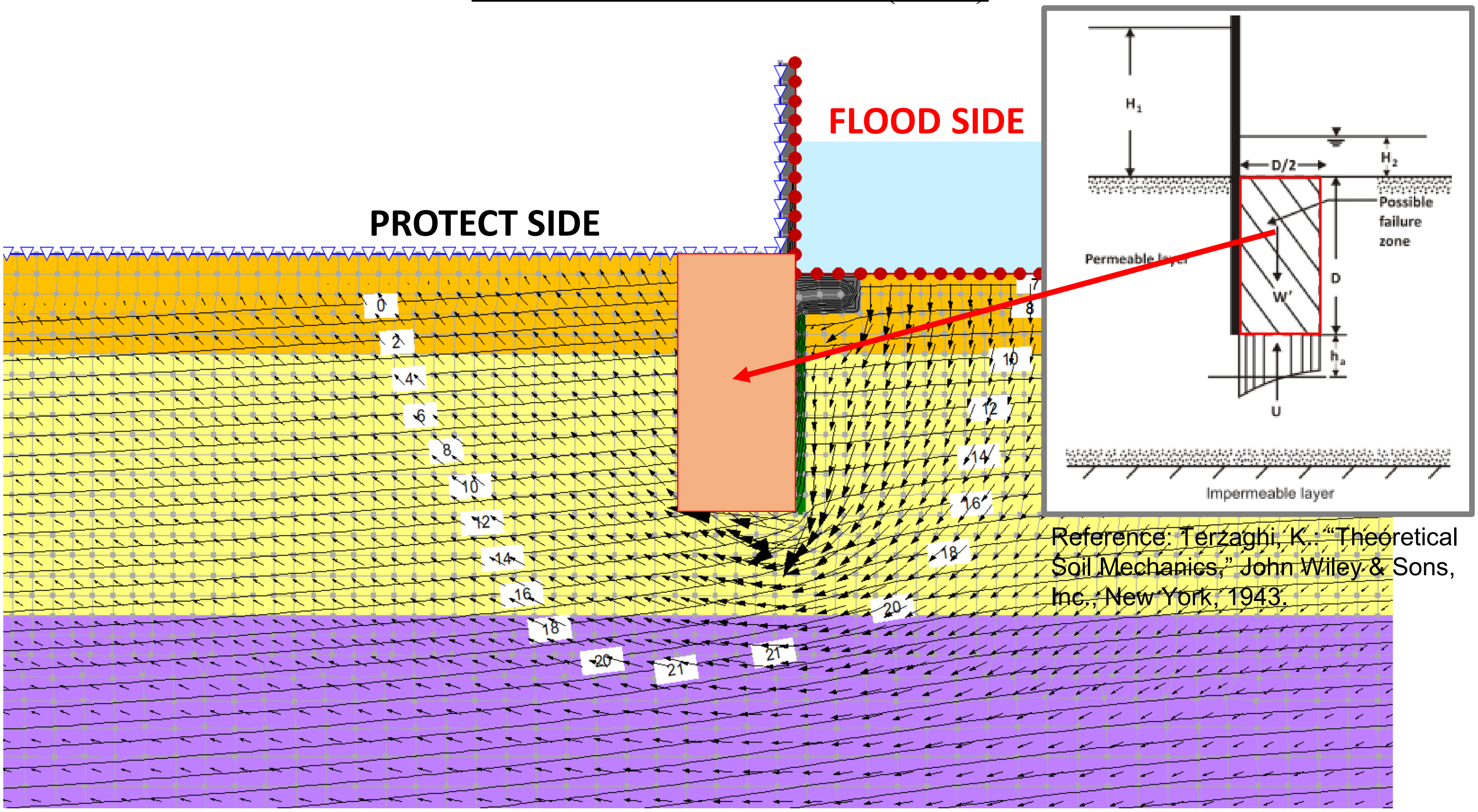
The highest level that water would rise to behind the sheet pile on the protected side: Y=196.8 (El.6.8).

Figure 14: Vertical Gradient behind the Sheet Pile at Peak Flood Elevation

Estimated Factor of safety based on gradient:
FS=1/0.15=6.67 > (FS=4~5 by EM 1110-2-1901, page 4-24), OK

Seepage Analysis Results and Factor of Safety against Piping for WP40~WP46 (Sta.25+00 to 28+00) (II)

ESITMATING FACTOR OF SAFETY AGAGINST PIPING BY AGAINST PIPING BY TERZAGHI (1943)



Reference: Terzaghi, K.: "Theoretical Soil Mechanics," John Wiley & Sons, Inc., New York, 1943.

Excess pore pressure at bottom of the possible failure zone: h_a=1.7ft
Height of unsaturated zone on the protected side : 1.0~1.2ft
Height of saturated zone above tip of the seepage barrier on the protected side : 11.3ft
Factor of safety against piping due to heave:

FS=[1.2*115+(115-62.4)*11.3]/(1.7*62.4)=6.9 (greater than FS=4~5 recommended by Harr, OK)

Harr (1962, p. 125) suggested that a factor of safety of 4 to 5 with should be sufficient for safe performance of the structure. [Harr, M.: "Groundwater and Seepage," McGraw-Hill Book Company, 1962.]

Seepage Analysis Results and Factor of Safety against Piping for W46~WP55 (Sta.28+00 to 30+04 (End)) (I)

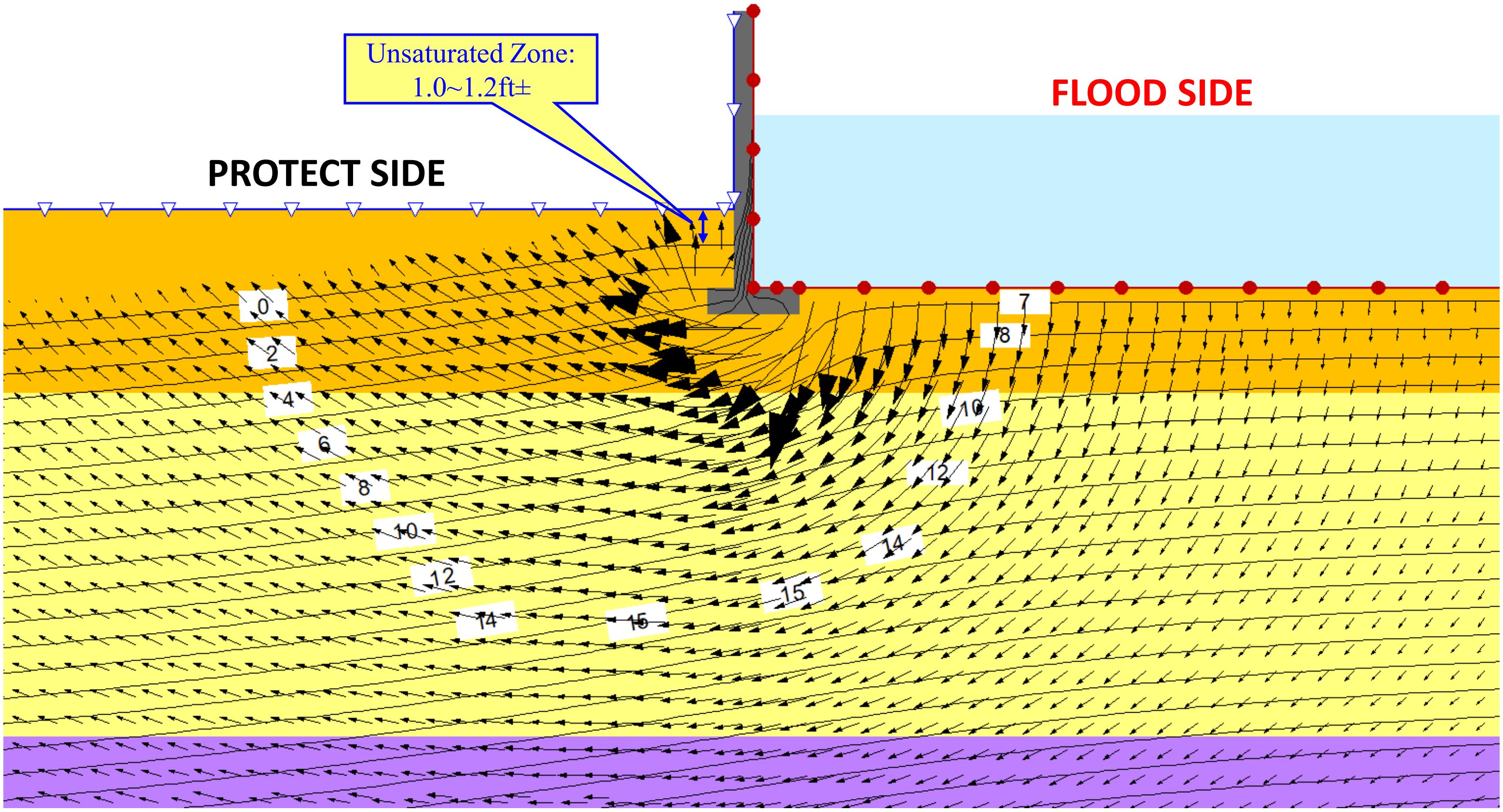
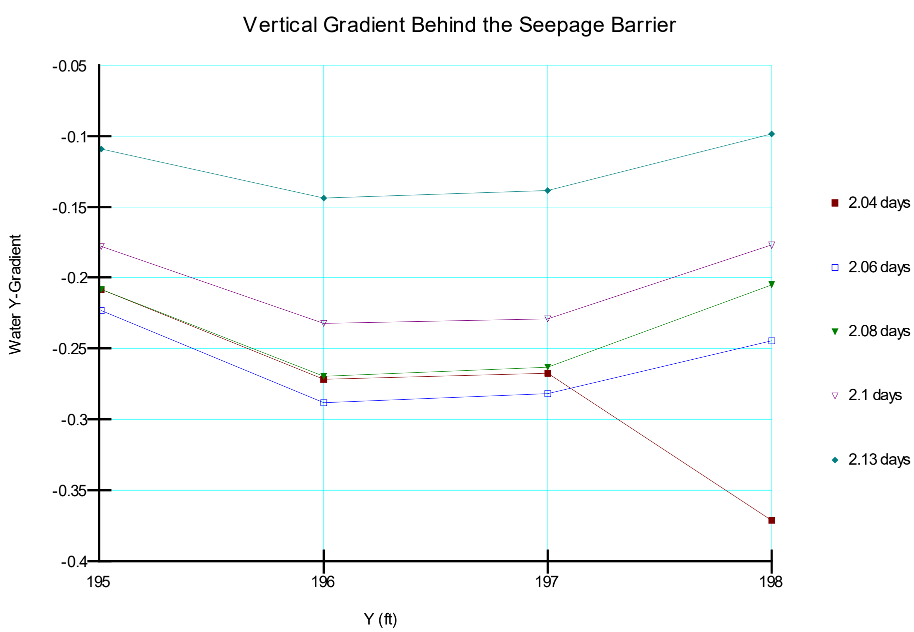


Figure 15: Water Pressure Head Contours for Seepage Barrier with Tip at El. 6.0



On the 2.08th day:
*Flood rises to its peak El. 13.55ft**

*(*insignificant impact on the safety factor against piping using flood elevation of 13.8. See sensitivity analyses performed for Sta.20+50 to 21+50 and Sta.23+00 to 25+00)*

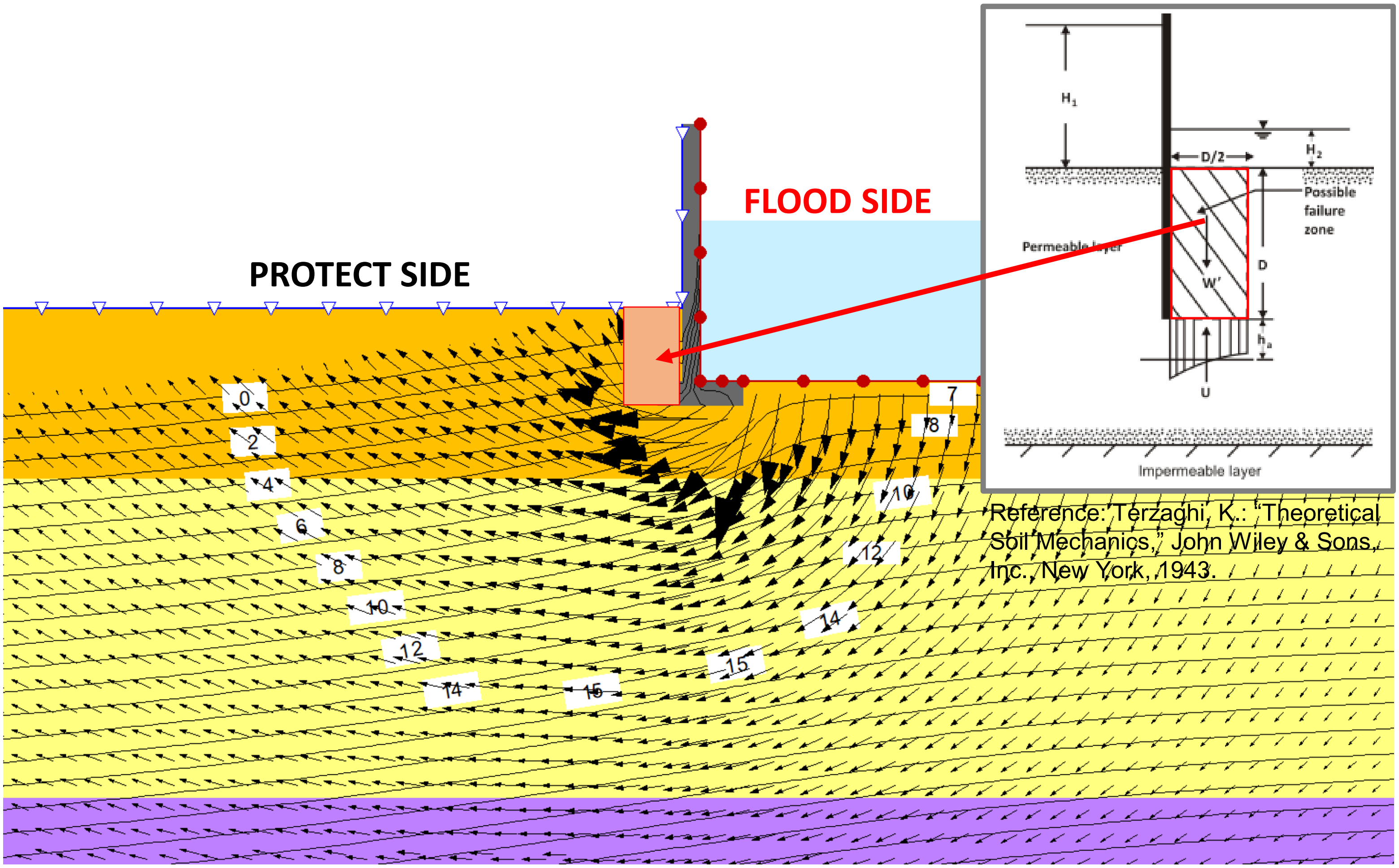
The highest level that water would rise to behind the sheet pile on the protected side: Y=198.8 (El.8.8).

Figure 16: Vertical Gradient behind the Sheet Pile at Peak Flood Elevation

Estimated Factor of safety based on gradient:
FS=1/0.3=3.33 > (FS=2.5~3.0 by EM 1110-2-1901, page 4-24), OK

Seepage Analysis Results and Factor of Safety against Piping for WP46~WP55 (Sta.28+00 to 30+04 (End)) (II)

ESITMATING FACTOR OF SAFETY AGAGINST PIPING BY AGAINST PIPING BY TERZAGHI (1943)



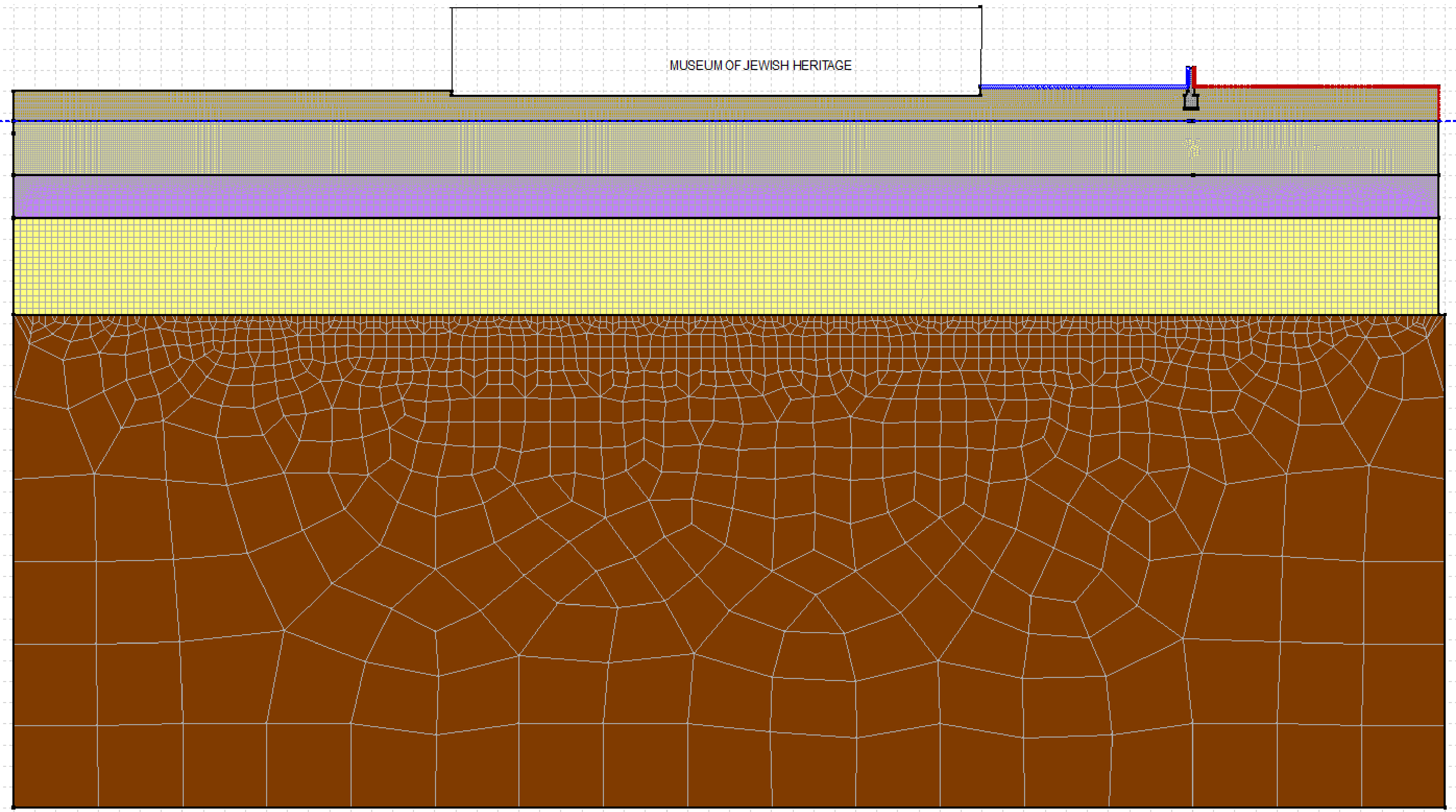
Reference: Terzaghi, K.: "Theoretical Soil Mechanics," John Wiley & Sons, Inc., New York, 1943.

Excess pore pressure at bottom of the possible failure zone: h_a=0.7ft
Height of unsaturated zone on the protected side : 1.0~1.2ft
Height of saturated zone above tip of the seepage barrier on the protected side : 2.8ft
Factor of safety against piping due to heave:

FS=[1.2*115+(115-62.4)*2.8]/(0.7*62.4)=6.5 (greater than FS=4~5 recommended by Harr, OK)

Harr (1962, p. 125) suggested that a factor of safety of 4 to 5 with should be sufficient for safe performance of the structure. [Harr, M.: "Groundwater and Seepage," McGraw-Hill Book Company, 1962.]

2D Model for Seepage Analyses for WP1 ~ WP7



See model inputs summarized in the following 9 pages:

SEEP/W Analysis

File Information

File Version: 9.00
Created By: Drafting
Last Edited By: Drafting
Revision Number: 151
Date: 07/14/2021
Time: 03:31:33 PM
Tool Version: 9.0.3.15488
File Name: Section 1 (1st Place) TIP 6.0 WL3ft.gsz
Directory: R:\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\SEEPW analyses\Seepage Calculations for Review\JMH\1st Place Flowable Fill\
Last Solved Date: 07/14/2021
Last Solved Time: 03:40:38 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SEEP/W Analysis

Kind: SEEP/W
Method: Transient
Physics
- Water Transfer
  - Free convection: thermal effects: No
  - Free convection: solute effects: No
  - Vapor transfer: isothermal: No
  - Vapor transfer: thermal: No

Water Settings
- Initial PWP Conditions from: Water Table
- Maximum Number of Iterations: 500

Maximum Difference: 0.005
Significant Digits: 2
Max # of Reviews: 10
Under-Relaxation Criteria
Initial Rate: 1
Minimum Rate: 0.1
Rate Reduction Factor: 0.65
Reduction Frequency (iterations): 10
Unit Weight of Water: 62.430189 pcf
Bulk Modulus of Pore-Fluid: 43,511,321 psf
Settings
Dimension: 2D
Exclude cumulative values: No
Time
Starting Time: 0 d
Duration: 4 d
# of Steps: 192
Step Generation Method: Linear
Time Increment: 0.020833333 d
Save Steps Every: 1

Materials

Fill saturated

Hydraulic
Model: Saturated Only
Sat Kx: 70 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.38
Beta: 2e-06 /psf

Bedrock

Hydraulic
Model: Saturated Only
Sat Kx: 0.1 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.2

Beta: 1e-08 /psf

Concrete Unsaturated

Hydraulic
- Model: Saturated / Unsaturated
- Vol. WC. Function: Concrete V-G
- K-Function: Concrete Permeability V-G
- Ky'/Kx' Ratio: 1
- Rotation: 0 °

Fill Unsaturated

Hydraulic
- Model: Saturated / Unsaturated
- Vol. WC. Function: V-G Model
- K-Function: V-G Unsaturated
- Ky'/Kx' Ratio: 1
- Rotation: 0 °

Higher permeability

Hydraulic
- Model: Saturated Only
- Sat Kx: 20 ft/d
- Ky'/Kx' Ratio: 1
- Rotation: 0 °
- Volumetric Water Content: 0.3
- Beta: 2e-06 /psf

Initial Water Tables

Initial Water Table 1

Max. negative head: 8 ft

Coordinates
- Coordinate 1: (0.1, 193) ft
- Coordinate 2: (600, 193) ft

Boundary Conditions

Transient Head

Type: Water Total Head
Seep Head vs. Time Function: Peak Reduced by 2.5ft
Review: No

Seepage faces

Type: Water Flux 0
Review: Yes

Water K Functions

V-G Unsaturated

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
    Curve Fit to Data: 100 %
    Segment Curvature: 100 %
Saturated Kx: 0.00081018519
Data Points: Matric Suction (psf), Water X-Conductivity (ft/d)
    Data Point: (0.01, 70)
    Data Point: (0.017988923, 69.999827)
    Data Point: (0.032360135, 69.999368)
    Data Point: (0.058212397, 69.998165)
    Data Point: (0.10471783, 69.995008)
    Data Point: (0.1883761, 69.986701)
    Data Point: (0.33886831, 69.964862)
    Data Point: (0.60958759, 69.907504)
    Data Point: (1.0965824, 69.756483)
    Data Point: (1.9726337, 69.359231)
    Data Point: (3.5485555, 68.316636)
    Data Point: (6.3834691, 65.592593)
    Data Point: (11.483173, 58.68425)
    Data Point: (20.656992, 42.971981)
    Data Point: (37.159703, 18.22063)
    Data Point: (66.846304, 2.6404636)
    Data Point: (120.2493, 0.13510349)
    Data Point: (216.31554, 0.0043672727)
    Data Point: (389.12836, 0.00012489347)
    Data Point: (700, 3.4750248e-06)
Estimation Properties
    Hyd. K-Function Estimation Method: Van Genuchten Function

Volume Water Content Function: V-G Model
Saturated Kx: 70 ft/d
Residual Water Content: 0.0447
Maximum: 700
Minimum: 0.01
Num. Points: 20

Concrete Permeability V-G

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 1e-09
Data Points: Matric Suction (psf), Water X-Conductivity (ft/d)
Data Point: (0.001, 8.64e-05)
Data Point: (0.0014506574, 8.64e-05)
Data Point: (0.002104407, 8.64e-05)
Data Point: (0.0030527737, 8.64e-05)
Data Point: (0.0044285289, 8.64e-05)
Data Point: (0.0064242785, 8.64e-05)
Data Point: (0.0093194274, 8.64e-05)
Data Point: (0.013519297, 8.64e-05)
Data Point: (0.019611869, 8.64e-05)
Data Point: (0.028450103, 8.64e-05)
Data Point: (0.041271354, 8.64e-05)
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Data Point: (0.086851727, 8.64e-05)
Data Point: (0.1259921, 8.64e-05)
Data Point: (0.18277139, 8.64e-05)
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Data Point: (33.405379, 4.5685015e-05)
Data Point: (48.459762, 9.7412672e-06)
Data Point: (70.298515, 4.8659722e-07)
Data Point: (101.97906, 1.0727195e-08)
Data Point: (147.93669, 1.8757487e-10)
Data Point: (214.60546, 3.1983129e-12)
Data Point: (311.31901, 5.3810329e-14)
Data Point: (451.61724, 9.0519556e-16)
Data Point: (655.14191, 1.522525e-17)
Data Point: (950.38649, 2.5598876e-19)
Data Point: (1,378.6852, 4.305468e-21)
Data Point: (2,000, 7.2403592e-23)

Estimation Properties

Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Concrete V-G
Saturated Kx: 8.64e-05 ft/d
Residual Water Content: 0.003
Maximum: 2,000
Minimum: 0.001
Num. Points: 40

Hydraulic Boundary Functions

Peak Reduced by 2.5ft

Model: Step Data Point Function
Function: Water Total Head vs. Time
Y-Intercept: 190
Data Set: Peak Flood El.11.3 - Updated

Vol. Water Content Functions

V-G Model

Model: Van Genuchten Function
Function: Volumetric Water Content vs. Water Pressure
Beta: 2e-06 /psf
Saturated Water Content: 0.38
Residual Water Content: 0.0447

A: 52 psf
N: 2.65
M: 0.6226415094339622
Suction Limit: 20885434.21089708
Porosity: 0.38000035

Concrete V-G

Model: Van Genuchten Function
Function: Volumetric Water Content vs. Water Pressure
Beta: 1e-10 /psf
Saturated Water Content: 0.05
Residual Water Content: 0.003
A: 47.25 psf
N: 4.6
M: 0.7826086956521738
Suction Limit: 20885434.21089708
Porosity: 0.05

Points

	X	Y
Point 1	600 ft	190 ft
Point 2	438.5 ft	201 ft
Point 3	329.7 ft	201 ft
Point 4	204 ft	200 ft
Point 5	100 ft	200 ft
Point 6	100 ft	30 ft
Point 7	440 ft	30 ft
Point 8	100 ft	147 ft
Point 9	440 ft	147 ft
Point 10	100 ft	190 ft
Point 11	438.5 ft	147 ft
Point 12	329.7 ft	220 ft
Point 13	438.49869 ft	180 ft
Point 14	438.51913 ft	170 ft
Point 15	100 ft	170 ft
Point 16	100 ft	180 ft
Point 17	379 ft	201 ft
Point 18	380.5 ft	201 ft

Point 19	379 ft	200 ft
Point 20	380.5 ft	199 ft
Point 21	378.25 ft	199 ft
Point 22	381.25 ft	199 ft
Point 23	378.25 ft	196 ft
Point 24	381.25 ft	196 ft
Point 25	379 ft	205.5 ft
Point 26	380.5 ft	205.5 ft
Point 27	379.25 ft	196 ft
Point 28	380.25 ft	196 ft
Point 29	380.25 ft	180 ft
Point 30	204 ft	199 ft
Point 31	329.7 ft	199 ft
Point 32	379.25 ft	193 ft
Point 33	100 ft	193 ft
Point 34	380.25 ft	193 ft
Point 35	438.5 ft	193 ft

Lines

	Start Point	End Point	Length	Angle	Hydraulic Boundary
Line 1	6	7	340 ft	0 °	
Line 2	7	9	117 ft	90 °	
Line 3	8	6	117 ft	90 °	
Line 4	9	11	1.5 ft	0 °	
Line 5	11	14	23 ft	90 °	
Line 6	14	13	10 ft	-89.9 °	
Line 7	15	8	23 ft	90 °	
Line 8	10	16	10 ft	90 °	
Line 9	16	15	10 ft	90 °	
Line 10	24	22	3 ft	90 °	
Line 11	22	20	0.75 ft	0 °	
Line 12	20	18	2 ft	90 °	
Line 13	17	19	1 ft	90 °	
Line 14	19	21	1.25 ft	53.1 °	
Line 15	21	23	3 ft	90 °	
Line 16	3	17	49.3 ft	0 °	Seepage faces
Line 17	18	2	58 ft	0 °	Transient Head

Line 18	26	18	4.5 ft	90 °	Transient Head
Line 19	17	25	4.5 ft	90 °	Seepage faces
Line 20	28	27	1 ft	0 °	
Line 21	27	23	1 ft	0 °	
Line 22	24	28	1 ft	0 °	
Line 23	11	8	338.5 ft	0 °	
Line 24	3	31	2 ft	90 °	
Line 25	31	30	125.7 ft	0 °	
Line 26	30	4	1 ft	90 °	
Line 27	4	5	104 ft	0 °	
Line 28	5	33	7 ft	90 °	
Line 29	33	32	279.25 ft	0 °	
Line 30	10	33	3 ft	90 °	
Line 31	32	34	1 ft	0 °	
Line 32	35	34	58.25 ft	0 °	
Line 33	15	14	338.52 ft	0 °	
Line 34	29	13	58.249 ft	0 °	
Line 35	35	2	8 ft	90 °	Transient Head
Line 36	13	35	13 ft	90 °	
Line 37	26	25	1.5 ft	0 °	
Line 38	29	16	280.25 ft	0 °	

Regions

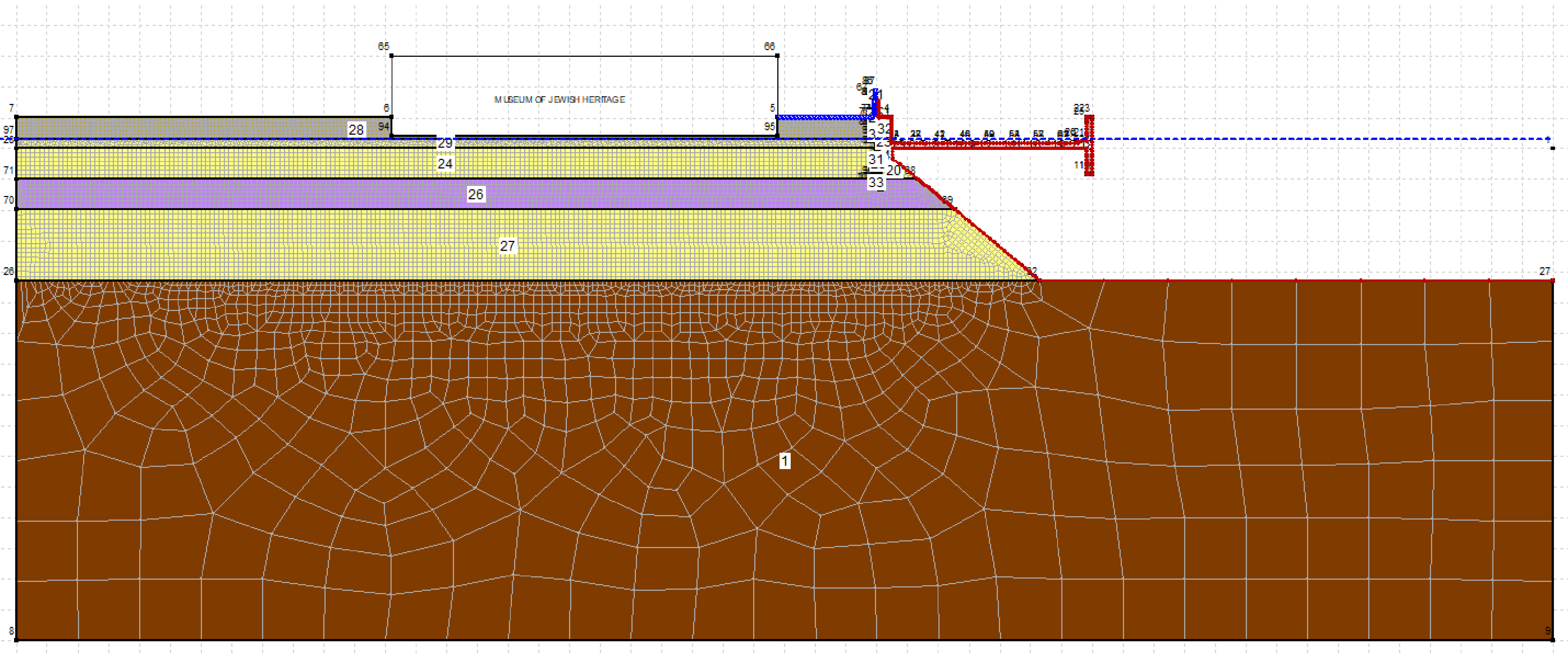
	Material	Points	Area
Region 1	Bedrock	8,6,7,9,11	39,780 ft^2
Region 2	Concrete Unsaturated	25,17,19,21,23,27,28,24,22,20,18,26	19.125 ft^2
Region 3	Higher permeability	16,15,14,13,29	3,385.1 ft^2
Region 4	Fill saturated	15,8,11,14	7,785.7 ft^2
Region 5	Fill Unsaturated	27,23,21,19,17,3,31,30,4,5,33,32,34,35,2,18,20,22,24,28	2,340.2 ft^2
Region 6	Fill saturated	32,33,10,16,29,13,35,34	4,400.5 ft^2

Mesh Properties

View: 2D

Element Thickness: 1 ft

2D Model for Seepage Analyses for WP7~WP20
(Sta.10+45 to Sta.14+61)



See model inputs summarized in the following 15 pages:

SEEP/W Analysis

File Information

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Created By: Drafting
Last Edited By: Drafting
Revision Number: 129
Date: 12/24/2020
Time: 12:01:43 PM
Tool Version: 9.0.3.15488
File Name: Sec on 1 (Sta. 10+45 to 14+61) TIP-12 WL3ft.gsz
Directory: R:\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\SEEPW analyses\Seepage Calcula ons for Review\JMH\1st FL Slab Sheet Pile\

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SEEP/W Analysis

Kind: SEEP/W
Method: Transient
Physics
- Water Transfer
  - Free convection: thermal effects: No
  - Free convection: solute effects: No
  - Vapor transfer: isothermal: No
  - Vapor transfer: thermal: No

Water Settings
- Initial PWP Conditions from: Water Table
- Maximum Number of Iterations: 500
- Maximum Difference: 0.005
- Significant Digits: 2

Max # of Reviews: 10
Under-Relaxation Criteria
Initial Rate: 1
Minimum Rate: 0.1
Rate Reduction Factor: 0.65
Reduction Frequency (iterations): 10
Unit Weight of Water: 62.430189 pcf
Bulk Modulus of Pore-Fluid: 43,511,321 psf
Settings
Dimension: 2D
Exclude cumulative values: No
Time
Starting Time: 0 d
Duration: 4 d
# of Steps: 192
Step Generation Method: Linear
Time Increment: 0.020833333 d
Save Steps Every: 1

Materials

Fill saturated

Hydraulic
Model: Saturated Only
Sat Kx: 20 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.38
Beta: 2e-06 /psf

Bedrock

Hydraulic
Model: Saturated Only
Sat Kx: 0.1 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.2
Beta: 1e-08 /psf

Concrete Unsaturated

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: Concrete V-G
K-Function: Concrete Permeability V-G
Ky'/Kx' Ratio: 1
Rotation: 0 °

Fill Unsaturated

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: V-G Model
K-Function: V-G Unsaturated
Ky'/Kx' Ratio: 1
Rotation: 0 °

Higher permeability

Hydraulic

Model: Saturated Only
Sat Kx: 20 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.3
Beta: 2e-06 /psf

Concrete Saturated

Hydraulic

Model: Saturated Only
Sat Kx: 8.64e-05 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0
Beta: 0 /psf

Sheetpile

Hydraulic

Model: Saturated Only
Sat Kx: 0.000935 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °

Volumetric Water Content: 0
Beta: 0 /psf

Initial Water Tables

Initial Water Table 1

Max. negative head: 8 ft
Coordinates
Coordinate 1: (0.1, 193) ft
Coordinate 2: (600, 193) ft

Boundary Conditions

Transient Head

Type: Water Total Head
Seep Head vs. Time Function: Long
Review: No

Seepage faces

Type: Water Flux 0
Review: Yes

Water K Functions

V-G Unsaturated

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 0.00023148148
Data Points: Matric Suction (psf), Water X-Conductivity (ft/d)
Data Point: (0.01, 20)
Data Point: (0.017988923, 19.99995)
Data Point: (0.032360135, 19.999819)
Data Point: (0.058212397, 19.999476)
Data Point: (0.10471783, 19.998574)

Data Point: (0.1883761, 19.9962)
Data Point: (0.33886831, 19.989961)
Data Point: (0.60958759, 19.973572)
Data Point: (1.0965824, 19.930424)
Data Point: (1.9726337, 19.816923)
Data Point: (3.5485555, 19.519039)
Data Point: (6.3834691, 18.740741)
Data Point: (11.483173, 16.766929)
Data Point: (20.656992, 12.277709)
Data Point: (37.159703, 5.2058944)
Data Point: (66.846304, 0.75441818)
Data Point: (120.2493, 0.038600998)
Data Point: (216.31554, 0.0012477922)
Data Point: (389.12836, 3.568385e-05)
Data Point: (700, 9.9286424e-07)

Estimation Properties

Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: V-G Model
Saturated Kx: 70 ft/d
Residual Water Content: 0.0447
Maximum: 700
Minimum: 0.01
Num. Points: 20

Concrete Permeability V-G

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 1e-09
Data Points: Matric Suction (psf), Water X-Conductivity (ft/d)
Data Point: (0.001, 8.64e-05)
Data Point: (0.0014506574, 8.64e-05)
Data Point: (0.002104407, 8.64e-05)
Data Point: (0.0030527737, 8.64e-05)
Data Point: (0.0044285289, 8.64e-05)
Data Point: (0.0064242785, 8.64e-05)
Data Point: (0.0093194274, 8.64e-05)
Data Point: (0.013519297, 8.64e-05)
Data Point: (0.019611869, 8.64e-05)
Data Point: (0.028450103, 8.64e-05)

Data Point: (0.041271354, 8.64e-05)
Data Point: (0.059870597, 8.64e-05)
Data Point: (0.086851727, 8.64e-05)
Data Point: (0.1259921, 8.64e-05)
Data Point: (0.18277139, 8.64e-05)
Data Point: (0.26513867, 8.6399998e-05)
Data Point: (0.38462539, 8.6399997e-05)
Data Point: (0.55795968, 8.6399979e-05)
Data Point: (0.80940837, 8.639991e-05)
Data Point: (1.1741743, 8.6399757e-05)
Data Point: (1.7033247, 8.6398742e-05)
Data Point: (2.4709406, 8.6395843e-05)
Data Point: (3.5844884, 8.6383756e-05)
Data Point: (5.1998648, 8.633371e-05)
Data Point: (7.5432225, 8.6167714e-05)
Data Point: (10.942632, 8.5459786e-05)
Data Point: (15.874011, 8.2780909e-05)
Data Point: (23.027752, 7.3231988e-05)
Data Point: (33.405379, 4.5685015e-05)
Data Point: (48.459762, 9.7412672e-06)
Data Point: (70.298515, 4.8659722e-07)
Data Point: (101.97906, 1.0727195e-08)
Data Point: (147.93669, 1.8757487e-10)
Data Point: (214.60546, 3.1983129e-12)
Data Point: (311.31901, 5.3810329e-14)
Data Point: (451.61724, 9.0519556e-16)
Data Point: (655.14191, 1.522525e-17)
Data Point: (950.38649, 2.5598876e-19)
Data Point: (1,378.6852, 4.305468e-21)
Data Point: (2,000, 7.2403592e-23)

Estimation Properties

Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Concrete V-G
Saturated Kx: 8.64e-05 ft/d
Residual Water Content: 0.003
Maximum: 2,000
Minimum: 0.001
Num. Points: 40

Hydraulic Boundary Functions

Long

- Model: Spline Data Point Function
- Function: Water Total Head vs. Time
  - Curve Fit to Data: 100 %
  - Segment Curvature: 100 %
- Y-Intercept: 190
- Data Set: Copy of Book2

Vol. Water Content Functions

V-G Model

- Model: Van Genuchten Function
- Function: Volumetric Water Content vs. Water Pressure
  - Beta: 2e-06 /psf
  - Saturated Water Content: 0.38
  - Residual Water Content: 0.0447
  - A: 52 psf
  - N: 2.65
  - M: 0.6226415094339622
  - Suction Limit: 20885434.21089708
- Porosity: 0.38000035

Concrete V-G

- Model: Van Genuchten Function
- Function: Volumetric Water Content vs. Water Pressure
  - Beta: 1e-10 /psf
  - Saturated Water Content: 0.05
  - Residual Water Content: 0.003
  - A: 47.25 psf
  - N: 4.6
  - M: 0.7826086956521738
  - Suction Limit: 20885434.21089708
- Porosity: 0.05

Points

	X	Y
Point 1	600 ft	190 ft
Point 2	450 ft	190 ft
Point 3	450 ft	200 ft
Point 4	384.7 ft	200 ft
Point 5	347.7 ft	200 ft
Point 6	222 ft	200 ft
Point 7	100 ft	200 ft
Point 8	100 ft	30 ft
Point 9	600 ft	30 ft
Point 10	450 ft	181.5 ft
Point 11	448.3 ft	181.5 ft
Point 12	448.3 ft	190.2 ft
Point 13	385.2 ft	190.2 ft
Point 14	385.2 ft	186.6 ft
Point 15	381.4 ft	186.6 ft
Point 16	381.4 ft	176.4 ft
Point 17	380.9 ft	176.4 ft
Point 18	380.9 ft	191.5 ft
Point 19	445.4 ft	191.5 ft
Point 20	445.4 ft	192.3 ft
Point 21	448.3 ft	192.3 ft
Point 22	448.3 ft	200 ft
Point 23	384.7 ft	191.5 ft
Point 24	384.7 ft	199 ft
Point 25	448.3 ft	199 ft
Point 26	100 ft	147 ft
Point 27	600 ft	147 ft
Point 28	100 ft	190 ft
Point 29	380.9 ft	190 ft
Point 30	448.3 ft	190 ft
Point 31	385.2 ft	190 ft
Point 32	433 ft	147 ft
Point 33	388 ft	191.5 ft
Point 34	388.1 ft	191.5 ft
Point 35	388.1 ft	190.2 ft
Point 36	388 ft	190.2 ft
Point 37	395 ft	191.5 ft
Point 38	395.1 ft	191.5 ft

Point 39	395.1 ft	190.2 ft
Point 40	395 ft	190.2 ft
Point 41	403 ft	191.5 ft
Point 42	403.1 ft	191.5 ft
Point 43	403.1 ft	190.2 ft
Point 44	403 ft	190.2 ft
Point 45	411 ft	191.5 ft
Point 46	411.1 ft	191.5 ft
Point 47	411.1 ft	190.2 ft
Point 48	411 ft	190.2 ft
Point 49	419 ft	191.5 ft
Point 50	419.1 ft	191.5 ft
Point 51	419.1 ft	190.2 ft
Point 52	419 ft	190.2 ft
Point 53	427 ft	191.5 ft
Point 54	427.1 ft	191.5 ft
Point 55	427.1 ft	190.2 ft
Point 56	427 ft	190.2 ft
Point 57	435 ft	191.5 ft
Point 58	435.1 ft	191.5 ft
Point 59	435.1 ft	190.2 ft
Point 60	435 ft	190.2 ft
Point 61	443 ft	191.5 ft
Point 62	443.1 ft	191.5 ft
Point 63	443.1 ft	190.2 ft
Point 64	443 ft	190.2 ft
Point 65	222 ft	220 ft
Point 66	347.7 ft	220 ft
Point 67	377.7 ft	207 ft
Point 68	393.27869 ft	180 ft
Point 69	405.51913 ft	170 ft
Point 70	100 ft	170 ft
Point 71	100 ft	180 ft
Point 72	380.9 ft	180 ft
Point 73	381.4 ft	180 ft
Point 74	379 ft	200 ft
Point 75	380.5 ft	200 ft
Point 76	379 ft	199 ft
Point 77	380.5 ft	199 ft

Point 78	378.25 ft	199 ft
Point 79	381.25 ft	199 ft
Point 80	378.25 ft	196 ft
Point 81	381.25 ft	196 ft
Point 82	379 ft	205.5 ft
Point 83	380.5 ft	205.5 ft
Point 84	379.5 ft	205.5 ft
Point 85	380 ft	205.5 ft
Point 86	379.5 ft	209 ft
Point 87	380 ft	209 ft
Point 88	379.25 ft	196 ft
Point 89	380.25 ft	196 ft
Point 90	380.25 ft	180 ft
Point 91	379.25 ft	180 ft
Point 92	380.25 ft	190 ft
Point 93	379.25 ft	190 ft
Point 94	222 ft	194 ft
Point 95	347.7 ft	194 ft
Point 96	379.25 ft	193 ft
Point 97	100 ft	193 ft
Point 98	380.25 ft	193 ft
Point 99	384.7 ft	193 ft
Point 100	380.25 ft	178 ft
Point 101	379.25 ft	178 ft

Lines

	Start Point	End Point	Hydraulic Boundary	Length	Angle
Line 1	10	11	Transient Head	1.7 ft	0 °
Line 2	14	15		3.8 ft	0 °
Line 3	16	17		0.5 ft	0 °
Line 4	19	20		0.8 ft	90 °
Line 5	20	21	Transient Head	2.9 ft	0 °
Line 6	22	3	Transient Head	1.7 ft	0 °
Line 7	21	25	Transient Head	6.7 ft	90 °
Line 8	24	4	Transient Head	1 ft	90 °
Line 9	22	25	Transient Head	1 ft	90 °
Line 10	23	18		3.8 ft	0 °

Line 11	8	9		500 ft	0 °
Line 12	2	10	Transient Head	8.5 ft	90 °
Line 13	2	3	Transient Head	10 ft	90 °
Line 14	9	27		117 ft	90 °
Line 15	26	8		117 ft	90 °
Line 16	13	31		0.2 ft	90 °
Line 17	31	14	Transient Head	3.4 ft	90 °
Line 18	11	30	Transient Head	8.5 ft	90 °
Line 19	30	31	Transient Head	63.1 ft	0 °
Line 20	29	18		1.5 ft	90 °
Line 21	12	30		0.2 ft	90 °
Line 22	27	32	Transient Head	167 ft	0 °
Line 23	23	33	Transient Head	3.3 ft	0 °
Line 24	33	34	Transient Head	0.1 ft	0 °
Line 25	35	36		0.1 ft	0 °
Line 26	36	13		2.8 ft	0 °
Line 27	33	36		1.3 ft	90 °
Line 28	35	34		1.3 ft	90 °
Line 29	34	37	Transient Head	6.9 ft	0 °
Line 30	37	38	Transient Head	0.1 ft	0 °
Line 31	39	40		0.1 ft	0 °
Line 32	40	35		6.9 ft	0 °
Line 33	37	40		1.3 ft	90 °
Line 34	39	38		1.3 ft	90 °
Line 35	38	41	Transient Head	7.9 ft	0 °
Line 36	41	42	Transient Head	0.1 ft	0 °
Line 37	43	44		0.1 ft	0 °
Line 38	44	39		7.9 ft	0 °
Line 39	41	44		1.3 ft	90 °
Line 40	43	42		1.3 ft	90 °
Line 41	42	45	Transient Head	7.9 ft	0 °
Line 42	45	46	Transient Head	0.1 ft	0 °
Line 43	47	48		0.1 ft	0 °
Line 44	48	43		7.9 ft	0 °
Line 45	45	48		1.3 ft	90 °
Line 46	47	46		1.3 ft	90 °
Line 47	46	49	Transient Head	7.9 ft	0 °
Line 48	49	50	Transient Head	0.1 ft	0 °
Line 49	51	52		0.1 ft	0 °

Line 50	52	47		7.9 ft	0 °
Line 51	49	52		1.3 ft	90 °
Line 52	51	50		1.3 ft	90 °
Line 53	50	53	Transient Head	7.9 ft	0 °
Line 54	53	54	Transient Head	0.1 ft	0 °
Line 55	55	56		0.1 ft	0 °
Line 56	56	51		7.9 ft	0 °
Line 57	53	56		1.3 ft	90 °
Line 58	55	54		1.3 ft	90 °
Line 59	54	57	Transient Head	7.9 ft	0 °
Line 60	57	58	Transient Head	0.1 ft	0 °
Line 61	59	60		0.1 ft	0 °
Line 62	60	55		7.9 ft	0 °
Line 63	57	60		1.3 ft	90 °
Line 64	59	58		1.3 ft	90 °
Line 65	58	61	Transient Head	7.9 ft	0 °
Line 66	61	62	Transient Head	0.1 ft	0 °
Line 67	62	19	Transient Head	2.3 ft	0 °
Line 68	12	63		5.2 ft	0 °
Line 69	63	64		0.1 ft	0 °
Line 70	64	59		7.9 ft	0 °
Line 71	61	64		1.3 ft	90 °
Line 72	63	62		1.3 ft	90 °
Line 73	68	14	Transient Head	10.432 ft	-39.2 °
Line 74	32	69	Transient Head	35.836 ft	-39.9 °
Line 75	69	68	Transient Head	15.806 ft	-39.2 °
Line 76	70	26		23 ft	90 °
Line 77	28	71		10 ft	90 °
Line 78	71	70		10 ft	90 °
Line 79	17	72		3.6 ft	90 °
Line 80	72	29		10 ft	90 °
Line 81	15	73		6.6 ft	90 °
Line 82	73	16		3.6 ft	90 °
Line 83	68	73		11.879 ft	0 °
Line 84	81	79		3 ft	90 °
Line 85	79	77		0.75 ft	0 °
Line 86	77	75		1 ft	90 °
Line 87	74	76		1 ft	90 °
Line 88	76	78		0.75 ft	0 °

Line 89	78	80		3 ft	90 °
Line 90	84	85		0.5 ft	0 °
Line 91	85	87		3.5 ft	90 °
Line 92	87	86		0.5 ft	0 °
Line 93	86	84	Seepage faces	3.5 ft	90 °
Line 94	5	74	Seepage faces	31.3 ft	0 °
Line 95	75	4	Transient Head	4.2 ft	0 °
Line 96	82	84	Seepage faces	0.5 ft	0 °
Line 97	85	83		0.5 ft	0 °
Line 98	83	75	Transient Head	5.5 ft	90 °
Line 99	74	82	Seepage faces	5.5 ft	90 °
Line 100	92	29		0.65 ft	0 °
Line 101	28	93		279.25 ft	0 °
Line 102	91	90		1 ft	0 °
Line 103	90	92		10 ft	90 °
Line 104	89	88		1 ft	0 °
Line 105	93	91		10 ft	90 °
Line 106	88	80		1 ft	0 °
Line 107	81	89		1 ft	0 °
Line 108	71	91		279.25 ft	0 °
Line 109	90	72		0.65 ft	0 °
Line 110	32	26		333 ft	0 °
Line 111	96	93		3 ft	90 °
Line 112	5	95		6 ft	90 °
Line 113	95	94		125.7 ft	0 °
Line 114	94	6		6 ft	90 °
Line 115	6	7		122 ft	0 °
Line 116	7	97		7 ft	90 °
Line 117	97	96		279.25 ft	0 °
Line 118	28	97		3 ft	90 °
Line 119	92	98		3 ft	90 °
Line 120	96	98		1 ft	0 °
Line 121	96	88		3 ft	90 °
Line 122	89	98		3 ft	90 °
Line 123	24	99	Transient Head	6 ft	90 °
Line 124	99	23	Transient Head	1.5 ft	90 °
Line 125	99	98		4.45 ft	0 °
Line 126	100	90		2 ft	90 °
Line 127	91	101		2 ft	90 °

Line 128	100	101		1 ft	0 °
Line 129	70	69		305.52 ft	0 °

Regions

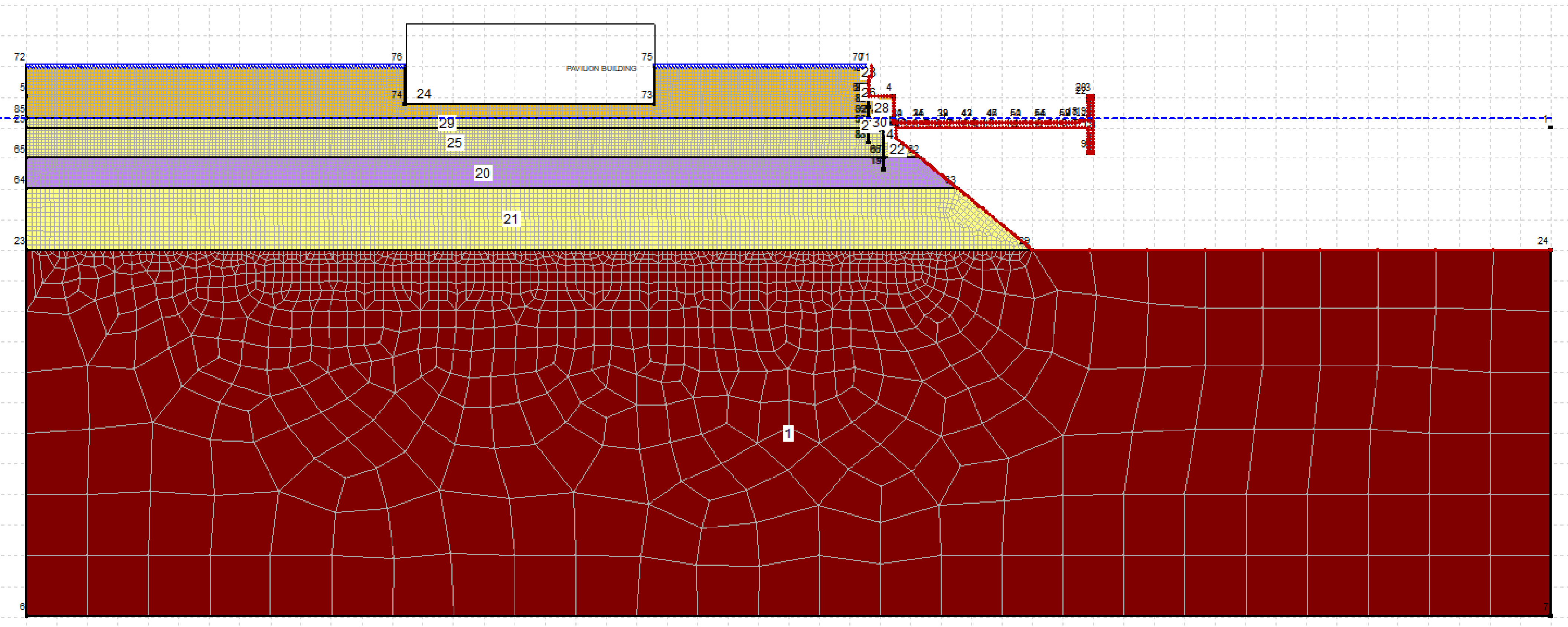
	Material	Points	Area
Region 1	Bedrock	26,8,9,27,32	58,500 ft²
Region 2	Fill Unsaturated	31,13,36,35,40,39,44,43,48,47,52,51,56,55,60,59,64,63,12,30	12.62 ft²
Region 3	Concrete Unsaturated	33,36,35,34	0.13 ft²
Region 4	Concrete Saturated	23,18,29,72,17,16,73,15,14,31,13,36,33	29.81 ft²
Region 5	Concrete Unsaturated	37,40,39,38	0.13 ft²
Region 6	Concrete Saturated	34,35,40,37	8.97 ft²
Region 7	Concrete Unsaturated	41,44,43,42	0.13 ft²
Region 8	Concrete Saturated	38,39,44,41	10.27 ft²
Region 9	Concrete Unsaturated	45,48,47,46	0.13 ft²
Region 10	Concrete Saturated	42,43,48,45	10.27 ft²
Region 11	Concrete Unsaturated	49,52,51,50	0.13 ft²
Region 12	Concrete Saturated	46,47,52,49	10.27 ft²
Region 13	Concrete Unsaturated	53,56,55,54	0.13 ft²
Region 14	Concrete Saturated	50,51,56,53	10.27 ft²
Region 15	Concrete Unsaturated	57,60,59,58	0.13 ft²
Region 16	Concrete Saturated	54,55,60,57	10.27 ft²
Region 17	Concrete Unsaturated	61,64,63,62	0.13 ft²
Region 18	Concrete Saturated	10,2,3,22,25,21,20,19,62,63,12,30,11	40.53 ft²
Region 19	Concrete Saturated	58,59,64,61	10.27 ft²
Region 20	Fill saturated	14,15,73,68	51.74 ft²
Region 21	Concrete Unsaturated	84,85,87,86	1.75 ft²
Region 22	Concrete Unsaturated	82,74,76,78,80,88,89,81,79,77,75,83,85,84	18.75 ft²
Region 23	Fill saturated	29,18,23,99,98,92	7.65 ft²
Region 24	Fill saturated	28,71,91,93	2,792.5 ft²
Region 25	Fill saturated	72,29,92,90	6.5 ft²
Region 26	Higher permeability	101,91,71,70,69,68,73,16,17,72,90,100	2,990.2 ft²
Region 27	Fill saturated	70,26,32,69	7,343 ft²
Region 28	Fill Unsaturated	78,76,74,5,95,94,6,7,97,96,88,80	1,197.3 ft²
Region 29	Fill saturated	96,93,28,97	837.75 ft²
Region 30	Sheetpile	88,96,98,89	3 ft²
Region 31	Sheetpile	96,93,91,90,92,98	13 ft²
Region 32	Fill Unsaturated	24,4,75,77,79,81,89,98,99	27.9 ft²

Region 33	Sheetpile	91,101,100,90	2 ft²

Mesh Properties

View: 2D
Element Thickness: 1 ft

2D Model for Seepage Analyses for WP20~WP26
Sta.14+61 to 20+50



See model inputs summarized in the following 14 pages:

SEEP/W Analysis

File Information

File Version: 9.00
Created By: Drafting
Last Edited By: Drafting
Revision Number: 94
Date: 12/24/2020
Time: 12:26:37 PM
Tool Version: 9.0.3.15488
File Name: Sec on 2 (Sta. 14+61 to 20+50) WT at 3.0.gsz
Directory: R:\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\SEEPW analyses\Seepage Calcula ons for Review\Pavilion\

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SEEP/W Analysis

Kind: SEEP/W
Method: Transient
Physics
- Water Transfer
  - Free convection: thermal effects: No
  - Free convection: solute effects: No
  - Vapor transfer: isothermal: No
  - Vapor transfer: thermal: No

Water Settings
- Initial PWP Conditions from: Water Table
- Maximum Number of Iterations: 500
- Maximum Difference: 0.005
- Significant Digits: 2

Max # of Reviews: 10
Under-Relaxation Criteria
Initial Rate: 1
Minimum Rate: 0.1
Rate Reduction Factor: 0.65
Reduction Frequency (iterations): 10
Unit Weight of Water: 62.430189 pcf
Bulk Modulus of Pore-Fluid: 43,511,321 psf
Settings
Dimension: 2D
Exclude cumulative values: No
Time
Starting Time: 0 d
Duration: 4 d
# of Steps: 192
Step Generation Method: Linear
Time Increment: 0.020833333 d
Save Steps Every: 1

Materials

Fill saturated

Hydraulic
Model: Saturated Only
Sat Kx: 20 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.32
Beta: 2e-06 /psf

Bedrock

Hydraulic
Model: Saturated Only
Sat Kx: 0.1 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.2
Beta: 1e-08 /psf

Concrete

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: Concrete V-G
K-Function: Concrete Permeability V-G
Ky'/Kx' Ratio: 1
Rotation: 0 °

Fill Unsaturated

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: V-G Model
K-Function: V-G Unsaturated
Ky'/Kx' Ratio: 1
Rotation: 0 °

Higher permeability

Hydraulic

Model: Saturated Only
Sat Kx: 20 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.3
Beta: 2e-06 /psf

Sheet Pile

Hydraulic

Model: Saturated Only
Sat Kx: 0.000467 ft/d
Ky'/Kx' Ratio: 0.5
Rotation: 0 °
Volumetric Water Content: 0.01
Beta: 1e-10 /psf

Concrete saturated

Hydraulic

Model: Saturated Only
Sat Kx: 8.46e-05 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °

Volumetric Water Content: 0.2
Beta: 1e-08 /psf

Initial Water Tables

Initial Water Table 1

Max. negative head: 10 ft
Coordinates
Coordinate 1: (0.1, 193) ft
Coordinate 2: (600, 193) ft

Boundary Conditions

Transient Head

Type: Water Total Head
Seep Head vs. Time Function: Long
Review: No

Seepage faces

Type: Water Flux 0
Review: Yes

Water K Functions

V-G Unsaturated

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 0.00023148148
Data Points: Matric Suction (psf), Water X-Conductivity (ft/d)
Data Point: (0.01, 20)
Data Point: (0.017988923, 19.99995)
Data Point: (0.032360135, 19.999819)
Data Point: (0.058212397, 19.999476)
Data Point: (0.10471783, 19.998574)

Data Point: (0.1883761, 19.9962)
Data Point: (0.33886831, 19.989961)
Data Point: (0.60958759, 19.973572)
Data Point: (1.0965824, 19.930424)
Data Point: (1.9726337, 19.816923)
Data Point: (3.5485555, 19.519039)
Data Point: (6.3834691, 18.740741)
Data Point: (11.483173, 16.766929)
Data Point: (20.656992, 12.277709)
Data Point: (37.159703, 5.2058944)
Data Point: (66.846304, 0.75441818)
Data Point: (120.2493, 0.038600998)
Data Point: (216.31554, 0.0012477922)
Data Point: (389.12836, 3.568385e-05)
Data Point: (700, 9.9286424e-07)
Estimation Properties
Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: V-G Model
Saturated Kx: 70 ft/d
Residual Water Content: 0.0447
Maximum: 700
Minimum: 0.01
Num. Points: 20

Concrete Permeability V-G

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 1e-09
Data Points: Matric Suction (psf), Water X-Conductivity (ft/d)
Data Point: (0.001, 8.64e-05)
Data Point: (0.0014506574, 8.64e-05)
Data Point: (0.002104407, 8.64e-05)
Data Point: (0.0030527737, 8.64e-05)
Data Point: (0.0044285289, 8.64e-05)
Data Point: (0.0064242785, 8.64e-05)
Data Point: (0.0093194274, 8.64e-05)
Data Point: (0.013519297, 8.64e-05)
Data Point: (0.019611869, 8.64e-05)
Data Point: (0.028450103, 8.64e-05)

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Data Point: (0.086851727, 8.64e-05)
Data Point: (0.1259921, 8.64e-05)
Data Point: (0.18277139, 8.64e-05)
Data Point: (0.26513867, 8.6399998e-05)
Data Point: (0.38462539, 8.6399997e-05)
Data Point: (0.55795968, 8.6399979e-05)
Data Point: (0.80940837, 8.639991e-05)
Data Point: (1.1741743, 8.6399757e-05)
Data Point: (1.7033247, 8.6398742e-05)
Data Point: (2.4709406, 8.6395843e-05)
Data Point: (3.5844884, 8.6383756e-05)
Data Point: (5.1998648, 8.633371e-05)
Data Point: (7.5432225, 8.6167714e-05)
Data Point: (10.942632, 8.5459786e-05)
Data Point: (15.874011, 8.2780909e-05)
Data Point: (23.027752, 7.3231988e-05)
Data Point: (33.405379, 4.5685015e-05)
Data Point: (48.459762, 9.7412672e-06)
Data Point: (70.298515, 4.8659722e-07)
Data Point: (101.97906, 1.0727195e-08)
Data Point: (147.93669, 1.8757487e-10)
Data Point: (214.60546, 3.1983129e-12)
Data Point: (311.31901, 5.3810329e-14)
Data Point: (451.61724, 9.0519556e-16)
Data Point: (655.14191, 1.522525e-17)
Data Point: (950.38649, 2.5598876e-19)
Data Point: (1,378.6852, 4.305468e-21)
Data Point: (2,000, 7.2403592e-23)

Estimation Properties

Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Concrete V-G
Saturated Kx: 8.64e-05 ft/d
Residual Water Content: 0.003
Maximum: 2,000
Minimum: 0.001
Num. Points: 40

Hydraulic Boundary Functions

Long

Model: Spline Data Point Function
Function: Water Total Head vs. Time
  Curve Fit to Data: 100 %
  Segment Curvature: 100 %
Y-Intercept: 190
Data Set: Copy of Book2

Vol. Water Content Functions

V-G Model

Model: Van Genuchten Function
Function: Volumetric Water Content vs. Water Pressure
  Beta: 2e-06 /psf
  Saturated Water Content: 0.38
  Residual Water Content: 0.0447
  A: 52 psf
  N: 2.65
  M: 0.6226415094339622
  Suction Limit: 20885434.21089708
Porosity: 0.38000035

Concrete V-G

Model: Van Genuchten Function
Function: Volumetric Water Content vs. Water Pressure
  Beta: 1e-10 /psf
  Saturated Water Content: 0.05
  Residual Water Content: 0.003
  A: 47.25 psf
  N: 4.6
  M: 0.7826086956521738
  Suction Limit: 20885434.21089708
Porosity: 0.05

Points

	X	Y
Point 1	600 ft	190 ft
Point 2	450 ft	190 ft
Point 3	450 ft	200 ft
Point 4	384.7 ft	200 ft
Point 5	100 ft	200 ft
Point 6	100 ft	30 ft
Point 7	600 ft	30 ft
Point 8	450 ft	181.5 ft
Point 9	448.3 ft	181.5 ft
Point 10	448.3 ft	190.2 ft
Point 11	385.2 ft	190.2 ft
Point 12	385.2 ft	186.6 ft
Point 13	381.4 ft	186.6 ft
Point 14	381.4 ft	176.4 ft
Point 15	380.9 ft	176.4 ft
Point 16	380.9 ft	191.5 ft
Point 17	445.4 ft	191.5 ft
Point 18	445.4 ft	192.3 ft
Point 19	448.3 ft	192.3 ft
Point 20	448.3 ft	200 ft
Point 21	384.7 ft	191.5 ft
Point 22	448.3 ft	199 ft
Point 23	100 ft	150 ft
Point 24	600 ft	150 ft
Point 25	100 ft	190 ft
Point 26	380.9 ft	190 ft
Point 27	448.3 ft	190 ft
Point 28	385.2 ft	190 ft
Point 29	430 ft	150 ft
Point 30	388 ft	191.5 ft
Point 31	388.1 ft	191.5 ft
Point 32	388.1 ft	190.2 ft
Point 33	388 ft	190.2 ft
Point 34	395 ft	191.5 ft
Point 35	395.1 ft	191.5 ft
Point 36	395.1 ft	190.2 ft
Point 37	395 ft	190.2 ft
Point 38	403 ft	191.5 ft

Point 39	403.1 ft	191.5 ft
Point 40	403.1 ft	190.2 ft
Point 41	403 ft	190.2 ft
Point 42	411 ft	191.5 ft
Point 43	411.1 ft	191.5 ft
Point 44	411.1 ft	190.2 ft
Point 45	411 ft	190.2 ft
Point 46	419 ft	191.5 ft
Point 47	419.1 ft	191.5 ft
Point 48	419.1 ft	190.2 ft
Point 49	419 ft	190.2 ft
Point 50	427 ft	191.5 ft
Point 51	427.1 ft	191.5 ft
Point 52	427.1 ft	190.2 ft
Point 53	427 ft	190.2 ft
Point 54	435 ft	191.5 ft
Point 55	435.1 ft	191.5 ft
Point 56	435.1 ft	190.2 ft
Point 57	435 ft	190.2 ft
Point 58	443 ft	191.5 ft
Point 59	443.1 ft	191.5 ft
Point 60	443.1 ft	190.2 ft
Point 61	443 ft	190.2 ft
Point 62	393.27869 ft	180 ft
Point 63	405.51913 ft	170 ft
Point 64	100 ft	170 ft
Point 65	100 ft	180 ft
Point 66	380.9 ft	180 ft
Point 67	381.4 ft	180 ft
Point 68	375.25 ft	200 ft
Point 69	377.25 ft	200 ft
Point 70	375.25 ft	210 ft
Point 71	377.25 ft	210 ft
Point 72	100 ft	210 ft
Point 73	306 ft	197.5 ft
Point 74	224 ft	197.5 ft
Point 75	306 ft	210 ft
Point 76	224 ft	210 ft
Point 77	375.25 ft	206.5 ft

Point 78	377.25 ft	206.5 ft
Point 79	376 ft	206.5 ft
Point 80	376.5 ft	206.5 ft
Point 81	376.5 ft	196.5 ft
Point 82	376 ft	196.5 ft
Point 83	376 ft	200 ft
Point 84	376.5 ft	200 ft
Point 85	100 ft	193 ft
Point 86	384.7 ft	193 ft
Point 87	376.5 ft	185 ft
Point 88	376 ft	185 ft
Point 89	376 ft	193 ft
Point 90	376 ft	190 ft
Point 91	376.5 ft	190 ft
Point 92	376.5 ft	193 ft

Lines

	Start Point	End Point	Hydraulic Boundary	Length	Angle
Line 1	8	9	Transient Head	1.7 ft	0 °
Line 2	12	13		3.8 ft	0 °
Line 3	14	15		0.5 ft	0 °
Line 4	17	18	Transient Head	0.8 ft	90 °
Line 5	18	19	Transient Head	2.9 ft	0 °
Line 6	20	3	Transient Head	1.7 ft	0 °
Line 7	19	22	Transient Head	6.7 ft	90 °
Line 8	20	22	Transient Head	1 ft	90 °
Line 9	21	16		3.8 ft	0 °
Line 10	6	7		500 ft	0 °
Line 11	2	8	Transient Head	8.5 ft	90 °
Line 12	2	3	Transient Head	10 ft	90 °
Line 13	7	24		120 ft	90 °
Line 14	23	6		120 ft	90 °
Line 15	11	28		0.2 ft	90 °
Line 16	28	12	Transient Head	3.4 ft	90 °
Line 17	9	27	Transient Head	8.5 ft	90 °
Line 18	27	28	Transient Head	63.1 ft	0 °
Line 19	26	16		1.5 ft	90 °

Line 20	10	27		0.2 ft	90 °
Line 21	23	29		330 ft	0 °
Line 22	24	29	Transient Head	170 ft	0 °
Line 23	21	30	Transient Head	3.3 ft	0 °
Line 24	30	31	Transient Head	0.1 ft	0 °
Line 25	32	33		0.1 ft	0 °
Line 26	33	11		2.8 ft	0 °
Line 27	30	33		1.3 ft	90 °
Line 28	32	31		1.3 ft	90 °
Line 29	31	34	Transient Head	6.9 ft	0 °
Line 30	34	35	Transient Head	0.1 ft	0 °
Line 31	36	37		0.1 ft	0 °
Line 32	37	32		6.9 ft	0 °
Line 33	34	37		1.3 ft	90 °
Line 34	36	35		1.3 ft	90 °
Line 35	35	38	Transient Head	7.9 ft	0 °
Line 36	38	39	Transient Head	0.1 ft	0 °
Line 37	40	41		0.1 ft	0 °
Line 38	41	36		7.9 ft	0 °
Line 39	38	41		1.3 ft	90 °
Line 40	40	39		1.3 ft	90 °
Line 41	39	42	Transient Head	7.9 ft	0 °
Line 42	42	43	Transient Head	0.1 ft	0 °
Line 43	44	45		0.1 ft	0 °
Line 44	45	40		7.9 ft	0 °
Line 45	42	45		1.3 ft	90 °
Line 46	44	43		1.3 ft	90 °
Line 47	43	46	Transient Head	7.9 ft	0 °
Line 48	46	47	Transient Head	0.1 ft	0 °
Line 49	48	49		0.1 ft	0 °
Line 50	49	44		7.9 ft	0 °
Line 51	46	49		1.3 ft	90 °
Line 52	48	47		1.3 ft	90 °
Line 53	47	50	Transient Head	7.9 ft	0 °
Line 54	50	51	Transient Head	0.1 ft	0 °
Line 55	52	53		0.1 ft	0 °
Line 56	53	48		7.9 ft	0 °
Line 57	50	53		1.3 ft	90 °
Line 58	52	51		1.3 ft	90 °

Line 59	51	54	Transient Head	7.9 ft	0 °
Line 60	54	55	Transient Head	0.1 ft	0 °
Line 61	56	57		0.1 ft	0 °
Line 62	57	52		7.9 ft	0 °
Line 63	54	57		1.3 ft	90 °
Line 64	56	55		1.3 ft	90 °
Line 65	55	58	Transient Head	7.9 ft	0 °
Line 66	58	59	Transient Head	0.1 ft	0 °
Line 67	59	17	Transient Head	2.3 ft	0 °
Line 68	10	60		5.2 ft	0 °
Line 69	60	61		0.1 ft	0 °
Line 70	61	56		7.9 ft	0 °
Line 71	58	61		1.3 ft	90 °
Line 72	60	59		1.3 ft	90 °
Line 73	62	12	Transient Head	10.432 ft	-39.2 °
Line 74	29	63	Transient Head	31.612 ft	-39.2 °
Line 75	63	62	Transient Head	15.806 ft	-39.2 °
Line 76	64	23		20 ft	90 °
Line 77	65	64		10 ft	90 °
Line 78	15	66		3.6 ft	90 °
Line 79	66	26		10 ft	90 °
Line 80	13	67		6.6 ft	90 °
Line 81	67	14		3.6 ft	90 °
Line 82	62	67		11.879 ft	0 °
Line 83	64	63		305.52 ft	0 °
Line 84	69	4	Transient Head	7.45 ft	0 °
Line 85	71	70		2 ft	0 °
Line 86	72	5		10 ft	90 °
Line 87	70	75	Seepage faces	69.25 ft	0 °
Line 88	75	73		12.5 ft	90 °
Line 89	73	74		82 ft	0 °
Line 90	74	76		12.5 ft	90 °
Line 91	76	72	Seepage faces	124 ft	0 °
Line 92	66	65		280.9 ft	0 °
Line 93	65	25		10 ft	90 °
Line 94	77	70		3.5 ft	90 °
Line 95	71	78	Transient Head	3.5 ft	90 °
Line 96	77	79		0.75 ft	0 °
Line 97	79	80		0.5 ft	0 °

Line 98	80	78	Transient Head	0.75 ft	0 °
Line 99	69	84	Transient Head	0.75 ft	0 °
Line 100	84	81		3.5 ft	90 °
Line 101	81	82		0.5 ft	0 °
Line 102	82	83		3.5 ft	90 °
Line 103	79	83		6.5 ft	90 °
Line 104	84	80	Transient Head	6.5 ft	90 °
Line 105	5	85		7 ft	90 °
Line 106	85	25		3 ft	90 °
Line 107	21	86	Transient Head	1.5 ft	90 °
Line 108	86	4	Transient Head	7 ft	90 °
Line 109	89	85		276 ft	0 °
Line 110	25	90		276 ft	0 °
Line 111	91	26		4.4 ft	0 °
Line 112	86	92		8.2 ft	0 °
Line 113	91	87		5 ft	90 °
Line 114	87	88		0.5 ft	0 °
Line 115	88	90		5 ft	90 °
Line 116	82	89		3.5 ft	90 °
Line 117	89	90		3 ft	90 °
Line 118	91	92		3 ft	90 °
Line 119	92	81		3.5 ft	90 °

Regions

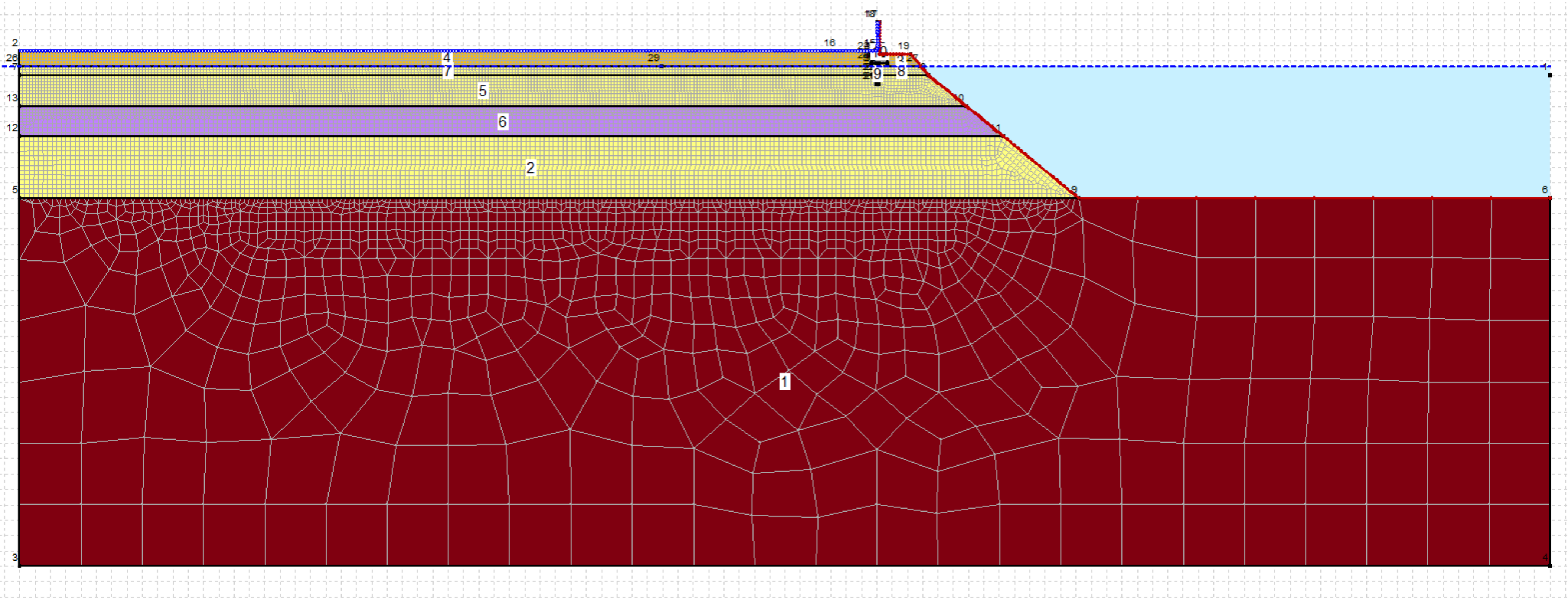
	Material	Points	Area
Region 1	Bedrock	6,7,24,29,23	60,000 ft^2
Region 2	Fill Unsaturated	28,11,33,32,37,36,41,40,45,44,49,48,53,52,57,56,61,60,10,27	12.62 ft^2
Region 3	Concrete	30,33,32,31	0.13 ft^2
Region 4	Concrete saturated	21,16,26,66,15,14,67,13,12,28,11,33,30	29.81 ft^2
Region 5	Concrete	34,37,36,35	0.13 ft^2
Region 6	Concrete saturated	31,32,37,34	8.97 ft^2
Region 7	Concrete	38,41,40,39	0.13 ft^2
Region 8	Concrete saturated	35,36,41,38	10.27 ft^2
Region 9	Concrete	42,45,44,43	0.13 ft^2
Region 10	Concrete saturated	39,40,45,42	10.27 ft^2
Region 11	Concrete	46,49,48,47	0.13 ft^2
Region 12	Concrete saturated	43,44,49,46	10.27 ft^2

Region 13	Concrete	50,53,52,51	0.13 ft²
Region 14	Concrete saturated	47,48,53,50	10.27 ft²
Region 15	Concrete	54,57,56,55	0.13 ft²
Region 16	Concrete saturated	51,52,57,54	10.27 ft²
Region 17	Concrete	58,61,60,59	0.13 ft²
Region 18	Concrete saturated	8,2,3,20,22,19,18,17,59,60,10,27,9	40.53 ft²
Region 19	Concrete saturated	55,56,61,58	10.27 ft²
Region 20	Higher permeability	62,67,14,15,66,65,64,63	2,992.2 ft²
Region 21	Fill saturated	23,29,63,64	6,355.2 ft²
Region 22	Fill saturated	12,13,67,62	51.74 ft²
Region 23	Concrete	70,77,79,80,78,71	7 ft²
Region 24	Fill Unsaturated	79,77,70,75,73,74,76,72,5,85,89,82,83	3,664.4 ft²
Region 25	Fill saturated	65,66,26,91,87,88,90,25	2,806.5 ft²
Region 26	Sheet Pile	79,83,82,81,84,80	5 ft²
Region 27	Sheet Pile	82,89,90,88,87,91,92,81	5.75 ft²
Region 28	Fill Unsaturated	4,69,84,81,92,86	57.4 ft²
Region 29	Fill saturated	85,25,90,89	828 ft²
Region 30	Fill saturated	26,16,21,86,92,91	18.9 ft²

Mesh Properties

View: 2D
Element Thickness: 1 ft

2D Model for Seepage Analyses for WP26~WP29/30
(Sta.20+50 and 21+50)



See model inputs summarized in the following 10 pages:

SEEP/W Analysis

File Information

File Version: 9.00
Created By: Drafting
Last Edited By: Drafting
Revision Number: 103
Date: 12/23/2020
Time: 02:06:51 PM
Tool Version: 9.0.3.15488
File Name: Section 3 Sta. 20+50 to 21+50 Flood El13.8.gsz
Directory: R:\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\SEEPW analyses\Seepage Calculations for Review\

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SEEP/W Analysis

- Kind: SEEP/W
- Method: Transient
- Physics
  - Water Transfer
    - Free convection: thermal effects: No
    - Free convection: solute effects: No
    - Vapor transfer: isothermal: No
    - Vapor transfer: thermal: No
- Water Settings
  - Initial PWP Conditions from: Water Table
  - Maximum Number of Iterations: 500
  - Maximum Difference: 0.005
  - Significant Digits: 2

Max # of Reviews: 10
Under-Relaxation Criteria
Initial Rate: 1
Minimum Rate: 0.1
Rate Reduction Factor: 0.65
Reduction Frequency (iterations): 10
Unit Weight of Water: 62.430189 pcf
Bulk Modulus of Pore-Fluid: 43,511,321 psf
Settings
Dimension: 2D
Exclude cumulative values: No
Time
Starting Time: 0 d
Duration: 4 d
# of Steps: 192
Step Generation Method: Linear
Time Increment: 0.020833333 d
Save Steps Every: 1

Materials

Fill saturated

Hydraulic
Model: Saturated Only
Sat Kx: 20 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.36
Beta: 2e-06 /psf

Bedrock

Hydraulic
Model: Saturated Only
Sat Kx: 0.1 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.2
Beta: 1e-08 /psf

Concrete

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: Concrete V-G
K-Function: Concrete Permeability V-G
Ky'/Kx' Ratio: 1
Rotation: 0 °

Fill Unsaturated

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: V-G Model
K-Function: V-G Unsaturated
Ky'/Kx' Ratio: 1
Rotation: 0 °

Higher permeability

Hydraulic

Model: Saturated Only
Sat Kx: 20 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.3
Beta: 2e-06 /psf

Sheet Pile

Hydraulic

Model: Saturated Only
Sat Kx: 0.0004675 ft/d
Ky'/Kx' Ratio: 2
Rotation: 0 °
Volumetric Water Content: 0.05
Beta: 1e-10 /psf

Initial Water Tables

Initial Water Table 1

Max. negative head: 8 ft
Coordinates

Coordinate 1: (0.1, 193) ft
Coordinate 2: (600, 193) ft

Boundary Conditions

Transient Head

Type: Water Total Head
Seep Head vs. Time Function: Peak Flood El.13.8
Review: No

Seepage faces

Type: Water Flux 0
Review: Yes

Water K Functions

V-G Unsaturated

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 0.00023148148
Data Points: Matric Suction (psf), Water X-Conductivity (ft/d)
Data Point: (0.01, 20)
Data Point: (0.017988923, 19.99995)
Data Point: (0.032360135, 19.999819)
Data Point: (0.058212397, 19.999476)
Data Point: (0.10471783, 19.998574)
Data Point: (0.1883761, 19.9962)
Data Point: (0.33886831, 19.989961)
Data Point: (0.60958759, 19.973572)
Data Point: (1.0965824, 19.930424)
Data Point: (1.9726337, 19.816923)
Data Point: (3.5485555, 19.519039)
Data Point: (6.3834691, 18.740741)
Data Point: (11.483173, 16.766929)
Data Point: (20.656992, 12.277709)
Data Point: (37.159703, 5.2058944)

Data Point: (66.846304, 0.75441818)
Data Point: (120.2493, 0.038600998)
Data Point: (216.31554, 0.0012477922)
Data Point: (389.12836, 3.568385e-05)
Data Point: (700, 9.9286424e-07)

Estimation Properties

Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: V-G Model
Saturated Kx: 70 ft/d
Residual Water Content: 0.0447
Maximum: 700
Minimum: 0.01
Num. Points: 20

Concrete Permeability V-G

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 1e-09
Data Points: Matric Suction (psf), Water X-Conductivity (ft/d)
Data Point: (0.001, 8.64e-05)
Data Point: (0.0014506574, 8.64e-05)
Data Point: (0.002104407, 8.64e-05)
Data Point: (0.0030527737, 8.64e-05)
Data Point: (0.0044285289, 8.64e-05)
Data Point: (0.0064242785, 8.64e-05)
Data Point: (0.0093194274, 8.64e-05)
Data Point: (0.013519297, 8.64e-05)
Data Point: (0.019611869, 8.64e-05)
Data Point: (0.028450103, 8.64e-05)
Data Point: (0.041271354, 8.64e-05)
Data Point: (0.059870597, 8.64e-05)
Data Point: (0.086851727, 8.64e-05)
Data Point: (0.1259921, 8.64e-05)
Data Point: (0.18277139, 8.64e-05)
Data Point: (0.26513867, 8.6399998e-05)
Data Point: (0.38462539, 8.6399997e-05)
Data Point: (0.55795968, 8.6399979e-05)
Data Point: (0.80940837, 8.639991e-05)
Data Point: (1.1741743, 8.6399757e-05)

Data Point: (1.7033247, 8.6398742e-05)
Data Point: (2.4709406, 8.6395843e-05)
Data Point: (3.5844884, 8.6383756e-05)
Data Point: (5.1998648, 8.633371e-05)
Data Point: (7.5432225, 8.6167714e-05)
Data Point: (10.942632, 8.5459786e-05)
Data Point: (15.874011, 8.2780909e-05)
Data Point: (23.027752, 7.3231988e-05)
Data Point: (33.405379, 4.5685015e-05)
Data Point: (48.459762, 9.7412672e-06)
Data Point: (70.298515, 4.8659722e-07)
Data Point: (101.97906, 1.0727195e-08)
Data Point: (147.93669, 1.8757487e-10)
Data Point: (214.60546, 3.1983129e-12)
Data Point: (311.31901, 5.3810329e-14)
Data Point: (451.61724, 9.0519556e-16)
Data Point: (655.14191, 1.522525e-17)
Data Point: (950.38649, 2.5598876e-19)
Data Point: (1,378.6852, 4.305468e-21)
Data Point: (2,000, 7.2403592e-23)

Estimation Properties
Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Concrete V-G
Saturated Kx: 8.64e-05 ft/d
Residual Water Content: 0.003
Maximum: 2,000
Minimum: 0.001
Num. Points: 40

Hydraulic Boundary Functions

Peak Flood El.13.8

Model: Spline Data Point Function
Function: Water Total Head vs. Time
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Y-Intercept: 190
Data Set: Peak Flood El.13.8

Vol. Water Content Functions

V-G Model

Model: Van Genuchten Function
Function: Volumetric Water Content vs. Water Pressure
Beta: 2e-06 /psf
Saturated Water Content: 0.38
Residual Water Content: 0.0447
A: 52 psf
N: 2.65
M: 0.6226415094339622
Suction Limit: 20885434.21089708
Porosity: 0.38000035

Concrete V-G

Model: Van Genuchten Function
Function: Volumetric Water Content vs. Water Pressure
Beta: 1e-10 /psf
Saturated Water Content: 0.05
Residual Water Content: 0.003
A: 47.25 psf
N: 4.6
M: 0.7826086956521738
Suction Limit: 20885434.21089708
Porosity: 0.05

Points

	X	Y
Point 1	600 ft	190 ft
Point 2	100 ft	198 ft
Point 3	100 ft	30 ft
Point 4	600 ft	30 ft
Point 5	100 ft	150 ft
Point 6	600 ft	150 ft
Point 7	100 ft	190 ft
Point 8	396.9 ft	190 ft
Point 9	446 ft	150 ft
Point 10	409.27869 ft	180 ft

Point 11	421.51913 ft	170 ft
Point 12	100 ft	170 ft
Point 13	100 ft	180 ft
Point 14	381 ft	197 ft
Point 15	380.25 ft	198 ft
Point 16	367.25 ft	198 ft
Point 17	381 ft	207.5 ft
Point 18	380.25 ft	207.5 ft
Point 19	391.25 ft	197 ft
Point 20	380.5 ft	187 ft
Point 21	380 ft	187 ft
Point 22	380 ft	190 ft
Point 23	380.5 ft	190 ft
Point 24	378.25 ft	197 ft
Point 25	380.25 ft	197 ft
Point 26	100 ft	193 ft
Point 27	394.4 ft	193.09735 ft
Point 28	378.25 ft	194 ft
Point 29	309.83333 ft	193 ft
Point 30	380 ft	194 ft
Point 31	380 ft	193 ft
Point 32	380.5 ft	194 ft
Point 33	380.5 ft	193 ft
Point 34	383.5 ft	194 ft
Point 35	383.5 ft	197 ft

Lines

	Start Point	End Point	Length	Angle	Hydraulic Boundary
Line 1	3	4	500 ft	0 °	
Line 2	4	6	120 ft	90 °	
Line 3	5	3	120 ft	90 °	
Line 4	5	9	346 ft	0 °	
Line 5	6	9	154 ft	0 °	Transient Head
Line 6	9	11	31.612 ft	-39.2 °	Transient Head
Line 7	12	5	20 ft	90 °	
Line 8	14	17	10.5 ft	90 °	Transient Head
Line 9	17	18	0.75 ft	0 °	

Line 10	18	15	9.5 ft	90 °	Seepage faces
Line 11	15	16	13 ft	0 °	Seepage faces
Line 12	16	2	267.25 ft	0 °	Seepage faces
Line 13	10	8	15.913 ft	-38.9 °	Transient Head
Line 14	7	13	10 ft	90 °	
Line 15	11	10	15.806 ft	-39.2 °	Transient Head
Line 16	13	12	10 ft	90 °	
Line 17	23	8	16.4 ft	0 °	
Line 18	23	20	3 ft	90 °	
Line 19	20	21	0.5 ft	0 °	
Line 20	21	22	3 ft	90 °	
Line 21	24	25	2 ft	0 °	
Line 22	25	15	1 ft	90 °	
Line 23	2	26	5 ft	90 °	
Line 24	26	7	3 ft	90 °	
Line 25	8	27	3.9804 ft	-51.1 °	Transient Head
Line 26	27	19	5.0153 ft	-51.1 °	Transient Head
Line 27	11	12	321.52 ft	0 °	
Line 28	24	28	3 ft	90 °	
Line 29	29	26	209.83 ft	0 °	
Line 30	31	30	1 ft	90 °	
Line 31	30	32	0.5 ft	0 °	
Line 32	33	32	1 ft	90 °	
Line 33	28	30	1.75 ft	0 °	
Line 34	32	34	3 ft	0 °	
Line 35	35	14	2.5 ft	0 °	Transient Head
Line 36	34	35	3 ft	90 °	
Line 37	13	10	309.28 ft	0 °	
Line 38	22	7	280 ft	0 °	
Line 39	29	31	70.167 ft	0 °	
Line 40	22	31	3 ft	90 °	
Line 41	33	23	3 ft	90 °	
Line 42	33	27	13.9 ft	0.401 °	
Line 43	19	35	7.75 ft	0 °	Transient Head

Regions

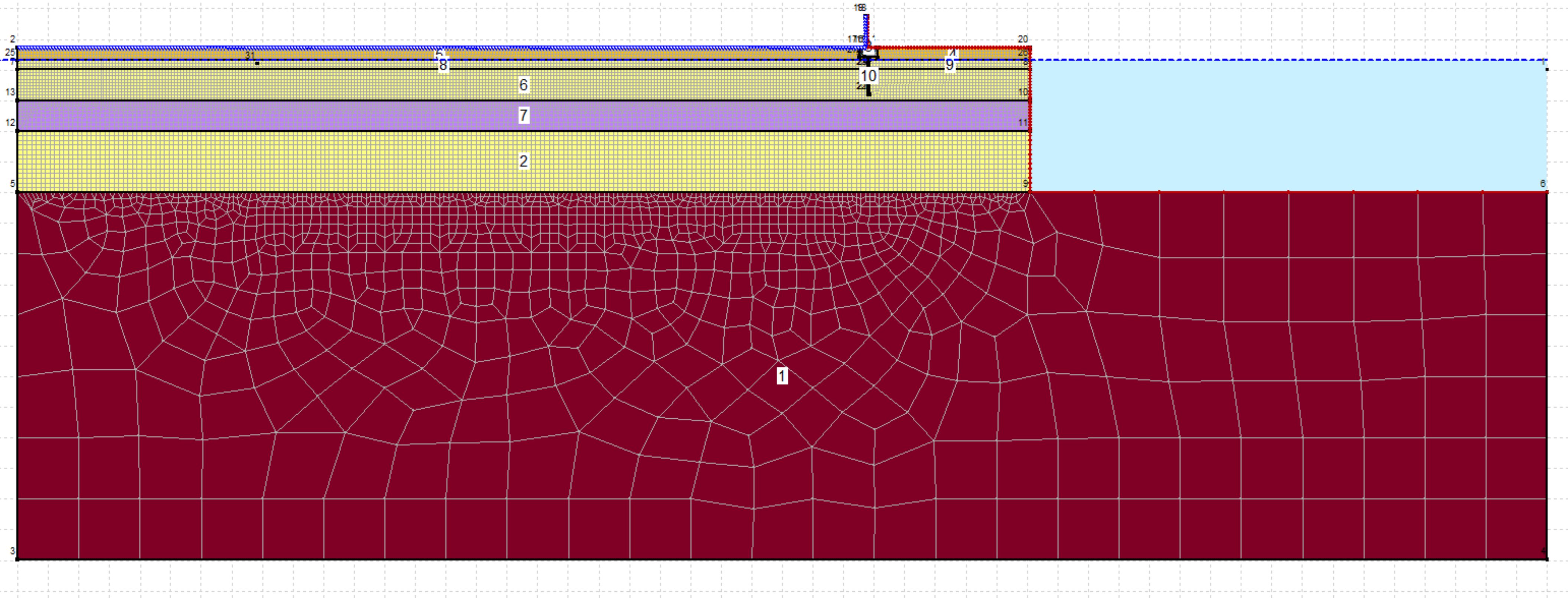
	Material	Points	Area

Region 1	Bedrock	3,4,6,9,5	60,000 ft²
Region 2	Fill saturated	12,5,9,11	6,675.2 ft²
Region 3	Fill Unsaturated	27,19,35,34,32,33	39.777 ft²
Region 4	Fill Unsaturated	24,25,15,16,2,26,29,31,30,28	1,395 ft²
Region 5	Fill saturated	21,22,7,13,10,8,23,20	3,029.4 ft²
Region 6	Higher permeability	13,12,11,10	3,154 ft²
Region 7	Fill saturated	29,26,7,22,31	840 ft²
Region 8	Fill saturated	33,23,8,27	46.248 ft²
Region 9	Sheet Pile	33,32,30,31,22,21,20,23	3.5 ft²
Region 10	Concrete	14,17,18,15,25,24,28,30,32,34,35	23.625 ft²

Mesh Properties

View: 2D
Element Thickness: 1 ft

2D Model for Seepage Analyses for WP29/30 ~ WP33
(Sta.21+50 and 23+00)



See model inputs summarized in the following 10 pages:

SEEP/W Analysis

File Information

File Version: 9.00
Created By: Drafting
Last Edited By: Drafting
Revision Number: 98
Date: 12/24/2020
Time: 12:42:05 PM
Tool Version: 9.0.3.15488
File Name: Section 3 Sta. 21+50 to 23+00.gsz
Directory: R:\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\SEEPW analyses\Seepage Calculations for Review\

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SEEP/W Analysis

Kind: SEEP/W
Method: Transient
Physics
- Water Transfer
  - Free convection: thermal effects: No
  - Free convection: solute effects: No
  - Vapor transfer: isothermal: No
  - Vapor transfer: thermal: No

Water Settings
- Initial PWP Conditions from: Water Table
- Maximum Number of Iterations: 500
- Maximum Difference: 0.005
- Significant Digits: 2

Max # of Reviews: 10
Under-Relaxation Criteria
Initial Rate: 1
Minimum Rate: 0.1
Rate Reduction Factor: 0.65
Reduction Frequency (iterations): 10
Unit Weight of Water: 62.430189 pcf
Bulk Modulus of Pore-Fluid: 43,511,321 psf
Settings
Dimension: 2D
Exclude cumulative values: No
Time
Starting Time: 0 d
Duration: 4 d
# of Steps: 192
Step Generation Method: Linear
Time Increment: 0.020833333 d
Save Steps Every: 1

Materials

Fill saturated

Hydraulic
Model: Saturated Only
Sat Kx: 20 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.36
Beta: 2e-06 /psf

Bedrock

Hydraulic
Model: Saturated Only
Sat Kx: 0.1 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.1
Beta: 1e-08 /psf

Concrete

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: Concrete V-G
K-Function: Concrete Permeability V-G
Ky'/Kx' Ratio: 1
Rotation: 0 °

Fill Unsaturated

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: V-G Model
K-Function: V-G Unsaturated
Ky'/Kx' Ratio: 1
Rotation: 0 °

Higher permeability

Hydraulic

Model: Saturated Only
Sat Kx: 20 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.3
Beta: 2e-06 /psf

Sheet Pile

Hydraulic

Model: Saturated Only
Sat Kx: 0.0004675 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.02
Beta: 1e-10 /psf

Initial Water Tables

Initial Water Table 1

Max. negative head: 8 ft
Coordinates

Coordinate 1: (0.1, 193) ft
Coordinate 2: (600, 193) ft

Boundary Conditions

Transient Head

Type: Water Total Head
Seep Head vs. Time Function: Long
Review: No

Seepage faces

Type: Water Flux 0
Review: Yes

Water K Functions

V-G Unsaturated

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 0.00023148148
Data Points: Matric Suction (psf), Water X-Conductivity (ft/d)
Data Point: (0.01, 20)
Data Point: (0.017988923, 19.99995)
Data Point: (0.032360135, 19.999819)
Data Point: (0.058212397, 19.999476)
Data Point: (0.10471783, 19.998574)
Data Point: (0.1883761, 19.9962)
Data Point: (0.33886831, 19.989961)
Data Point: (0.60958759, 19.973572)
Data Point: (1.0965824, 19.930424)
Data Point: (1.9726337, 19.816923)
Data Point: (3.5485555, 19.519039)
Data Point: (6.3834691, 18.740741)
Data Point: (11.483173, 16.766929)
Data Point: (20.656992, 12.277709)
Data Point: (37.159703, 5.2058944)

Data Point: (66.846304, 0.75441818)
Data Point: (120.2493, 0.038600998)
Data Point: (216.31554, 0.0012477922)
Data Point: (389.12836, 3.568385e-05)
Data Point: (700, 9.9286424e-07)

Estimation Properties
Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: V-G Model
Saturated Kx: 70 ft/d
Residual Water Content: 0.0447
Maximum: 700
Minimum: 0.01
Num. Points: 20

Concrete Permeability V-G

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 1e-09
Data Points: Matric Suction (psf), Water X-Conductivity (ft/d)
Data Point: (0.001, 8.64e-05)
Data Point: (0.0014506574, 8.64e-05)
Data Point: (0.002104407, 8.64e-05)
Data Point: (0.0030527737, 8.64e-05)
Data Point: (0.0044285289, 8.64e-05)
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Data Point: (0.0093194274, 8.64e-05)
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Data Point: (101.97906, 1.0727195e-08)
Data Point: (147.93669, 1.8757487e-10)
Data Point: (214.60546, 3.1983129e-12)
Data Point: (311.31901, 5.3810329e-14)
Data Point: (451.61724, 9.0519556e-16)
Data Point: (655.14191, 1.522525e-17)
Data Point: (950.38649, 2.5598876e-19)
Data Point: (1,378.6852, 4.305468e-21)
Data Point: (2,000, 7.2403592e-23)

Estimation Properties

Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Concrete V-G
Saturated Kx: 8.64e-05 ft/d
Residual Water Content: 0.003
Maximum: 2,000
Minimum: 0.001
Num. Points: 40

Hydraulic Boundary Functions

Long

Model: Spline Data Point Function
Function: Water Total Head vs. Time
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Y-Intercept: 190
Data Set: Copy of Book2

Vol. Water Content Functions

V-G Model

Model: Van Genuchten Function
Function: Volumetric Water Content vs. Water Pressure
Beta: 2e-06 /psf
Saturated Water Content: 0.38
Residual Water Content: 0.0447
A: 52 psf
N: 2.65
M: 0.6226415094339622
Suction Limit: 20885434.21089708
Porosity: 0.38000035

Concrete V-G

Model: Van Genuchten Function
Function: Volumetric Water Content vs. Water Pressure
Beta: 1e-10 /psf
Saturated Water Content: 0.05
Residual Water Content: 0.003
A: 47.25 psf
N: 4.6
M: 0.7826086956521738
Suction Limit: 20885434.21089708
Porosity: 0.05

Points

	X	Y
Point 1	600 ft	190 ft
Point 2	100 ft	197 ft
Point 3	100 ft	30 ft
Point 4	600 ft	30 ft
Point 5	100 ft	150 ft
Point 6	600 ft	150 ft
Point 7	100 ft	190 ft
Point 8	431 ft	190 ft
Point 9	431 ft	150 ft
Point 10	431 ft	180 ft

Point 11	431 ft	170 ft
Point 12	100 ft	170 ft
Point 13	100 ft	180 ft
Point 14	381.25 ft	197 ft
Point 15	378 ft	197 ft
Point 16	377.25 ft	197 ft
Point 17	375.25 ft	197 ft
Point 18	378 ft	207.5 ft
Point 19	377.25 ft	207.5 ft
Point 20	431 ft	197 ft
Point 21	378.5 ft	182 ft
Point 22	378 ft	182 ft
Point 23	378 ft	190 ft
Point 24	378.5 ft	190 ft
Point 25	100 ft	193 ft
Point 26	431 ft	193 ft
Point 27	375.25 ft	194 ft
Point 28	381.25 ft	194 ft
Point 29	378 ft	194 ft
Point 30	378 ft	193 ft
Point 31	178.5 ft	192 ft
Point 32	378.5 ft	194 ft
Point 33	378.5 ft	193 ft

Lines

	Start Point	End Point	Length	Angle	Hydraulic Boundary
Line 1	3	4	500 ft	0 °	
Line 2	4	6	120 ft	90 °	
Line 3	5	3	120 ft	90 °	
Line 4	5	9	331 ft	0 °	
Line 5	6	9	169 ft	0 °	Transient Head
Line 6	9	11	20 ft	90 °	Transient Head
Line 7	12	5	20 ft	90 °	
Line 8	15	18	10.5 ft	90 °	Transient Head
Line 9	18	19	0.75 ft	0 °	
Line 10	19	16	10.5 ft	90 °	Seepage faces
Line 11	16	17	2 ft	0 °	Seepage faces

Line 12	20	14	49.75 ft	0 °	Transient Head
Line 13	17	2	275.25 ft	0 °	Seepage faces
Line 14	10	8	10 ft	90 °	Transient Head
Line 15	7	13	10 ft	90 °	
Line 16	11	10	10 ft	90 °	Transient Head
Line 17	13	12	10 ft	90 °	
Line 18	7	23	278 ft	0 °	
Line 19	24	8	52.5 ft	0 °	
Line 20	24	21	8 ft	90 °	
Line 21	21	22	0.5 ft	0 °	
Line 22	22	23	8 ft	90 °	
Line 23	2	25	4 ft	90 °	
Line 24	25	7	3 ft	90 °	
Line 25	8	26	3 ft	90 °	Transient Head
Line 26	26	20	4 ft	90 °	Transient Head
Line 27	11	12	331 ft	0 °	
Line 28	14	15	3.25 ft	0 °	Transient Head
Line 29	17	27	3 ft	90 °	
Line 30	28	14	3 ft	90 °	
Line 31	27	29	2.75 ft	0 °	
Line 32	30	29	1 ft	90 °	
Line 33	29	32	0.5 ft	0 °	
Line 34	32	28	2.75 ft	0 °	
Line 35	33	32	1 ft	90 °	
Line 36	25	30	278 ft	0 °	
Line 37	23	30	3 ft	90 °	
Line 38	33	24	3 ft	90 °	
Line 39	33	26	52.5 ft	0 °	
Line 40	13	10	331 ft	0 °	

Regions

	Material	Points	Area
Region 1	Bedrock	3,4,6,9,5	60,000 ft²
Region 2	Fill saturated	12,5,9,11	6,620 ft²
Region 3	Concrete	14,15,18,19,16,17,27,29,32,28	25.875 ft²
Region 4	Fill Unsaturated	26,20,14,28,32,33	201.75 ft²
Region 5	Fill Unsaturated	17,2,25,30,29,27	1,103.8 ft²

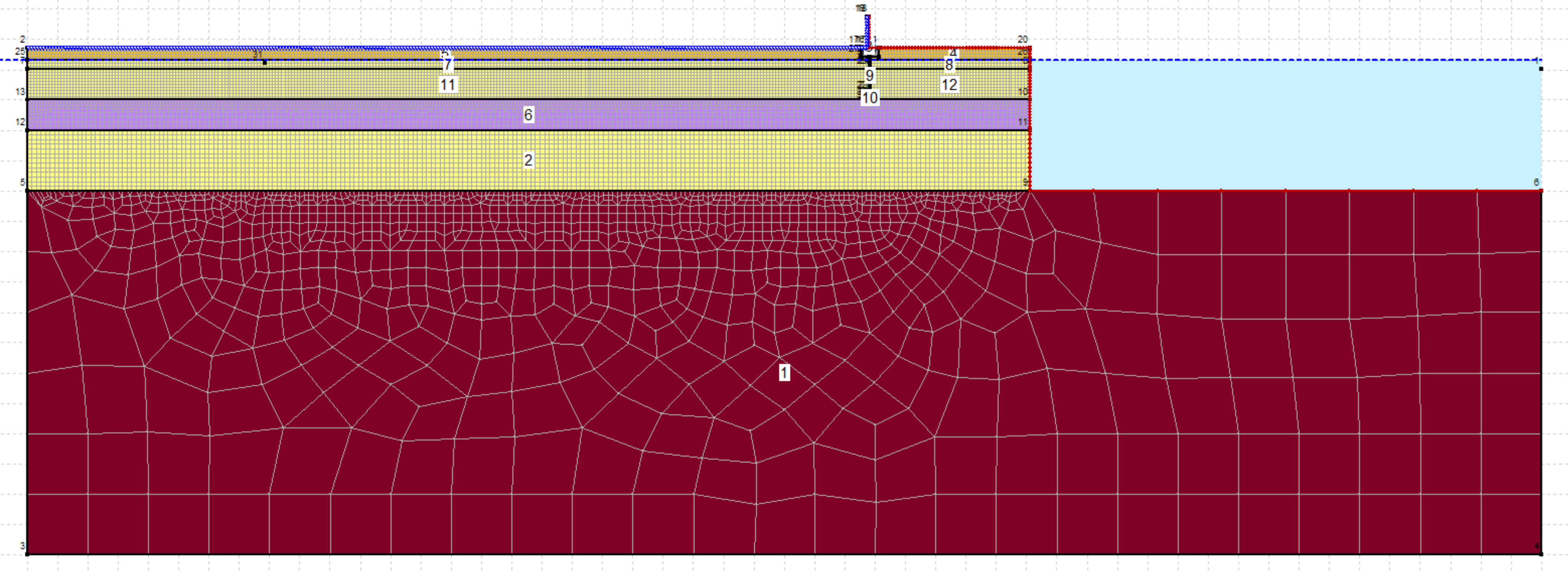
Region 6	Fill saturated	22,23,7,13,10,8,24,21	3,306 ft^2
Region 7	Higher permeability	13,12,11,10	3,310 ft^2
Region 8	Fill saturated	25,7,23,30	834 ft^2
Region 9	Fill saturated	33,24,8,26	157.5 ft^2
Region 10	Sheet Pile	33,32,29,30,23,22,21,24	6 ft^2

Mesh Properties

View: 2D

Element Thickness: 1 ft

2D Model for Seepage Analyses for WP33~WP40
(Sta.23+00 to Sta.25+00)



See model inputs summarized in the following 10 pages:

SEEP/W Analysis

File Information

File Version: 9.00
Created By: Drafting
Last Edited By: Drafting
Revision Number: 100
Date: 12/24/2020
Time: 12:54:11 PM
Tool Version: 9.0.3.15488
File Name: Section 3 Sta. 23+00 to 25+00.gsz
Directory: R:\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\SEEPW analyses\Seepage Calculations for Review\

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SEEP/W Analysis

Kind: SEEP/W
Method: Transient
Physics
  Water Transfer
    Free convection: thermal effects: No
    Free convection: solute effects: No
    Vapor transfer: isothermal: No
    Vapor transfer: thermal: No
Water Settings
  Initial PWP Conditions from: Water Table
  Maximum Number of Iterations: 500
  Maximum Difference: 0.005
  Significant Digits: 2

Max # of Reviews: 10
Under-Relaxation Criteria
Initial Rate: 1
Minimum Rate: 0.1
Rate Reduction Factor: 0.65
Reduction Frequency (iterations): 10
Unit Weight of Water: 62.430189 pcf
Bulk Modulus of Pore-Fluid: 43,511,321 psf
Settings
Dimension: 2D
Exclude cumulative values: No
Time
Starting Time: 0 d
Duration: 4 d
# of Steps: 192
Step Generation Method: Linear
Time Increment: 0.020833333 d
Save Steps Every: 1

Materials

Fill saturated

Hydraulic
Model: Saturated Only
Sat Kx: 30 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.36
Beta: 2e-06 /psf

Bedrock

Hydraulic
Model: Saturated Only
Sat Kx: 0.1 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.1
Beta: 1e-08 /psf

Concrete

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: Concrete V-G
K-Function: Concrete Permeability V-G
Ky'/Kx' Ratio: 1
Rotation: 0 °

Fill Unsaturated

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: V-G Model
K-Function: V-G Unsaturated
Ky'/Kx' Ratio: 1
Rotation: 0 °

Higher permeability

Hydraulic

Model: Saturated Only
Sat Kx: 30 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.3
Beta: 2e-06 /psf

Sheet Pile

Hydraulic

Model: Saturated Only
Sat Kx: 0.0004675 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.02
Beta: 1e-10 /psf

Initial Water Tables

Initial Water Table 1

Max. negative head: 8 ft

Coordinates

Coordinate 1: (0.1, 193) ft
Coordinate 2: (600, 193) ft

Boundary Conditions

Transient Head

Type: Water Total Head
Seep Head vs. Time Function: Long
Review: No

Seepage faces

Type: Water Flux 0
Review: Yes

Water K Functions

V-G Unsaturated

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 0.00034722222
Data Points: Matric Suction (psf), Water X-Conductivity (ft/d)
Data Point: (0.01, 30)
Data Point: (0.017988923, 29.999926)
Data Point: (0.032360135, 29.999729)
Data Point: (0.058212397, 29.999214)
Data Point: (0.10471783, 29.99786)
Data Point: (0.1883761, 29.9943)
Data Point: (0.33886831, 29.984941)
Data Point: (0.60958759, 29.960359)
Data Point: (1.0965824, 29.895636)
Data Point: (1.9726337, 29.725385)
Data Point: (3.5485555, 29.278558)
Data Point: (6.3834691, 28.111111)
Data Point: (11.483173, 25.150393)
Data Point: (20.656992, 18.416563)
Data Point: (37.159703, 7.8088416)

Data Point: (66.846304, 1.1316273)
Data Point: (120.2493, 0.057901497)
Data Point: (216.31554, 0.0018716883)
Data Point: (389.12836, 5.3525775e-05)
Data Point: (700, 1.4892964e-06)
Estimation Properties
Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: V-G Model
Saturated Kx: 70 ft/d
Residual Water Content: 0.0447
Maximum: 700
Minimum: 0.01
Num. Points: 20

Concrete Permeability V-G

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 1e-09
Data Points: Matric Suction (psf), Water X-Conductivity (ft/d)
Data Point: (0.001, 8.64e-05)
Data Point: (0.0014506574, 8.64e-05)
Data Point: (0.002104407, 8.64e-05)
Data Point: (0.0030527737, 8.64e-05)
Data Point: (0.0044285289, 8.64e-05)
Data Point: (0.0064242785, 8.64e-05)
Data Point: (0.0093194274, 8.64e-05)
Data Point: (0.013519297, 8.64e-05)
Data Point: (0.019611869, 8.64e-05)
Data Point: (0.028450103, 8.64e-05)
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Data Point: (0.38462539, 8.6399997e-05)
Data Point: (0.55795968, 8.6399979e-05)
Data Point: (0.80940837, 8.639991e-05)
Data Point: (1.1741743, 8.6399757e-05)

Data Point: (1.7033247, 8.6398742e-05)
Data Point: (2.4709406, 8.6395843e-05)
Data Point: (3.5844884, 8.6383756e-05)
Data Point: (5.1998648, 8.633371e-05)
Data Point: (7.5432225, 8.6167714e-05)
Data Point: (10.942632, 8.5459786e-05)
Data Point: (15.874011, 8.2780909e-05)
Data Point: (23.027752, 7.3231988e-05)
Data Point: (33.405379, 4.5685015e-05)
Data Point: (48.459762, 9.7412672e-06)
Data Point: (70.298515, 4.8659722e-07)
Data Point: (101.97906, 1.0727195e-08)
Data Point: (147.93669, 1.8757487e-10)
Data Point: (214.60546, 3.1983129e-12)
Data Point: (311.31901, 5.3810329e-14)
Data Point: (451.61724, 9.0519556e-16)
Data Point: (655.14191, 1.522525e-17)
Data Point: (950.38649, 2.5598876e-19)
Data Point: (1,378.6852, 4.305468e-21)
Data Point: (2,000, 7.2403592e-23)

Estimation Properties

Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Concrete V-G
Saturated Kx: 8.64e-05 ft/d
Residual Water Content: 0.003
Maximum: 2,000
Minimum: 0.001
Num. Points: 40

Hydraulic Boundary Functions

Long

Model: Spline Data Point Function
Function: Water Total Head vs. Time
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Y-Intercept: 190
Data Set: Copy of Book2

Vol. Water Content Functions

V-G Model

Model: Van Genuchten Function
Function: Volumetric Water Content vs. Water Pressure
Beta: 2e-06 /psf
Saturated Water Content: 0.38
Residual Water Content: 0.0447
A: 52 psf
N: 2.65
M: 0.6226415094339622
Suction Limit: 20885434.21089708
Porosity: 0.38000035

Concrete V-G

Model: Van Genuchten Function
Function: Volumetric Water Content vs. Water Pressure
Beta: 1e-10 /psf
Saturated Water Content: 0.05
Residual Water Content: 0.003
A: 47.25 psf
N: 4.6
M: 0.7826086956521738
Suction Limit: 20885434.21089708
Porosity: 0.05

Points

	X	Y
Point 1	600 ft	190 ft
Point 2	100 ft	197 ft
Point 3	100 ft	30 ft
Point 4	600 ft	30 ft
Point 5	100 ft	150 ft
Point 6	600 ft	150 ft
Point 7	100 ft	190 ft
Point 8	431 ft	190 ft
Point 9	431 ft	150 ft
Point 10	431 ft	180 ft

Point 11	431 ft	170 ft
Point 12	100 ft	170 ft
Point 13	100 ft	180 ft
Point 14	381.25 ft	197 ft
Point 15	378 ft	197 ft
Point 16	377.25 ft	197 ft
Point 17	375.25 ft	197 ft
Point 18	378 ft	207.5 ft
Point 19	377.25 ft	207.5 ft
Point 20	431 ft	197 ft
Point 21	378.5 ft	182 ft
Point 22	378 ft	182 ft
Point 23	378 ft	190 ft
Point 24	378.5 ft	190 ft
Point 25	100 ft	193 ft
Point 26	431 ft	193 ft
Point 27	375.25 ft	194 ft
Point 28	381.25 ft	194 ft
Point 29	378 ft	194 ft
Point 30	378 ft	193 ft
Point 31	178.5 ft	192 ft
Point 32	378.5 ft	194 ft
Point 33	378.5 ft	193 ft
Point 34	378 ft	179 ft
Point 35	378.5 ft	179 ft
Point 36	378 ft	180 ft
Point 37	378.5 ft	180 ft

Lines

	Start Point	End Point	Length	Angle	Hydraulic Boundary
Line 1	3	4	500 ft	0 °	
Line 2	4	6	120 ft	90 °	
Line 3	5	3	120 ft	90 °	
Line 4	5	9	331 ft	0 °	
Line 5	6	9	169 ft	0 °	Transient Head
Line 6	9	11	20 ft	90 °	Transient Head
Line 7	12	5	20 ft	90 °	

Line 8	15	18	10.5 ft	90 °	Transient Head
Line 9	18	19	0.75 ft	0 °	
Line 10	19	16	10.5 ft	90 °	Seepage faces
Line 11	16	17	2 ft	0 °	Seepage faces
Line 12	20	14	49.75 ft	0 °	Transient Head
Line 13	17	2	275.25 ft	0 °	Seepage faces
Line 14	10	8	10 ft	90 °	Transient Head
Line 15	7	13	10 ft	90 °	
Line 16	11	10	10 ft	90 °	Transient Head
Line 17	13	12	10 ft	90 °	
Line 18	7	23	278 ft	0 °	
Line 19	24	8	52.5 ft	0 °	
Line 20	24	21	8 ft	90 °	
Line 21	21	22	0.5 ft	0 °	
Line 22	22	23	8 ft	90 °	
Line 23	2	25	4 ft	90 °	
Line 24	25	7	3 ft	90 °	
Line 25	8	26	3 ft	90 °	Transient Head
Line 26	26	20	4 ft	90 °	Transient Head
Line 27	11	12	331 ft	0 °	
Line 28	14	15	3.25 ft	0 °	Transient Head
Line 29	17	27	3 ft	90 °	
Line 30	28	14	3 ft	90 °	
Line 31	27	29	2.75 ft	0 °	
Line 32	30	29	1 ft	90 °	
Line 33	29	32	0.5 ft	0 °	
Line 34	32	28	2.75 ft	0 °	
Line 35	33	32	1 ft	90 °	
Line 36	25	30	278 ft	0 °	
Line 37	23	30	3 ft	90 °	
Line 38	33	24	3 ft	90 °	
Line 39	33	26	52.5 ft	0 °	
Line 40	13	36	278 ft	0 °	
Line 41	37	10	52.5 ft	0 °	
Line 42	37	35	1 ft	90 °	
Line 43	35	34	0.5 ft	0 °	
Line 44	34	36	1 ft	90 °	
Line 45	22	36	2 ft	90 °	
Line 46	37	21	2 ft	90 °	

Regions

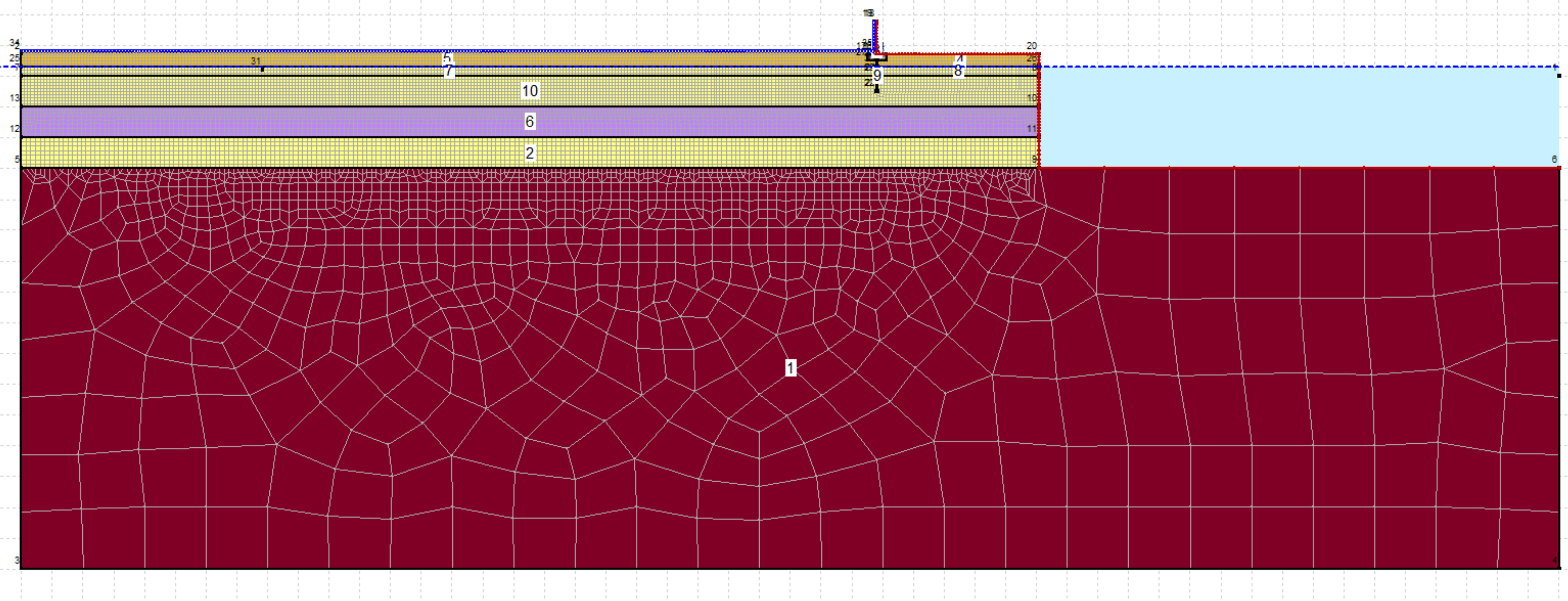
	Material	Points	Area
Region 1	Bedrock	3,4,6,9,5	60,000 ft^2
Region 2	Fill saturated	12,5,9,11	6,620 ft^2
Region 3	Concrete	14,15,18,19,16,17,27,29,32,28	25.875 ft^2
Region 4	Fill Unsaturated	26,20,14,28,32,33	201.75 ft^2
Region 5	Fill Unsaturated	17,2,25,30,29,27	1,103.8 ft^2
Region 6	Higher permeability	13,12,11,10,37,35,34,36	3,309.5 ft^2
Region 7	Fill saturated	25,7,23,30	834 ft^2
Region 8	Fill saturated	33,24,8,26	157.5 ft^2
Region 9	Sheet Pile	33,32,29,30,23,22,21,24	6 ft^2
Region 10	Sheet Pile	22,36,34,35,37,21	1.5 ft^2
Region 11	Fill saturated	23,7,13,36,22	2,780 ft^2
Region 12	Fill saturated	10,8,24,21,37	525 ft^2

Mesh Properties

View: 2D

Element Thickness: 1 ft

2D Model for Seepage Analyses for WP40~WP46
(Sta.25+00 to Sta.28+00)



See model inputs summarized in the following 10 pages:

SEEP/W Analysis

File Information

File Version: 9.00
Created By: Drafting
Last Edited By: Drafting
Revision Number: 107
Date: 12/28/2020
Time: 09:40:56 AM
Tool Version: 9.0.3.15488
File Name: Section 4 Sta. 25+00 to 28+00.gsz
Directory: R:\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\SEEPW analyses\Seepage Calculations for Review\

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SEEP/W Analysis

Kind: SEEP/W
Method: Transient
Physics
- Water Transfer
  - Free convection: thermal effects: No
  - Free convection: solute effects: No
  - Vapor transfer: isothermal: No
  - Vapor transfer: thermal: No

Water Settings
- Initial PWP Conditions from: Water Table
- Maximum Number of Iterations: 500
- Maximum Difference: 0.005
- Significant Digits: 2

Max # of Reviews: 10
Under-Relaxation Criteria
Initial Rate: 1
Minimum Rate: 0.1
Rate Reduction Factor: 0.65
Reduction Frequency (iterations): 10
Unit Weight of Water: 62.430189 pcf
Bulk Modulus of Pore-Fluid: 43,511,321 psf
Settings
Dimension: 2D
Exclude cumulative values: No
Time
Starting Time: 0 d
Duration: 4 d
# of Steps: 192
Step Generation Method: Linear
Time Increment: 0.020833333 d
Save Steps Every: 1

Materials

Fill saturated

Hydraulic
Model: Saturated Only
Sat Kx: 30 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.36
Beta: 2e-06 /psf

Bedrock

Hydraulic
Model: Saturated Only
Sat Kx: 0.1 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.1
Beta: 1e-08 /psf

Concrete

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: Concrete V-G
K-Function: Concrete Permeability V-G
Ky'/Kx' Ratio: 1
Rotation: 0 °

Fill Unsaturated

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: V-G Model
K-Function: V-G Unsaturated
Ky'/Kx' Ratio: 1
Rotation: 0 °

Higher permeability

Hydraulic

Model: Saturated Only
Sat Kx: 30 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.3
Beta: 2e-06 /psf

Sheet Pile

Hydraulic

Model: Saturated Only
Sat Kx: 0.0004675 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.02
Beta: 1e-10 /psf

Initial Water Tables

Initial Water Table 1

Max. negative head: 8 ft
Coordinates

Coordinate 1: (0.1, 193) ft
Coordinate 2: (600, 193) ft

Boundary Conditions

Transient Head

Type: Water Total Head
Seep Head vs. Time Function: Long
Review: No

Seepage faces

Type: Water Flux 0
Review: Yes

Water K Functions

V-G Unsaturated

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 0.00034722222
Data Points: Matric Suction (psf), Water X-Conductivity (ft/d)
Data Point: (0.01, 30)
Data Point: (0.017988923, 29.999926)
Data Point: (0.032360135, 29.999729)
Data Point: (0.058212397, 29.999214)
Data Point: (0.10471783, 29.99786)
Data Point: (0.1883761, 29.9943)
Data Point: (0.33886831, 29.984941)
Data Point: (0.60958759, 29.960359)
Data Point: (1.0965824, 29.895636)
Data Point: (1.9726337, 29.725385)
Data Point: (3.5485555, 29.278558)
Data Point: (6.3834691, 28.111111)
Data Point: (11.483173, 25.150393)
Data Point: (20.656992, 18.416563)
Data Point: (37.159703, 7.8088416)

Data Point: (66.846304, 1.1316273)
Data Point: (120.2493, 0.057901497)
Data Point: (216.31554, 0.0018716883)
Data Point: (389.12836, 5.3525775e-05)
Data Point: (700, 1.4892964e-06)
Estimation Properties
Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: V-G Model
Saturated Kx: 70 ft/d
Residual Water Content: 0.0447
Maximum: 700
Minimum: 0.01
Num. Points: 20

Concrete Permeability V-G

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 1e-09
Data Points: Matric Suction (psf), Water X-Conductivity (ft/d)
Data Point: (0.001, 8.64e-05)
Data Point: (0.0014506574, 8.64e-05)
Data Point: (0.002104407, 8.64e-05)
Data Point: (0.0030527737, 8.64e-05)
Data Point: (0.0044285289, 8.64e-05)
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Data Point: (0.0093194274, 8.64e-05)
Data Point: (0.013519297, 8.64e-05)
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Data Point: (0.086851727, 8.64e-05)
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Data Point: (1.1741743, 8.6399757e-05)

Data Point: (1.7033247, 8.6398742e-05)
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Data Point: (23.027752, 7.3231988e-05)
Data Point: (33.405379, 4.5685015e-05)
Data Point: (48.459762, 9.7412672e-06)
Data Point: (70.298515, 4.8659722e-07)
Data Point: (101.97906, 1.0727195e-08)
Data Point: (147.93669, 1.8757487e-10)
Data Point: (214.60546, 3.1983129e-12)
Data Point: (311.31901, 5.3810329e-14)
Data Point: (451.61724, 9.0519556e-16)
Data Point: (655.14191, 1.522525e-17)
Data Point: (950.38649, 2.5598876e-19)
Data Point: (1,378.6852, 4.305468e-21)
Data Point: (2,000, 7.2403592e-23)

Estimation Properties

Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Concrete V-G
Saturated Kx: 8.64e-05 ft/d
Residual Water Content: 0.003
Maximum: 2,000
Minimum: 0.001
Num. Points: 40

Hydraulic Boundary Functions

Long

Model: Spline Data Point Function
Function: Water Total Head vs. Time
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Y-Intercept: 190
Data Set: Copy of Book2

Vol. Water Content Functions

V-G Model

Model: Van Genuchten Function
Function: Volumetric Water Content vs. Water Pressure
Beta: 2e-06 /psf
Saturated Water Content: 0.38
Residual Water Content: 0.0447
A: 52 psf
N: 2.65
M: 0.6226415094339622
Suction Limit: 20885434.21089708
Porosity: 0.38000035

Concrete V-G

Model: Van Genuchten Function
Function: Volumetric Water Content vs. Water Pressure
Beta: 1e-10 /psf
Saturated Water Content: 0.05
Residual Water Content: 0.003
A: 47.25 psf
N: 4.6
M: 0.7826086956521738
Suction Limit: 20885434.21089708
Porosity: 0.05

Points

	X	Y
Point 1	600 ft	190 ft
Point 2	100 ft	197 ft
Point 3	100 ft	30 ft
Point 4	600 ft	30 ft
Point 5	100 ft	160 ft
Point 6	600 ft	160 ft
Point 7	100 ft	190 ft
Point 8	431 ft	190 ft
Point 9	431 ft	160 ft
Point 10	431 ft	180 ft

Point 11	431 ft	170 ft
Point 12	100 ft	170 ft
Point 13	100 ft	180 ft
Point 14	381.25 ft	197 ft
Point 15	378 ft	197 ft
Point 16	377.25 ft	197 ft
Point 17	375.25 ft	197 ft
Point 18	378 ft	207.5 ft
Point 19	377.25 ft	207.5 ft
Point 20	431 ft	197 ft
Point 21	378.5 ft	185 ft
Point 22	378 ft	185 ft
Point 23	378 ft	190 ft
Point 24	378.5 ft	190 ft
Point 25	100 ft	193 ft
Point 26	431 ft	193 ft
Point 27	375.25 ft	195 ft
Point 28	381.25 ft	195 ft
Point 29	378 ft	195 ft
Point 30	378 ft	193 ft
Point 31	178.5 ft	192 ft
Point 32	378.5 ft	195 ft
Point 33	378.5 ft	193 ft
Point 34	100 ft	198 ft
Point 35	377.25 ft	198 ft

Lines

	Start Point	End Point	Length	Angle	Hydraulic Boundary
Line 1	3	4	500 ft	0 °	
Line 2	4	6	130 ft	90 °	
Line 3	5	3	130 ft	90 °	
Line 4	5	9	331 ft	0 °	
Line 5	6	9	169 ft	0 °	Transient Head
Line 6	9	11	10 ft	90 °	Transient Head
Line 7	12	5	10 ft	90 °	
Line 8	15	18	10.5 ft	90 °	Transient Head
Line 9	18	19	0.75 ft	0 °	

Line 10	16	17	2 ft	0 °	
Line 11	20	14	49.75 ft	0 °	Transient Head
Line 12	10	8	10 ft	90 °	Transient Head
Line 13	7	13	10 ft	90 °	
Line 14	11	10	10 ft	90 °	Transient Head
Line 15	13	12	10 ft	90 °	
Line 16	7	23	278 ft	0 °	
Line 17	24	8	52.5 ft	0 °	
Line 18	24	21	5 ft	90 °	
Line 19	21	22	0.5 ft	0 °	
Line 20	22	23	5 ft	90 °	
Line 21	2	25	4 ft	90 °	
Line 22	25	7	3 ft	90 °	
Line 23	8	26	3 ft	90 °	Transient Head
Line 24	26	20	4 ft	90 °	Transient Head
Line 25	11	12	331 ft	0 °	
Line 26	14	15	3.25 ft	0 °	Transient Head
Line 27	17	27	2 ft	90 °	
Line 28	28	14	2 ft	90 °	
Line 29	27	29	2.75 ft	0 °	
Line 30	30	29	2 ft	90 °	
Line 31	29	32	0.5 ft	0 °	
Line 32	32	28	2.75 ft	0 °	
Line 33	33	32	2 ft	90 °	
Line 34	25	30	278 ft	0 °	
Line 35	23	30	3 ft	90 °	
Line 36	33	24	3 ft	90 °	
Line 37	33	26	52.5 ft	0 °	
Line 38	19	35	9.5 ft	90 °	Seepage faces
Line 39	35	16	1 ft	90 °	
Line 40	34	2	1 ft	90 °	
Line 41	35	34	277.25 ft	0 °	Seepage faces
Line 42	10	13	331 ft	0 °	

Regions

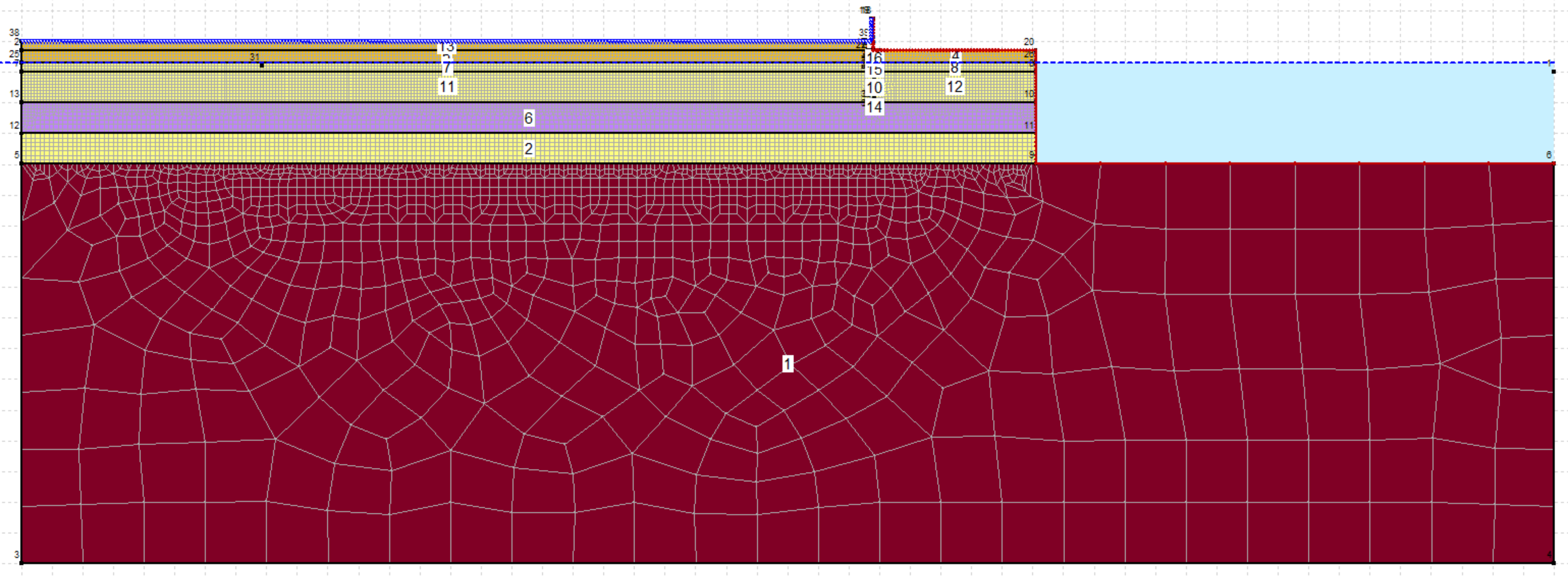
	Material	Points	Area
Region 1	Bedrock	3,4,6,9,5	65,000 ft^2

Region 2	Fill saturated	12,5,9,11	3,310 ft²
Region 3	Concrete	14,15,18,19,35,16,17,27,29,32,28	19.875 ft²
Region 4	Fill Unsaturated	26,20,14,28,32,33	204.5 ft²
Region 5	Fill Unsaturated	25,30,29,27,17,16,35,34,2	1,383.8 ft²
Region 6	Higher permeability	13,12,11,10	3,310 ft²
Region 7	Fill saturated	25,7,23,30	834 ft²
Region 8	Fill saturated	33,24,8,26	157.5 ft²
Region 9	Sheet Pile	33,32,29,30,23,22,21,24	5 ft²
Region 10	Fill saturated	22,23,7,13,10,8,24,21	3,307.5 ft²

Mesh Properties

View: 2D
Element Thickness: 1 ft

2D Model for Seepage Analyses for WP46~WP55
(Sta.28+00 to Sta. 30+04 (End))



See model inputs summarized in the following 10 pages:

SEEP/W Analysis

File Information

File Version: 9.00
Created By: Drafting
Last Edited By: Drafting
Revision Number: 114
Date: 03/05/2021
Time: 01:09:24 PM
Tool Version: 9.0.3.15488
File Name: Section 5 Sta. 28+00 to End.gsz
Directory: R:\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00 South Battery Park Resiliancy\REPORT\Report calcs\SEEPW analyses\Seepage Calculations for Review\

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SEEP/W Analysis

Kind: SEEP/W
Method: Transient
Physics
- Water Transfer
  - Free convection: thermal effects: No
  - Free convection: solute effects: No
  - Vapor transfer: isothermal: No
  - Vapor transfer: thermal: No

Water Settings
- Initial PWP Conditions from: Water Table
- Maximum Number of Iterations: 500
- Maximum Difference: 0.005
- Significant Digits: 2

Max # of Reviews: 10
Under-Relaxation Criteria
Initial Rate: 1
Minimum Rate: 0.1
Rate Reduction Factor: 0.65
Reduction Frequency (iterations): 10
Unit Weight of Water: 62.430189 pcf
Bulk Modulus of Pore-Fluid: 43,511,321 psf
Settings
Dimension: 2D
Exclude cumulative values: No
Time
Starting Time: 0 d
Duration: 4 d
# of Steps: 192
Step Generation Method: Linear
Time Increment: 0.020833333 d
Save Steps Every: 1

Materials

Fill saturated

Hydraulic
Model: Saturated Only
Sat Kx: 30 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.36
Beta: 2e-06 /psf

Bedrock

Hydraulic
Model: Saturated Only
Sat Kx: 0.1 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.1
Beta: 1e-08 /psf

Concrete

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: Concrete V-G
K-Function: Concrete Permeability V-G
Ky'/Kx' Ratio: 1
Rotation: 0 °

Fill Unsaturated

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: V-G Model
K-Function: V-G Unsaturated
Ky'/Kx' Ratio: 1
Rotation: 0 °

Higher permeability

Hydraulic

Model: Saturated Only
Sat Kx: 30 ft/d
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.3
Beta: 2e-06 /psf

Initial Water Tables

Initial Water Table 1

Max. negative head: 8 ft

Coordinates

Coordinate 1: (0.1, 193) ft
Coordinate 2: (600, 193) ft

Boundary Conditions

Transient Head

Type: Water Total Head

Seep Head vs. Time Function: Long
Review: No

Seepage faces

Type: Water Flux 0
Review: Yes

Water K Functions

V-G Unsaturated

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 0.00034722222
Data Points: Matric Suction (psf), Water X-Conductivity (ft/d)
Data Point: (0.01, 30)
Data Point: (0.017988923, 29.999926)
Data Point: (0.032360135, 29.999729)
Data Point: (0.058212397, 29.999214)
Data Point: (0.10471783, 29.99786)
Data Point: (0.1883761, 29.9943)
Data Point: (0.33886831, 29.984941)
Data Point: (0.60958759, 29.960359)
Data Point: (1.0965824, 29.895636)
Data Point: (1.9726337, 29.725385)
Data Point: (3.5485555, 29.278558)
Data Point: (6.3834691, 28.111111)
Data Point: (11.483173, 25.150393)
Data Point: (20.656992, 18.416563)
Data Point: (37.159703, 7.8088416)
Data Point: (66.846304, 1.1316273)
Data Point: (120.2493, 0.057901497)
Data Point: (216.31554, 0.0018716883)
Data Point: (389.12836, 5.3525775e-05)
Data Point: (700, 1.4892964e-06)
Estimation Properties
Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: V-G Model

Saturated Kx: 70 ft/d
Residual Water Content: 0.0447
Maximum: 700
Minimum: 0.01
Num. Points: 20

Concrete Permeability V-G

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 1e-09
Data Points: Matric Suction (psf), Water X-Conductivity (ft/d)
Data Point: (0.001, 8.64e-05)
Data Point: (0.0014506574, 8.64e-05)
Data Point: (0.002104407, 8.64e-05)
Data Point: (0.0030527737, 8.64e-05)
Data Point: (0.0044285289, 8.64e-05)
Data Point: (0.0064242785, 8.64e-05)
Data Point: (0.0093194274, 8.64e-05)
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Data Point: (0.80940837, 8.639991e-05)
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Data Point: (1.7033247, 8.6398742e-05)
Data Point: (2.4709406, 8.6395843e-05)
Data Point: (3.5844884, 8.6383756e-05)
Data Point: (5.1998648, 8.633371e-05)
Data Point: (7.5432225, 8.6167714e-05)
Data Point: (10.942632, 8.5459786e-05)
Data Point: (15.874011, 8.2780909e-05)
Data Point: (23.027752, 7.3231988e-05)

Data Point: (33.405379, 4.5685015e-05)
Data Point: (48.459762, 9.7412672e-06)
Data Point: (70.298515, 4.8659722e-07)
Data Point: (101.97906, 1.0727195e-08)
Data Point: (147.93669, 1.8757487e-10)
Data Point: (214.60546, 3.1983129e-12)
Data Point: (311.31901, 5.3810329e-14)
Data Point: (451.61724, 9.0519556e-16)
Data Point: (655.14191, 1.522525e-17)
Data Point: (950.38649, 2.5598876e-19)
Data Point: (1,378.6852, 4.305468e-21)
Data Point: (2,000, 7.2403592e-23)

Estimation Properties

Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Concrete V-G
Saturated Kx: 8.64e-05 ft/d
Residual Water Content: 0.003
Maximum: 2,000
Minimum: 0.001
Num. Points: 40

Hydraulic Boundary Functions

Long

Model: Spline Data Point Function
Function: Water Total Head vs. Time
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Y-Intercept: 190
Data Set: Copy of Book2

Vol. Water Content Functions

V-G Model

Model: Van Genuchten Function
Function: Volumetric Water Content vs. Water Pressure
Beta: 2e-06 /psf
Saturated Water Content: 0.38

Residual Water Content: 0.0447
A: 52 psf
N: 2.65
M: 0.6226415094339622
Suction Limit: 20885434.21089708
Porosity: 0.38000035

Concrete V-G

Model: Van Genuchten Function
Function: Volumetric Water Content vs. Water Pressure
Beta: 1e-10 /psf
Saturated Water Content: 0.05
Residual Water Content: 0.003
A: 47.25 psf
N: 4.6
M: 0.7826086956521738
Suction Limit: 20885434.21089708
Porosity: 0.05

Points

	X	Y
Point 1	600 ft	190 ft
Point 2	100 ft	197 ft
Point 3	100 ft	30 ft
Point 4	600 ft	30 ft
Point 5	100 ft	160 ft
Point 6	600 ft	160 ft
Point 7	100 ft	190 ft
Point 8	431 ft	190 ft
Point 9	431 ft	160 ft
Point 10	431 ft	180 ft
Point 11	431 ft	170 ft
Point 12	100 ft	170 ft
Point 13	100 ft	180 ft
Point 14	379.75 ft	197 ft
Point 15	378 ft	197 ft
Point 16	377.25 ft	197 ft
Point 17	376.25 ft	197 ft

Point 18	378 ft	207.5 ft
Point 19	377.25 ft	207.5 ft
Point 20	431 ft	197 ft
Point 21	378.5 ft	189.5 ft
Point 22	378 ft	189.5 ft
Point 23	378 ft	190 ft
Point 24	378.5 ft	190 ft
Point 25	100 ft	193 ft
Point 26	431 ft	193 ft
Point 27	376.25 ft	196 ft
Point 28	379.75 ft	196 ft
Point 29	378 ft	196 ft
Point 30	378 ft	193 ft
Point 31	178.5 ft	192 ft
Point 32	378.5 ft	196 ft
Point 33	378.5 ft	193 ft
Point 34	378 ft	177 ft
Point 35	378.5 ft	177 ft
Point 36	378 ft	180 ft
Point 37	378.5 ft	180 ft
Point 38	100 ft	200 ft
Point 39	377.25 ft	200 ft
Point 40	378 ft	192 ft
Point 41	378.5 ft	192 ft

Lines

	Start Point	End Point	Length	Angle	Hydraulic Boundary
Line 1	3	4	500 ft	0 °	
Line 2	4	6	130 ft	90 °	
Line 3	5	3	130 ft	90 °	
Line 4	5	9	331 ft	0 °	
Line 5	6	9	169 ft	0 °	Transient Head
Line 6	9	11	10 ft	90 °	Transient Head
Line 7	12	5	10 ft	90 °	
Line 8	15	18	10.5 ft	90 °	Transient Head
Line 9	18	19	0.75 ft	0 °	
Line 10	16	17	1 ft	0 °	

Line 11	20	14	51.25 ft	0 °	Transient Head
Line 12	17	2	276.25 ft	0 °	
Line 13	10	8	10 ft	90 °	Transient Head
Line 14	7	13	10 ft	90 °	
Line 15	11	10	10 ft	90 °	Transient Head
Line 16	13	12	10 ft	90 °	
Line 17	7	23	278 ft	0 °	
Line 18	24	8	52.5 ft	0 °	
Line 19	24	21	0.5 ft	90 °	
Line 20	21	22	0.5 ft	0 °	
Line 21	22	23	0.5 ft	90 °	
Line 22	2	25	4 ft	90 °	
Line 23	25	7	3 ft	90 °	
Line 24	8	26	3 ft	90 °	Transient Head
Line 25	26	20	4 ft	90 °	Transient Head
Line 26	11	12	331 ft	0 °	
Line 27	14	15	1.75 ft	0 °	Transient Head
Line 28	17	27	1 ft	90 °	
Line 29	28	14	1 ft	90 °	
Line 30	27	29	1.75 ft	0 °	
Line 31	30	29	3 ft	90 °	
Line 32	29	32	0.5 ft	0 °	
Line 33	32	28	1.25 ft	0 °	
Line 34	33	32	3 ft	90 °	
Line 35	25	30	278 ft	0 °	
Line 36	33	26	52.5 ft	0 °	
Line 37	13	36	278 ft	0 °	
Line 38	37	10	52.5 ft	0 °	
Line 39	37	35	3 ft	90 °	
Line 40	35	34	0.5 ft	0 °	
Line 41	34	36	3 ft	90 °	
Line 42	22	36	9.5 ft	90 °	
Line 43	37	21	9.5 ft	90 °	
Line 44	19	39	7.5 ft	90 °	Seepage faces
Line 45	39	16	3 ft	90 °	
Line 46	2	38	3 ft	90 °	
Line 47	38	39	277.25 ft	0 °	Seepage faces
Line 48	36	37	0.5 ft	0 °	
Line 49	23	40	2 ft	90 °	

Line 50	40	30	1 ft	90 °	
Line 51	33	41	1 ft	90 °	
Line 52	41	24	2 ft	90 °	
Line 53	40	41	0.5 ft	0 °	
Line 54	30	33	0.5 ft	0 °	

Regions

	Material	Points	Area
Region 1	Bedrock	3,4,6,9,5	65,000 ft²
Region 2	Fill saturated	12,5,9,11	3,310 ft²
Region 3	Concrete	14,15,18,19,39,16,17,27,29,32,28	11.375 ft²
Region 4	Fill Unsaturated	26,20,14,28,32,33	208.75 ft²
Region 5	Fill Unsaturated	17,2,25,30,29,27	1,110.3 ft²
Region 6	Higher permeability	13,12,11,10,37,35,34,36	3,308.5 ft²
Region 7	Fill saturated	25,7,23,40,30	834 ft²
Region 8	Fill saturated	33,41,24,8,26	157.5 ft²
Region 9	Fill saturated	33,30,40,41	0.5 ft²
Region 10	Fill saturated	22,36,37,21	4.75 ft²
Region 11	Fill saturated	23,7,13,36,22	2,780 ft²
Region 12	Fill saturated	10,8,24,21,37	525 ft²
Region 13	Fill Unsaturated	2,38,39,16,17	831.75 ft²
Region 14	Higher permeability	34,35,37,36	1.5 ft²
Region 15	Fill saturated	23,22,21,24,41,40	1.25 ft²
Region 16	Fill Unsaturated	32,29,30,33	1.5 ft²

Mesh Properties

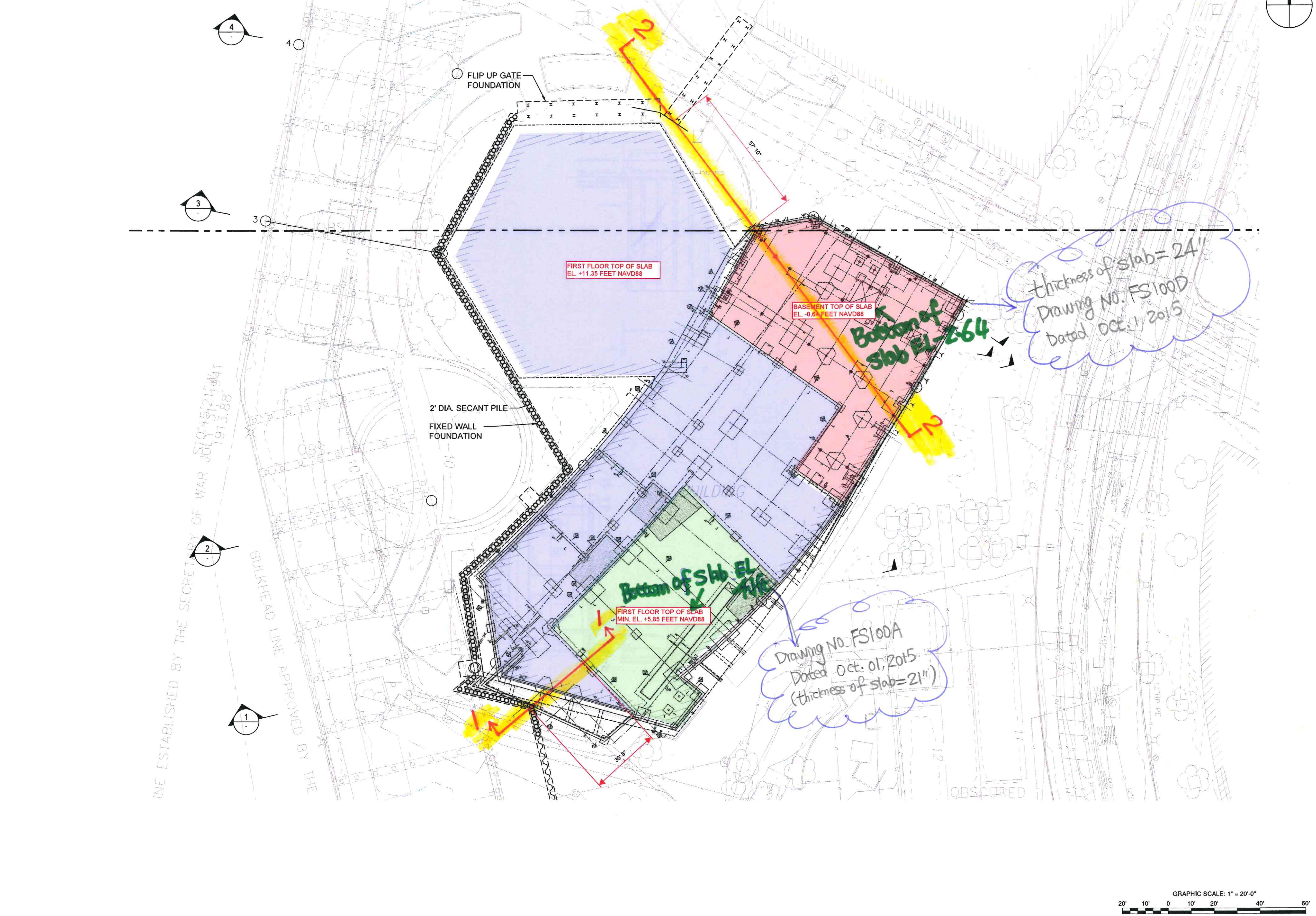
View: 2D

Element Thickness: 1 ft

APPENDIX J-2

J-2: SENSITIVITY ANALYSES OF TRANSIENT FLOW NEAR MJH

APPENDIX J-2: SENSITIVITY ANALYSES OF TRANSIENT FLOW NEAR MJH



ANSI D 22" x 34"

Last saved by: LOUIS.DIAZ(2020-01-30) Last Plotted: 2020-01-30
Filename: C:\PWWORKING\AECOM_D316_N\LOUIS.DIAZ@AECOM.COM\D0356128\MJH SECTIONS EXHIBIT_SEEPAGE.DWG

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PROJECT

SOUTH BATTERY PARK RESILIENCY DESIGN SERVICES

CLIENT

HUGH L. CAREY BATTERY PARK CITY AUTHORITY

CONSULTANT

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SITEWORKS

KEY PLAN

SOUTH BATTERY PARK

REGISTRATION

PRELIMINARY
NOT FOR CONSTRUCTION

ISSUE/REVISION

I/R	DATE	DESCRIPTION
	YYYY-MM-DD	

PROJECT/TERM CONTRACT NUMBER

Contract No. 18-2586

SHEET TITLE

MJH SECTIONS PLAN

SHEET NUMBER

30% DRAFT DESIGN DOCUMENTS

Oweis ENGINEERING INC. INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

Appendix J2-Summary of Seepage Analyses Near MJH

SEEPAGE ANALYSES NEAR JMH

Note: This analysis supersedes any previous submittals.

HYDRAGRAPH

The SEEP/W analysis was performed using the 100-year Storm water level (SLR included 2050s) with longer storm peak duration provided by AECOM. The highest flood head is assumed at El. 13.55.

PERMEABILITIES USED IN THE SEEPAGE ANALYSES

- Saturated permeability of soil above bedrock = 20ft/day
- Saturated permeability of concrete = 8.46×10^{-5} ft/day (the effective thickness of the secant pile wall is 12 inches for 24-inch secant piles with 21 inches center to center spacing). As explained below the results for steel sheet pile are similar to the secant wall.
- Saturated permeability of bedrock (slightly fractured to decomposed) = 0.1ft/day
- Permeability of Sheet pile = 9.35×10^{-4} ft/day (with fictious thickness of 1.0 foot)

It is noted here that unsaturated hydraulic properties of the soil which were estimated by the software ROSETTA - a program used to translate the basic soil data into hydraulic properties were applied to the soil/concrete above the static water level.

SOIL BOUNDARY ELEVATIONS

Top of Bedrock Elevation: -43ft

Existing Grade at Elevation: 10ft

ANALYTICAL SECTIONS (SEE ATTACHEMENT)

Section 1: **1st floor slab**

- Top of the slab elevation 5.85ft
- Bottom of the slab elevation **4.1ft** (the thickness of the slab 21-inch Drawing No. FS100A dated Oct 01, 2015)

Section 2: (Basement slab)

- Top of the slab elevation -0.64ft
- Bottom of the slab elevation **-2.64ft** (The thickness of the slab is 24inch Drawing No. FS100D dated Oct 01, 2015)

SOFTWARE AND ANALYSYS TYPE

Software-SEEP/W was used to perform the seepage analyses, and transient flow was analyzed with time step of half an hour.

SUMMARY OF ANALYSES PERFORMED

- Six penetration depths are considered with tip of secant pile/sheet pile at: El.-12, El. -31, El.-34, El.-37, El.-41 and El. -44 (full cutoff)
- Static water level was assumed at EL.1.5 which is close to the highest water level measured in field during OEI's field investigation. However, it does not reflect the fluctuations due to tides and precipitations.
- Sensitivity Analyses:
  1) Repeated the above analyses with static water level at El. 2.0 and El.3.0, respectively.
  2) Repeated the seepage analyses with pile tip elevation at El.-37 and water level at El.1.5 and with pile tip elevation at El.-12 and water level at El. 3.0 for soil above bedrock with saturated soil permeability of 70ft/day. It is understood that 70 ft/day is based on empirical correlations with grain size and is likely to be less reliable than 20 ft/day.

SUMMARY OF RESULTS:

[The following results are based on seepage analyses using secant pile wall. While sheet pile wall is used, the elevation of the top of saturation would be 0.0~0.02higher that of secant pile. Due to different between the two types of wall are negligible, the results of the sheet pile are not presented here].

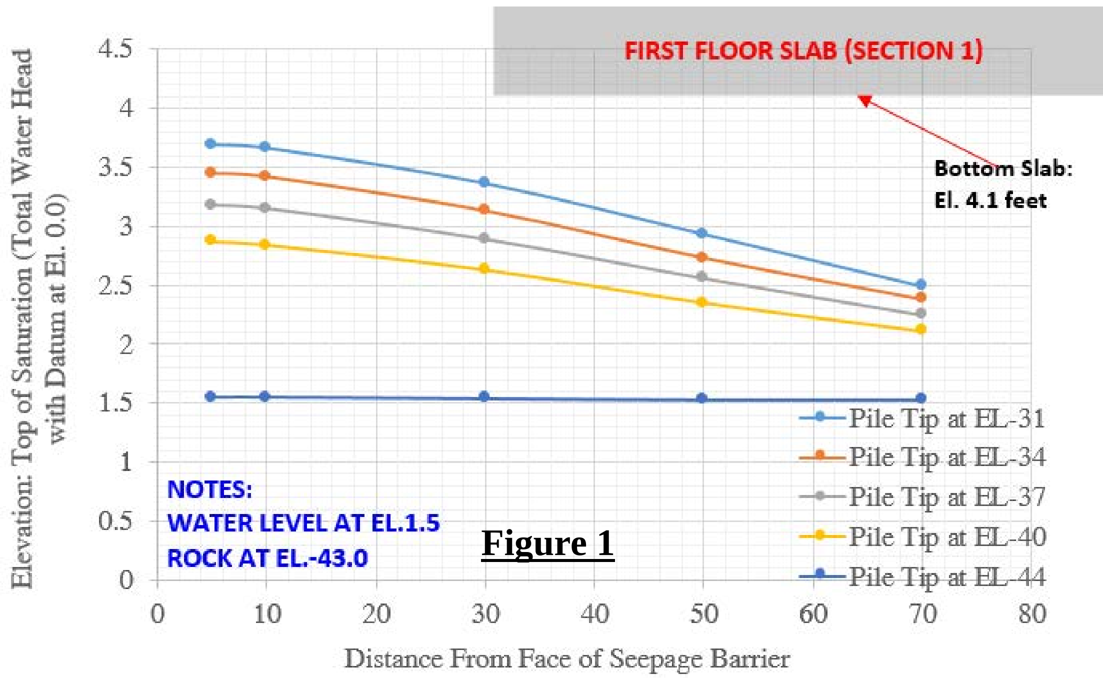
For Section 1 where the bottom of the slab is at elevation +4.1, the saturated zone is well below the bottom of the slab for initial static water level (SWL) of 1.5 and 2 considering a hydraulic conductivity of 20 feet per day (Figures 1 and Figure 2). In the event that the pre-event SWL is at +3 (hypothetical) the bottom of the slab for Section 1 will be subjected to pressure equivalent of about 1 inch to 28 inches for pile tip ranging from El. -40 to El.-12. The generated water head pressure is fine for the slab of which the tie-down system was designed for a water elevation near existing grade (El.10.0±) or even above according to AECOM. It is noted here that with tip elevation above El.-12, the seepage barrier may not be able meet the structural requirements.

Case 1 for initial SWL of 1.5(Figure 1) was repeated using a hydraulic conductivity of 70 ft/day and a pile tip of -37 (Figure 4). Despite the very high conductivity assumptions the pressure against the bottom of the slab does not exceed 9 inches of water for pile tip at -37 about 6 feet above the bedrock. For the pile tip at elevation El.-12, the generate water pressure at bottom of the slab of 4.6ft is still below the design capacity of tie-down system of the slab.

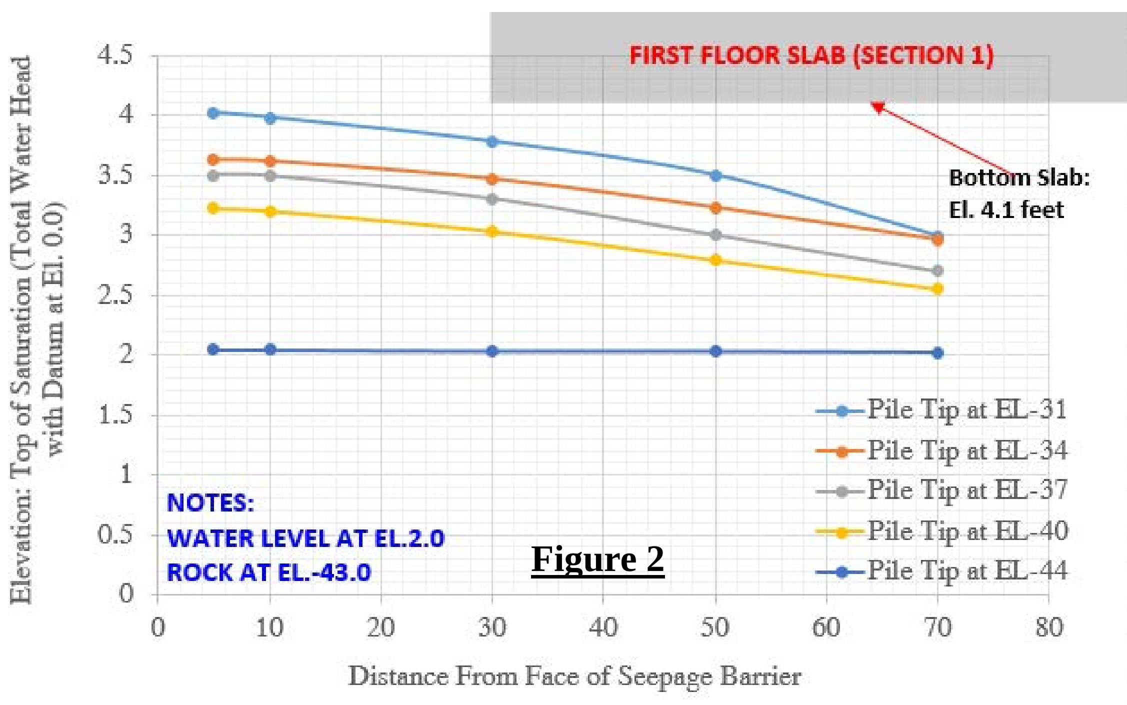
For Section 2 where the bottom the slab is lower than section 1, the bottom of the slab will be subjected to pressure for all initial SWL of 1.5, 2 and 3 as explained in Figures 5, 6 and 7, respectively. With the highest tip elevation at El.-12, the bottom of the basement slab will be subject to pressure equivalent of about 8.0 ft and 11.0ft for soil permeability of 20ft/day and 70ft/day, respectively. As the tiedown of the basement slab is designed for water level at the existing grade (El.10.0±) or even above according to AECOM, it should be able to resist an uplift water pressure over 12.64ft considering the bottom of the basement slab at El. -2.64. Therefore, the sensitivity analyses indicate that the design with tip elevation at El.-12.0 is ok for the basement slab even using K=70ft/day. As noted above, with tip elevation above El.-12 the seepage barrier may not be able meet the structural requirements.

Although the existing pile caps for this structure are approximately 4 feet lower than the floor slabs, it is assumed that any impacts to the pile caps are acceptable and the floor slab elevations are considered the critical element.

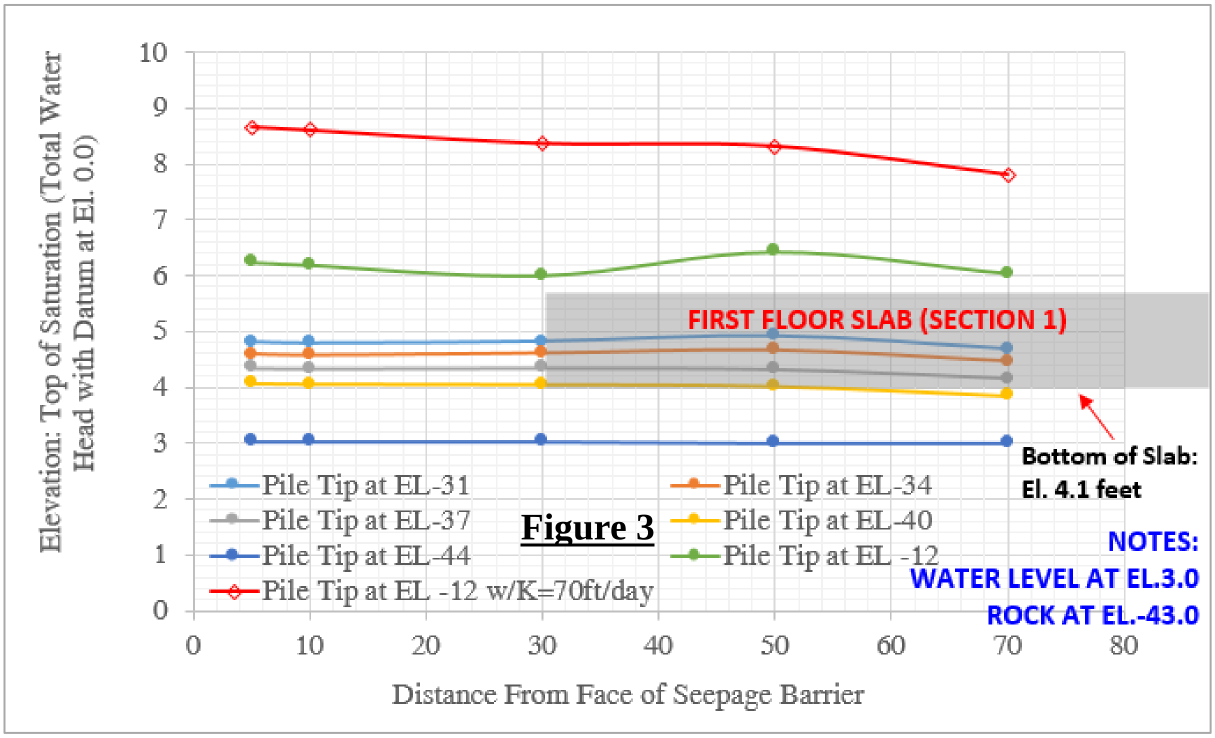
- **SECTION 1 (FIGURE 1): WATER LEVEL AT EL. 1.5, SOIL ABOVE ROCK K=20FT/DAY**



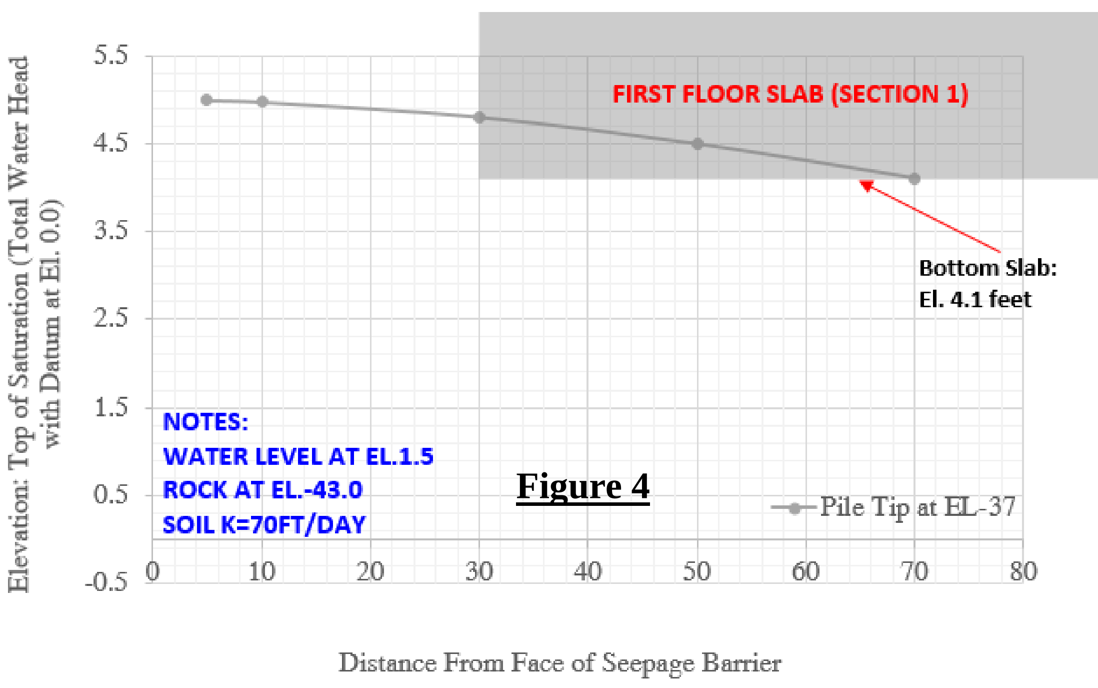
- **SECTION 1 (FIGURE 2): WATER LEVEL AT EL. 2.0, SOIL ABOVE ROCK K=20FT/DAY**



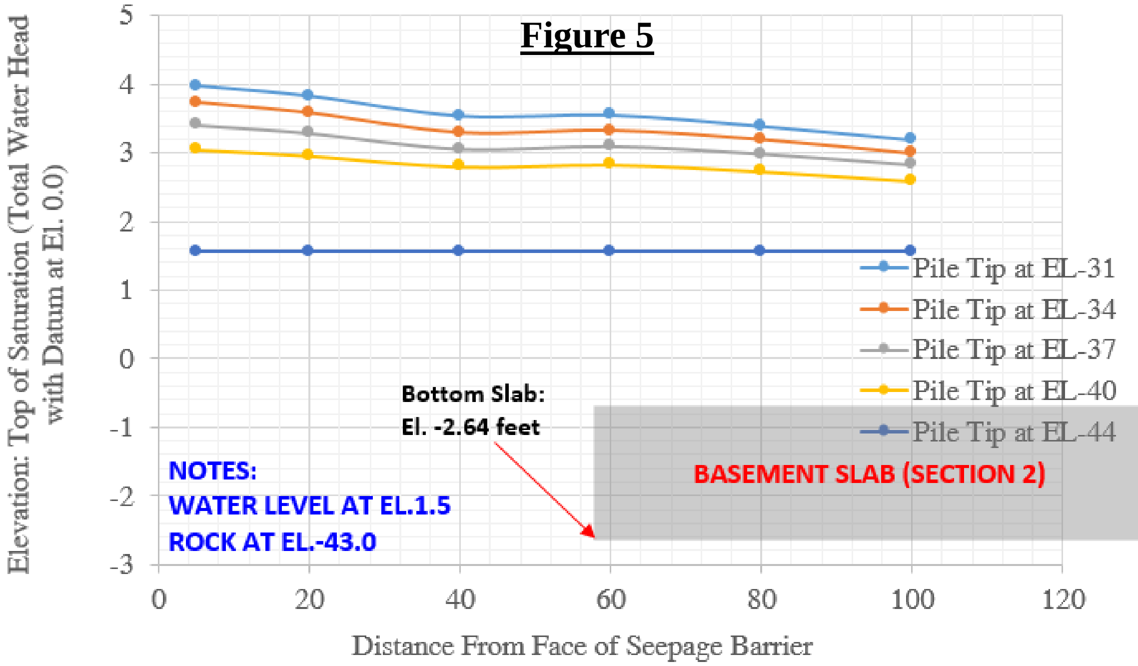
- **SECTION 1 (FIGURE 3): WATER LEVEL AT EL. 3.0, SOIL ABOVE ROCK K=20FT/DAY AND K=70FT/DAY**



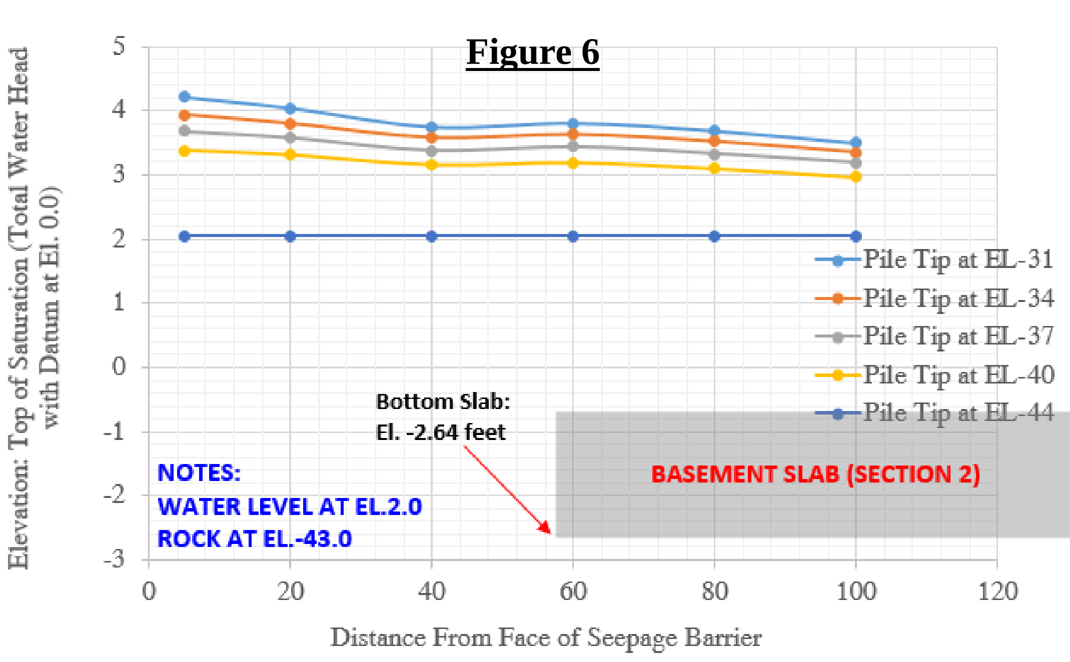
- **SECTION 1(FIGURE 4): WATER LEVEL AT EL. 1.5, SOIL ABOVE ROCK K=70FT/DAY**



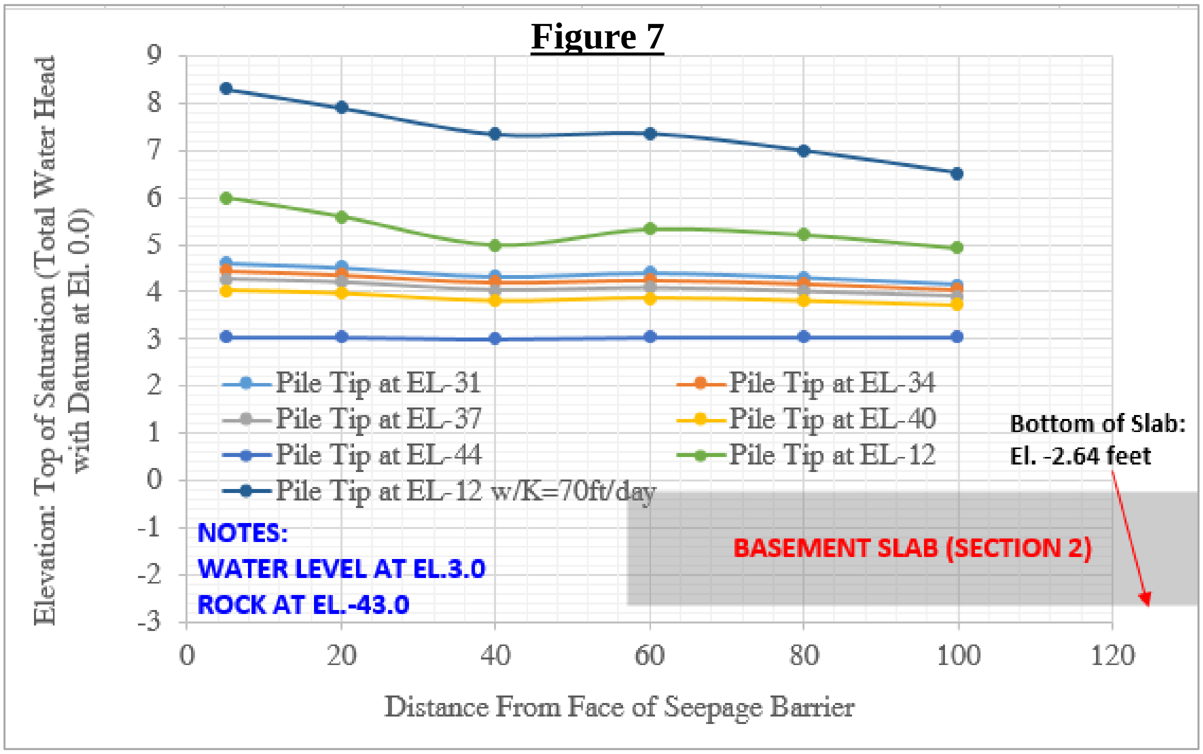
- **SECTION 2 FIGURE 5: WATER LEVEL AT EL. 1.5, SOIL ABOVE ROCK K=20FT/DAY**



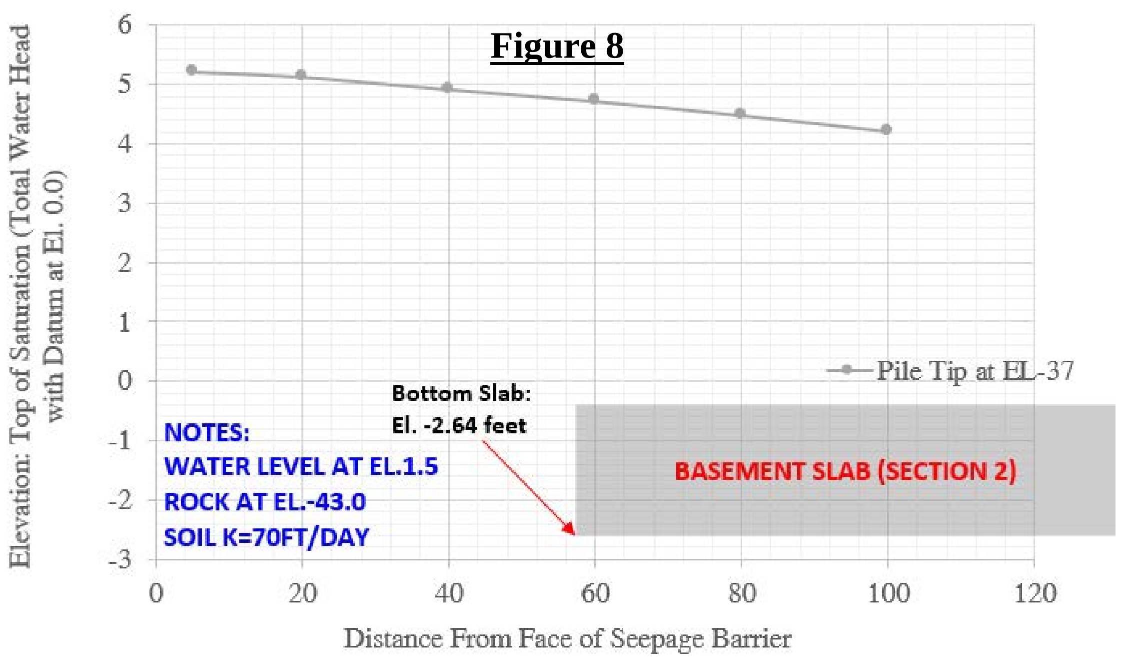
- **SECTION 2 FIGURE 6: WATER LEVEL AT EL. 2.0, SOIL ABOVE ROCK K=20FT/DAY**



- **SECTION 2(FIGURE 7): WATER LEVEL AT EL. 3.0, SOIL ABOVE ROCK K=20FT/DAY**



- **SECTION 2(FIGURE 8) : WATER LEVEL AT EL. 1.5, SOIL ABOVE ROCK K=70FT/DAY**



APPENDIX K

SHEET PILE WALL ANALYSES
K-1: SHEET PILE DESIGN FOR WP11-WP20
K-2: SHEET PILE DESIGN FOR WP20-WP21
K-3: SHEET PILE DESIGN FOR WP21-WP26
K-4: GLOBAL STABILITY ANALYSES

APPENDIX K-1

SHEET PILE WALL ANALYSES
K-1: SHEET PILE DESIGN FOR WP11-WP20

Flood Loads - MJH - Section 2.2

1. Wall Geometry

Stem Geometry

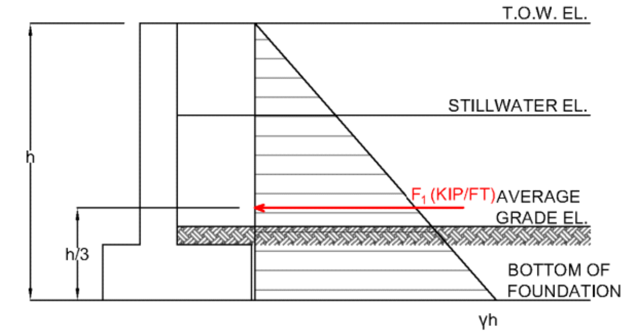
Top of wall elevation	$EL_{TOW} := 18ft$
Stillwater elevation	$EL_{SWL} := 13.8ft$
Grade elevation	$EL_{GR} := 10.5ft$
Stem height above grade	$h_s := EL_{TOW} - EL_{GR} = 7.5\ ft$
Stem thickness	$b := 18in$

Base Geometry

Base thickness	$h_f := 0in$
Toe	$x_t := 9in$
Heel	$x_h := 9in$
Base	$B := b + x_t + x_h = 3\ ft$
Height of soil above base	$d_s := 1ft$

2. Hydrostatic Loads

Hydrostatic Load at the Top of the Wall



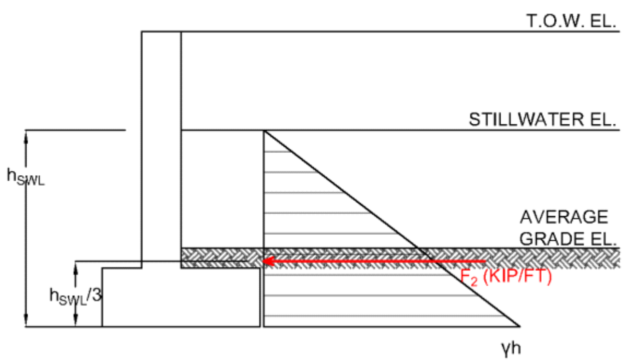
Height of wall $h := h_s + d_s + h_f = 8.5\ \text{ft}$

Distance from bottom of footing to hydrostatic load $y_1 := \frac{h}{3} = 2.83\ \text{ft}$

Unit weight of seawater $\gamma_w := 64 \frac{\text{lb}}{\text{ft}^3}$

Hydrostatic force $F_1 := .5 \cdot \gamma_w \cdot h^2 = 2.31 \times 10^3 \cdot \frac{\text{lb}}{\text{ft}}$

Hydrostatic Load at the Stillwater



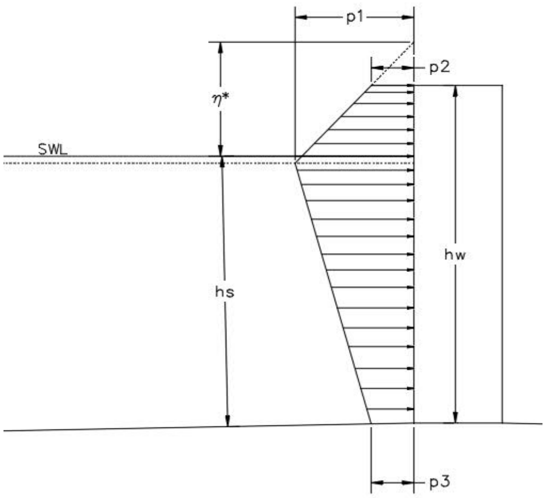
Distance from BOF to stillwater $h_{swl} := EL_{SWL} - EL_{GR} + d_s + h_f = 4.3\ \text{ft}$

Distance to from bottom of footing to hydrostatic load $y_2 := \frac{h_{swl}}{3} = 1.43\ \text{ft}$

Hydrostatic force $F_2 := .5 \cdot \gamma_w \cdot h_{swl}^{\ 2} = 591.68 \frac{\text{lb}}{\text{ft}}$

3. Hydrodynamic Loads

100-year wave dynamic wave force by Goda's Formula 2050 SLR per coastal analysis



Pressure 1 $P_1 := 783.6 \frac{lb}{ft^2}$

Elevation of P1 $EL_{P1} := 13.8ft$

Pressure 2 $P_2 := 500.1 \frac{lb}{ft^2}$

Elevation of P2 $EL_{P2} := 18ft$

Pressure 3 $P_3 := 730.7 \frac{lb}{ft^2}$

Elevation of P3 $EL_{P3} := 10ft$

Height of wall $h_w := EL_{TOW} - EL_{GR} = 7.5\ ft$

Height of stillwater level $h_s := EL_{SWL} - EL_{GR} = 3.3\ ft$

Horizontal wave force above stillwater rectangular component $F_{3\_above.r} := P_2 \cdot (h_w - h_s) = 2100.42 \frac{lb}{ft}$

Horizontal wave force above stillwater triangular component $F_{3\_above.t} := \frac{[(P_1 - P_2) \cdot (h_w - h_s)]}{2} = 595.35 \frac{lb}{ft}$

Horizontal wave force above stillwater $F_{3\_above} := F_{3\_above.r} + F_{3\_above.t} = 2.7 \times 10^3 \frac{lb}{ft}$

Distance between grade and centroid of *rectagular component above stillwater*

$$y_{3\_above.t} := \left[\frac{(h_w - h_s)}{3}\right] + h_s = 4.7\,\text{ft}$$

Distance between grade and centroid of *traingular component above stillwater*

$$y_{3\_above.r} := \left[\frac{(h_w - h_s)}{2}\right] + h_s = 5.4\,\text{ft}$$

Distance between grade and centroid of *wave force above stillwater elevation*

$$y_{3\_above} := \frac{\left(y_{3\_above.t} \cdot F_{3\_above.t} \cdots + y_{3\_above.r} \cdot F_{3\_above.r}\right)}{F_{3\_above}} = 5.25\,\text{ft}$$

Horizontal wave force below stillwater elevation triangular component

$$F_{3\_below.t} := (P_1 - P_3) \cdot \frac{h_s}{2} = 87.28\,\frac{\text{lb}}{\text{ft}}$$

Horizontal wave force below stillwater elevation rectangular component

$$F_{3\_below.r} := P_3 \cdot h_s = 2.41 \times 10^3\,\frac{\text{lb}}{\text{ft}}$$

Horizontal wave force below stillwater

$$F_{3\_below} := F_{3\_below.t} + F_{3\_below.r} = 2.5 \times 10^3\,\frac{\text{lb}}{\text{ft}}$$

Distance between grade and centroid of *triangular component below stillwater*

$$y_{3\_below.t} := \frac{2h_s}{3} = 2.2\,\text{ft}$$

Distance between grade and centroid of *rectangular component below stillwater*

$$y_{3\_below.r} := \frac{h_s}{2} = 1.65\,\text{ft}$$

Distance between grade and centroid of *wave force below stillwater elevation*

$$y_{3\_below} := \frac{\left(y_{3\_below.t} \cdot F_{3\_below.t} \cdots + y_{3\_below.r} \cdot F_{3\_below.r}\right)}{F_{3\_below}} = 1.67\,\text{ft}$$

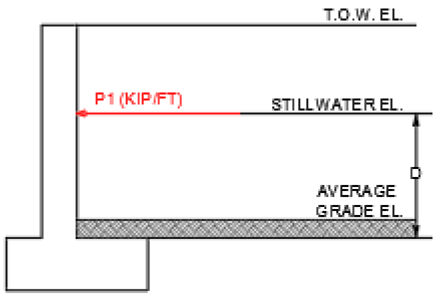
Total hydrodynamic wave force

$$F_3 := F_{3\_above} + F_{3\_below} = 5.19 \times 10^3\,\frac{\text{lb}}{\text{ft}}$$

Distance between bottom of footing and location of total hydrodynamic wave force

$$y_3 := \left[\frac{(y_{3\_above} \cdot F_{3\_above} + y_{3\_below} \cdot F_{3\_below})}{F_3}\right] + d_s + h_f = 4.53\,\text{ft}$$

4. Debris Impact Loads



Weight of object
Per ASCE 7-16 Section C5.4.5 debris in coastal areas other then the Pacific Northwest

$W_d := 2000lb$

Velocity of water
Per Coastal Model

$V_w := 2 \quad knots$

$3.4 \ \frac{ft}{s}$

Depth Coefficient
Per FEMA 55 Table 8-3

$C_D := 1.0$

Blockage Coefficient
Per FEMA 55 Table 8-4

$C_B := 1.0$

Building Structure Coefficient
Per FEMA 55 Section 8.5.10

$C_{st\_walls} := 0.8$

Wave directionality
Per Coastal Model

$\theta := 90deg$

Debris impact point load

$F_{4\_point} := \sin(\theta) \cdot W_d \cdot V_w \cdot C_D \cdot C_B \cdot C_{st\_walls} = 3.2 \times 10^3 \, lb$

Length of debris load impact
Assume 45 degrees load path to bottom of Stem

$debris := 2 \cdot (h_s) = 6.6\, ft$

Debris impact distributed load

$F_{4\_dist} := \frac{F_{4\_point}}{debris} = 484.85 \, \frac{lb}{ft}$

Distance between bottom of footing and debris impact load

$y_4 := (EL_{SWL} - EL_{GR}) + d_s + h_f = 4.3\, ft$

5. Flood Load Cases

Load Case 1 - Hydrostatic Loading at the Top of the Wall

Unfactored base shear $V_1 := F_1 = 2.31 \cdot \frac{kip}{ft}$

Factored base shear $V_{1\_F} := V_1 \cdot 2 = 4.62 \cdot \frac{kip}{ft}$

Unfactored base moment at bottom of footing $M_1 := F_1 \cdot y_1 = 6.55 \cdot \frac{kip \cdot ft}{ft}$

Factored base moment at bottom of footing $M_{1\_F} := M_1 \cdot 2 = 13.1 \cdot \frac{kip \cdot ft}{ft}$

Load Case 2 - Hydrostatic Loading at Stillwater + Wave Loading + Distributed Debris Impact Load

Unfactored base shear $V_2 := F_2 + F_3 + F_{4\_dist} = 6.271 \cdot \frac{kip}{ft}$

Factored base shear $V_{2\_F} := V_2 \cdot 2 = 12.54 \cdot \frac{kip}{ft}$

Unfactored base moment at bottom of footing $M_2 := \left(F_2 \cdot y_2 + F_3 \cdot y_3 + F_{4\_dist} \cdot y_4\right) = 26.4 \cdot kip \cdot \frac{ft}{ft}$

Factored base moment at bottom of footing $M_{2\_F} := M_2 \cdot 2 = 52.88\, ft \cdot \frac{kip}{ft}$

6. References

1.ASCE 7-16

2. FEMA 55 Coastal Construction Manual 2011

3. AECOM Coastal Model

Concrete Beam

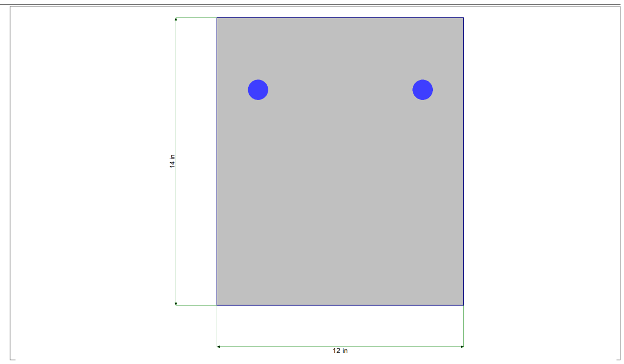
DESCRIPTION: SBPC_MJH_2.1.2.1 - Section 2.2 Hydrostatic to Top of Wall

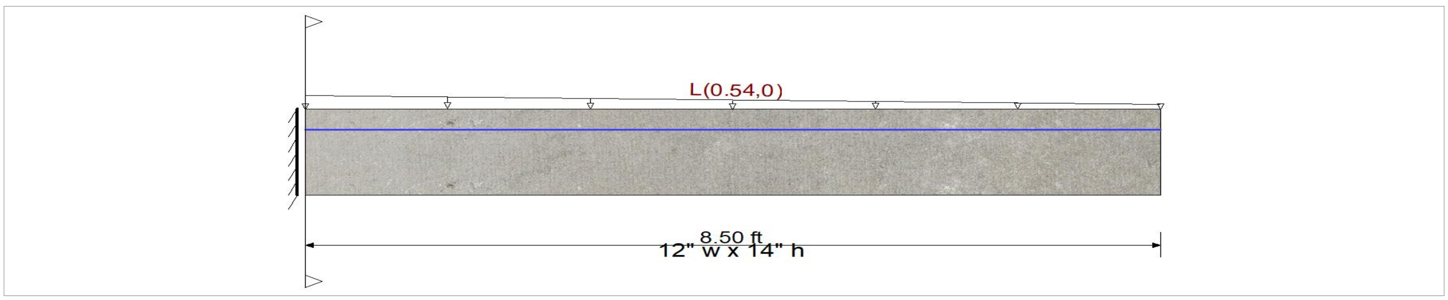
CODE REFERENCES

Calculations per ACI 318-11, IBC 2012, CBC 2013, ASCE 7-10
Load Combination Set : ASCE 7-16

Material Properties

f'c	=	5.0 ksi	ϕ Phi Values	Flexure :	0.90
$fr = f'c^{1/2} * 7.50$	=	530.33 psi		Shear :	0.750
ψ Density	=	145.0 pcf	β_1	=	0.80
λ LtWt Factor	=	1.0			
Elastic Modulus	=	4,074.28 ksi	Fy - Stirrups		40.0 ksi
fy - Main Rebar	=	60.0 ksi	E - Stirrups	=	29,000.0 ksi
E - Main Rebar	=	29,000.0 ksi	Stirrup Bar Size #		3
			Number of Resisting Legs Per Stirrup =		2





Cross Section & Reinforcing Details

Rectangular Section, Width = 12.0 in, Height = 14.0 in
Span #1 Reinforcing....
2-#8 at 3.50 in from Top, from 0.0 to 8.50 ft in this span

Load for Span Number 1
Varying Uniform Load : L= 0.540->0.0 k/ft, Extent = 0.0 -->> 8.50 ft, Trib Width = 1.0 ft, (Hydrostatic)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.191** : 1		
Section used for this span	**Typical Section**		
Mu : Applied	-13.005 k-ft		
Mn * Phi : Allowable	68.047 k-ft		
Location of maximum on span	0.000 ft		
Span # where maximum occurs	Span # 1		

Maximum Deflection			
Max Downward Transient Deflection	0.022 in	Ratio =	9364 >=360.
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360.0
Max Downward Total Deflection	0.022 in	Ratio =	9364 >=180.
Max Upward Total Deflection	0.000 in	Ratio =	0 <180.0

Vertical Reactions

Support notation : Far left is #1

Load Combination	Support 1	Support 2
Overall MAXimum	4.590	
Overall MINimum	4.590	
+2.0L	4.590	

Shear Stirrup Requirements

Entire Beam Span Length : Vu < PhiVc/2, Req'd Vs = Not Reqd 11.4.6.1, use #3 stirrups spaced at 0.000 in

Maximum Forces & Stresses for Load Combinations

Load Combination		Location (ft)	Bending Stress Results (k-ft)		
Segment	Span #	along Beam	Mu : Max	Phi*Mnx	Stress Ratio
MAXimum BENDING Envelope					
Span # 1	1	8.500	-13.01	68.05	0.19
+2.0L					
Span # 1	1	8.500	-13.01	68.05	0.19

DESCRIPTION: SBPC_MJH_2.1.2.1 - Section 2.2 Hydrostatic to Top of Wall

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl (in)	Location in Span (ft)	Load Combination	Max. "+" Defl (in)	Location in Span (ft)
+1.50L	1	0.0218	8.500		0.0000	0.000

Concrete Beam

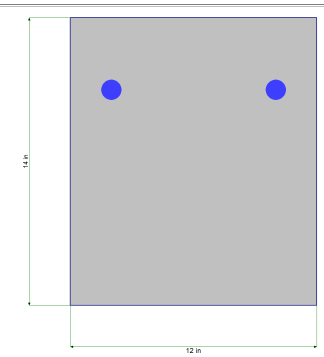
DESCRIPTION: SBPC_MJH_2.1.2.2 - Section 2.2 Hydrostatic + Hydrodynamic + Debris

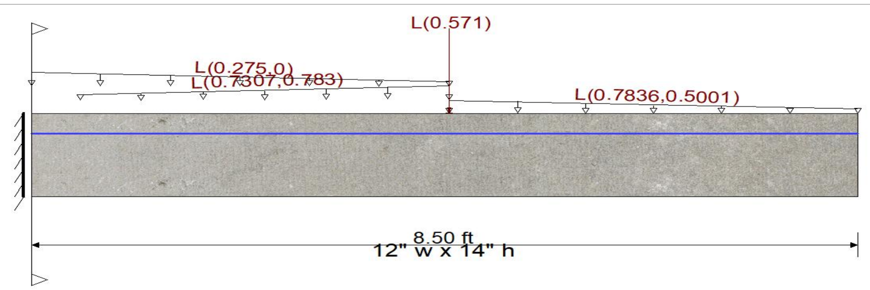
CODE REFERENCES

Calculations per ACI 318-11, IBC 2012, CBC 2013, ASCE 7-10
Load Combination Set : ASCE 7-16

Material Properties

f'c	=	5.0 ksi	ϕ Phi Values	Flexure :		0.90
fr = $f'c^{1/2}$ * 7.50	=	530.33 psi		Shear :		0.750
ψ Density	=	145.0 pcf	β_1		=	0.80
λ LtWt Factor	=	1.0				
Elastic Modulus	=	4,074.28 ksi	Fy - Stirrups			40.0 ksi
fy - Main Rebar	=	60.0 ksi	E - Stirrups		=	29,000.0 ksi
E - Main Rebar	=	29,000.0 ksi	Stirrup Bar Size #			3
			Number of Resisting Legs Per Stirrup		=	2





Cross Section & Reinforcing Details

Rectangular Section, Width = 12.0 in, Height = 14.0 in
Span #1 Reinforcing....
2-#8 at 3.50 in from Top, from 0.0 to 8.50 ft in this span

Load for Span Number 1
Varying Uniform Load : L= 0.7836->0.5001 k/ft, Extent = 4.30 -->> 8.50 ft, Trib Width = 1.0 ft, (Hydrodynamic (p2/p1))

Varying Uniform Load : L= 0.7307->0.7830 k/ft, Extent = 0.50 -->> 4.30 ft, Trib Width = 1.0 ft, (Hydrodynamic (p3/p1))

Varying Uniform Load : L= 0.2750->0.0 k/ft, Extent = 0.0 -->> 4.30 ft, Trib Width = 1.0 ft, (Hydrostatic (SWL))

Point Load : L = 0.5710 k @ 4.30 ft, (Debris Impact Load)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.797** : 1	
Section used for this span	**Typical Section**	
Mu : Applied	-54.209	k-ft
Mn * Phi : Allowable	68.047	k-ft
Location of maximum on span	0.000	ft
Span # where maximum occurs	Span # 1	

Maximum Deflection

Max Downward Transient Deflection	0.258 in	Ratio =	790	>=360.
Max Upward Transient Deflection	0.000 in	Ratio =	0	<360.0
Max Downward Total Deflection	0.258 in	Ratio =	790	>=180.
Max Upward Total Deflection	0.000 in	Ratio =	0	<180.0

Vertical Reactions

Support notation : Far left is #1

Load Combination	Support 1	Support 2
Overall MAXimum	13.468	
Overall MINimum	13.468	
+2.0L	13.468	

Shear Stirrup Requirements

Between 0.00 to 3.96 ft, PhiVc/2 < Vu <= PhiVc, Req'd Vs = Min 11.4.6.1, use #3 stirrups spaced at 5.000 in
Between 3.98 to 8.48 ft, Vu < PhiVc/2, Req'd Vs = Not Reqd 11.4.6.1, use #3 stirrups spaced at 0.000 in

Concrete Beam

DESCRIPTION: SBPC_MJH_2.1.2.2 - Section 2.2 Hydrostatic + Hydrodynamic + Debris

Maximum Forces & Stresses for Load Combinations

Load Combination / Segment	Span #	Location (ft) along Beam	Bending Stress Results (k-ft) Mu : Max	Phi*Mnx	Stress Ratio
MAXimum BENDING Envelope					
Span # 1	1	8.500	-54.21	68.05	0.80
+2.0L					
Span # 1	1	8.500	-54.21	68.05	0.80

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl (in)	Location in Span (ft)	Load Combination	Max. "+" Defl (in)	Location in Span (ft)
+1.50L	1	0.2581	8.500		0.0000	0.000

APPENDIX K1: PART 2 SECANT PILE/SHEET PILE ANALYSES

This part of the Appendix K1 presents the detailed calculation of sheet pile design by software CWALSHT (US Army Corps of Engineers) between working points WP11 and WP20 which is near MJH.

SOIL PARAMTERS

Table 1: Generalized Soil Profile for Foundation Design between Sta. 10+00 and Sta.16+00 (WP6~WP21) Based on Borings B-1, B-2 and B-3

Elevation (ft)	Soil Type	Typical Field SPT Range*		Recommended Key Soil/Rock Parameters
		Field N	N_{60}	
10.5/11.0 ~ 3	Fill (medium dense sand, little silt)	12~21	15~27	ϒ=125pcf, ϕ=31.5~34.8° (Ave=33.2°)
3 ~ -2.5				ϒ'=62.6pcf, ϕ=31.5~34.8° (Ave=33.2°)
-2.5 ~ -21.5	Fill (loose to medium dense sand, trace silt)	5~12	6~15	ϒ'=52.6pcf, ϕ=28.9~31.5°(Ave=30.0°)
-21.5 ~ -34.5	Fill (loose to medium dense sand, little silty clay, trace gravel)	8~17	10~22	ϒ'=57.6pcf, ϕ=30~33.4° Ave=31.8°)
-34.5 ~ -38.5	Soft Clay, with little gravel	4	5	ϒ'=44.6pcf, C=600psf
-38.5 ~ -43	Sand (medium dense), with little/some silty clay	10	13	ϒ'=57.6pcf, ϕ=30.9°
<-43	Bedrock-Schist	-	-	ϒ'=87.6pcf, Strain Factor=0.0001, q_u=5000psi, E_{ini}=1.5E+6psi, RQD=75%

*The typical field SPT range is not the actual range of field SPT values, but it is determined based on engineer's judgement.

SOFTWARES

CWALSHT (US Army Corps of Engineers).

DESIGN LOADS PROVIDED BY AECOM

Original Loads:

- Unfactored Moment: 28 kip-ft/ft
- Unfactored Shear: 7.4 kip/ft
- Load Acting at EL.9.5 ft (NAVD88)
- Ground Elevation: 10.5 ft (NAVD88)*

Final Loads *(Provided by AECOM on July 20 2021 via Email)***:**

- Unfactored Moment: 39.6 kip - ft. / ft.
- Unfactored Vertical: 3.0 kip / ft.
- Unfactored Lateral: -6.2 kip / ft.
- Load Acting at EL.7.0 ft. (BOF EL)
- Ground Elevation: 11 ft *

(* For the section between Sta. 19+50 and Sta. 22+50 which has lower existing grade, the current grade is still assumed at El.10.5ft for the Original Loads or El.11.0 for the New Loads in the analysis, and the derived soil parameters for the layer between El. 6~El.3 was used for the fictious layer between El.10.5/El.11.0 and El. 6.0.

LOAD AND WATER LEVEL CONDITIONS CONSIDERED IN THE ANALYSES

- Water level at protected side: EL.4.0~6.0 based on seepage analyses results summarized in Table 13 of the report, Water level at flood side: EL.13.8
- For the case for **Original Loads**: In order to use the design unfactored shears and moments at +9.5 and at the same time maintaining water level of 13.8 at flood side, the sheet pile was extended to +13.8 and a load of 6.89 kips/ft was applied at elevation 13.47. The net result is equal to AECOM shear and moment at EL.9.5.
- For the case for **Final Loads**: In order to use the design unfactored shears and moments at +7.0 and at the same time maintaining water level of 13.8 at flood side, the sheet pile was extended to +15.1 and a load of 4.72 kips/ft was applied at elevation 15.1. The net result is equal to AECOM shear and moment at EL.7.0.

OTHER PARAMETERS/ASSUMPTIONS

- **For Determination of Depth of Penetration**
  1. Wall friction: 14 degree (Table 3-3 of Design of Sheet Pile Walls - *EM 1110-2-2504* by U.S. Army Corps of Engineers)
  2. Safety factor applied to the active earth pressure=1.0
  3. Safety factor applied to the passive earth pressure=1.5 (Table 5-1 of Design of Sheet Pile Walls - *EM 1110-2-2504* by U.S. Army Corps of Engineers)

- **For Estimation of the Maximum Moment and Shear for Structural Design**
  1. Wall friction: 10 degree (about 1/3 of soil friction angle)
  2. Safety factor applied to the active earth pressure=1.0
  3. Safety factor applied to the passive earth pressure=1.0

SUMMARY OF RESULTS

It should be noted here that since the software CWALSHT treats both secant pile wall and sheet pile wall same, the structural parameters summarized below are applicable to both types of walls. The results are summarized below while the detailed outputs are presented in Appendix K-1:

SECTION LIMITS	LOAD	MAXIMUM UNFACTORED MOMENT[1]	MAXIMUM UNFACTORED SHEAR[1]	SCALED DEFLECTION AT TOP OF SHEET PILE[2]	REQUIRED PILE TIP ELEVATION[3]
WP11~WP20	Original Loads	60.2kips-ft. / ft.	9.7kips	6.63×10^9 (lb. - in^3)	-12.0ft.
	Final Loads	39.5kips-ft. / ft.	6.6kips	4.0×10^9 (lb. - in^3)	-8.0ft.

Notes: [1] These unfactored moment and shear provided here are for structural design and they are calculated using a factor of safety of 1.0 for both active and passive pressures in accordance with Design of Sheet Pile Wall (EM 1110-2-2504) by U.S. Army Corps of Engineers. [2] Top of sheet pile refers to the bottom of footing elevation. Divide scaled deflection by the modulus of elasticity in psi times pile moment of inertia in in^4 to obtain deflection in inches. [3] The required pile tip elevation was determined in accordance with U.S. Army Corps of Engineers ETL 1110-2-575 (Evaluation of I-Walls), and FS=1.5 was applied to the passive pressures for loads most frequently experienced by the system in performing it is primary function throughout its service life according to U.S. Army Corps of Engineers EM 1110-2-2504 (Design of Sheet Pile Walls).

DETTAILED OUTPUT

Please see the attached for the detailed outputs.

WP11~WP20-ORIGINAL LOADS: Mmax,Smax, Deflection for Structural Design

```
PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 2-JUNE-2021                                          TIME: 11:26:39

                            ****************
                            *  INPUT DATA  *
                            ****************

     I.--HEADING
    'SOUTH BATTERY PARK ADJACENT TO JEWISH MESUM

    II.--CONTROL
       CANTILEVER WALL DESIGN
       FACTOR OF SAFETY FOR ACTIVE PRESSURES  = 1.00
       FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

   III.--WALL DATA
       ELEVATION AT TOP OF WALL    = 13.80 FT.

    IV.--SURFACE POINT DATA

         IV.A.--RIGHTSIDE
            DIST. FROM     ELEVATION
            WALL (FT)         (FT)
                 0.00        10.50

         IV.B.--LEFTSIDE
            DIST. FROM     ELEVATION
            WALL (FT)         (FT)
                 0.00         9.50

     V.--SOIL LAYER DATA

        V.A.--RIGHTSIDE
            LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
            LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT
```

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	<--BOTTOM--> SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

```
        V.B.--LEFTSIDE
            LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
```

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH- ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH- ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 62.00 (PCF)
RIGHTSIDE ELEVATION = 13.80 (FT)
LEFTSIDE ELEVATION = 6.00 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

NONE

VIII.--HORIZONTAL LOADS

VIII.A.--HORIZONTAL LINE LOADS

ELEVATION (FT)	LINE LOAD (PLF)
13.47	6890.00

VIII.B.--HORIZONTAL DISTRIBUTED LOADS

NONE


```
*************************
*   SOIL PRESSURES FOR   *
* CANTILEVER WALL DESIGN *
*************************
```

I.--HEADING
'SOUTH BATTERY PARK ADJACENT TO JEWISH MESUM

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

				<------NET------>			
	NET	<---LEFTSIDE--->		(SOIL + WATER)		<--RIGHTSIDE--->	
ELEV. (FT)	WATER (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
13.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.5	20.5	0.0	0.0	20.5	20.5	0.0	0.0
12.8	62.0	0.0	0.0	62.0	62.0	0.0	0.0
11.8	124.0	0.0	0.0	124.0	124.0	0.0	0.0
10.8	186.0	0.0	0.0	186.0	186.0	0.0	0.0
10.5	204.6	0.0	0.0	204.6	204.6	0.0	0.0
9.8	248.0	0.0	0.0	259.8	458.7	11.8	210.7
9.5	266.6	0.0	0.0	283.5	567.6	16.9	301.0
9.0	300.5	326.6	18.3	0.0	747.8	26.1	465.6
8.8	310.0	418.0	23.4	-79.4	798.2	28.7	511.7
8.5	328.6	597.2	33.5	-234.9	897.1	33.7	602.0
7.8	372.0	1015.2	56.9	-597.7	1127.8	45.5	812.7
6.8	434.0	1612.4	90.3	-1116.0	1457.3	62.4	1113.6
6.0	483.6	2066.5	115.8	-1507.0	1722.2	75.9	1354.4
5.8	483.6	2150.4	120.5	-1587.5	1777.7	79.3	1414.6
4.8	483.6	2451.3	137.3	-1871.6	2061.9	96.1	1715.6
3.8	483.6	2752.3	154.2	-2155.7	2346.0	113.0	2016.6
2.8	483.6	3053.3	171.1	-2439.9	2630.1	129.8	2317.6
1.8	483.6	3354.3	187.9	-2724.0	2914.2	146.7	2618.5
0.8	483.6	3655.3	204.8	-3008.1	3198.3	163.6	2919.5
-0.2	483.6	3956.2	221.6	-3292.2	3482.5	180.4	3220.5
-1.2	483.6	4257.2	238.5	-3576.3	3766.6	197.3	3521.5
-2.2	483.6	4558.2	255.4	-3860.5	4050.7	214.1	3822.5
-2.5	483.6	3905.1	262.0	-3200.6	3536.1	221.0	3314.5
-3.2	483.6	3080.9	289.2	-2351.2	2868.2	246.1	2673.7
-4.2	483.6	4338.9	322.6	-3579.4	3871.4	275.8	3710.3
-5.2	483.6	4555.2	338.6	-3779.7	4071.6	291.9	3926.6
-6.2	483.6	4771.5	354.7	-3979.9	4271.8	308.0	4143.0
-7.2	483.6	4987.8	370.8	-4180.1	4472.1	324.1	4359.3
-8.2	483.6	5204.1	386.9	-4380.3	4672.3	340.2	4575.6
-9.2	483.6	5420.4	403.0	-4580.6	4872.5	356.2	4791.9
-10.2	483.6	5636.7	419.0	-4780.8	5072.8	372.3	5008.2
-11.2	483.6	5853.0	435.1	-4981.0	5273.0	388.4	5224.5
-12.2	483.6	6069.3	451.2	-5181.3	5473.2	404.5	5440.8
-13.2	483.6	6285.7	467.3	-5381.5	5673.4	420.6	5657.1
-14.2	483.6	6502.0	483.4	-5581.7	5873.7	436.6	5873.4
-15.2	483.6	6718.3	499.4	-5782.0	6073.9	452.7	6089.7

-16.2	483.6	6934.6	515.5	-5982.2	6274.1	468.8	6306.1
-17.2	483.6	7150.9	531.6	-6182.4	6474.4	484.9	6522.4
-18.2	483.6	7367.2	547.7	-6382.6	6674.6	501.0	6738.7
-19.2	483.6	7583.5	563.8	-6582.9	6874.8	517.0	6955.0
-20.2	483.6	7799.8	579.8	-6783.1	7075.1	533.1	7171.3
-21.2	483.6	8016.1	595.9	-6983.3	7275.3	549.2	7387.6

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE FOR THIS ELEVATION.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 2-JUNE-2021 TIME: 11:26:42

```
***************************
*  SUMMARY OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
***************************
```

I.--HEADING

'SOUTH BATTERY PARK ADJACENT TO JEWISH MESUM

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

*****WARNING: STANDARD WEDGE SOLUTION DOES NOT EXIST AT ALL ELEVATIONS. SEE COMPLETE OUTPUT.

```
WALL BOTTOM ELEV. (FT)     :       -6.40
      PENETRATION (FT)     :       15.90

MAX. BEND. MOMENT (LB-FT)  :  6.0168E+04
      AT ELEVATION (FT)    :        3.24

MAX. SCALED DEFL. (LB-IN^3):  1.1407E+10
      AT ELEVATION (FT)    :       13.80
```

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT

OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
IN INCHES.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 2-JUNE-2021 TIME: 11:26:42

```
***************************
* COMPLETE OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
***************************
```

I.--HEADING

'SOUTH BATTERY PARK ADJACENT TO JEWISH MESUM

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
13.80	0.0000E+00	0.	1.1407E+10	0.00
13.47+	3.7135E-01	3.	1.1031E+10	20.46
13.47-	3.7135E-01	6893.	1.1031E+10	20.46
12.80	4.6266E+03	6921.	1.0268E+10	62.00
11.80	1.1589E+04	7014.	9.1376E+09	124.00
10.80	1.8675E+04	7169.	8.0269E+09	186.00
10.50	2.0835E+04	7228.	7.6995E+09	204.60
9.80	2.5949E+04	7390.	6.9486E+09	259.80
9.50	2.8178E+04	7472.	6.6333E+09	283.46
8.95	3.2292E+04	7549.	6.0700E+09	0.00
8.80	3.3448E+04	7543.	5.9151E+09	-79.37
8.50	3.5705E+04	7496.	5.6158E+09	-234.86
7.80	4.0865E+04	7205.	4.9395E+09	-597.69
6.80	4.7684E+04	6348.	4.0343E+09	-1116.01
6.00	5.2363E+04	5298.	3.3689E+09	-1506.98
5.80	5.3392E+04	4989.	3.2114E+09	-1587.50
4.80	5.7540E+04	3259.	2.4805E+09	-1871.62
3.80	5.9816E+04	1246.	1.8488E+09	-2155.74
2.80	5.9937E+04	-1052.	1.3201E+09	-2439.86
1.80	5.7618E+04	-3634.	8.9466E+08	-2723.98
1.19	5.4866E+04	-5358.	6.8327E+08	-2898.21
0.80	5.2586E+04	-6408.	5.6839E+08	-2530.53
-0.20	4.5072E+04	-8463.	3.3262E+08	-1579.85
-1.20	3.5978E+04	-9567.	1.7450E+08	-629.18
-2.20	2.6254E+04	-9721.	7.8467E+07	321.50
-2.50	2.3357E+04	-9582.	5.9271E+07	606.70

-3.20	1.6852E+04	-8924.	2.7846E+07	1272.18
-4.20	8.7225E+03	-7177.	6.5280E+06	2222.86
-5.20	2.8156E+03	-4479.	6.0306E+05	3173.53
-6.20	8.2214E+01	-830.	4.6078E+02	4124.21
-6.40	0.0000E+00	0.	0.0000E+00	4311.23

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES-------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
13.80	0.	0.	0.	0.	0.
13.47	20.	0.	0.	0.	0.
12.80	62.	0.	0.	0.	0.
11.80	124.	0.	0.	0.	0.
10.80	186.	0.	0.	0.	0.
10.50	205.	0.	0.	0.	0.
9.80	248.	0.	0.	12.	211.
9.50	267.	0.	0.	17.	301.
8.95	301.	327.	18.	26.	466.
8.80	310.	418.	23.	29.	512.
8.50	329.	597.	33.	34.	602.
7.80	372.	1015.	57.	46.	813.
6.80	434.	1612.	90.	62.	1114.
6.00	484.	2066.	116.	76.	1354.
5.80	484.	2150.	120.	79.	1415.
4.80	484.	2451.	137.	96.	1716.
3.80	484.	2752.	154.	113.	2017.
2.80	484.	3053.	171.	130.	2318.
1.80	484.	3354.	188.	147.	2619.
1.19	484.	3539.	198.	157.	2803.
0.80	484.	3655.	205.	164.	2920.
-0.20	484.	3956.	222.	180.	3221.
-1.20	484.	4257.	239.	197.	3521.
-2.20	484.	4558.	255.	214.	3822.
-2.50	484.	3905.	262.	221.	3314.
-3.20	484.	3081.	289.	246.	2674.
-4.20	484.	4339.	323.	276.	3710.
-5.20	484.	4555.	339.	292.	3927.
-6.20	484.	4771.	355.	308.	4143.
-6.40	484.	4988.	371.	324.	4359.
-8.20	484.	5204.	387.	340.	4576.

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE

AT THIS ELEVATION.

WP11~WP20-ORIGINAL LOADS: for Determination of Required Penetration

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 2-JUNE-2021 TIME: 11:30:38

****
* INPUT DATA *
****

I.--HEADING
'SOUTH BATTERY PARK ADJACENT TO JEWISH MESUM

II.--CONTROL
CANTILEVER WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

III.--WALL DATA
ELEVATION AT TOP OF WALL = 13.80 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.50

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	9.50

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	14.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	14.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	14.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	14.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	22.00	4000.00			DEF	DEF

V.B.--LEFTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH- ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH- ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	14.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	14.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	14.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	14.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	22.00	4000.00			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 13.80 (FT)
LEFTSIDE ELEVATION = 6.00 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

NONE

VIII.--HORIZONTAL LOADS

VIII.A.--HORIZONTAL LINE LOADS

ELEVATION (FT)	LINE LOAD (PLF)
13.47	6890.00

VIII.B.--HORIZONTAL DISTRIBUTED LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS BY CLASSICAL METHODS

DATE: 2-JUNE-2021 TIME: 11:30:40

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*   SOIL PRESSURES FOR   *
* CANTILEVER WALL DESIGN *
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I.--HEADING
'SOUTH BATTERY PARK ADJACENT TO JEWISH MESUM

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

		<---LEFTSIDE--->		<------NET------> (SOIL + WATER)		<--RIGHTSIDE--->	
ELEV. (FT)	NET WATER (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
13.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.5	21.1	0.0	0.0	21.1	21.1	0.0	0.0
12.8	64.0	0.0	0.0	64.0	64.0	0.0	0.0
11.8	128.0	0.0	0.0	128.0	128.0	0.0	0.0
10.8	192.0	0.0	0.0	192.0	192.0	0.0	0.0
10.5	211.2	0.0	0.0	211.2	211.2	0.0	0.0
9.8	256.0	0.0	0.0	267.1	383.7	11.1	127.7
9.5	275.2	0.0	0.0	291.0	457.7	15.8	182.5
8.8	320.0	261.7	22.7	85.1	607.5	26.9	310.2
8.5	338.5	370.0	32.1	0.0	669.5	31.5	363.0
8.5	339.2	373.9	32.4	-3.1	671.7	31.6	365.0
7.8	384.0	635.7	55.1	-209.0	821.6	42.7	492.7
6.8	448.0	1009.6	87.5	-503.1	1035.7	58.5	675.2
6.0	499.2	1293.4	112.1	-723.1	1208.3	71.2	821.1
5.8	499.2	1345.2	116.6	-771.7	1240.3	74.3	857.6
4.8	499.2	1527.7	132.4	-938.4	1406.9	90.1	1040.1
3.8	499.2	1710.2	148.2	-1105.0	1573.6	105.9	1222.6
2.8	499.2	1892.7	164.0	-1271.7	1740.3	121.8	1405.1
1.8	499.2	2075.1	179.8	-1438.4	1906.9	137.6	1587.5
0.8	499.2	2257.6	195.6	-1605.0	2073.6	153.4	1770.0
-0.2	499.2	2440.1	211.4	-1771.7	2240.2	169.2	1952.5
-1.2	499.2	2622.6	227.3	-1938.4	2406.9	185.0	2135.0
-2.2	499.2	2805.0	243.1	-2105.0	2573.6	200.8	2317.4
-2.5	499.2	2584.5	245.8	-1880.8	2407.1	204.5	2153.6
-3.2	499.2	2302.2	267.6	-1577.9	2178.4	225.1	1946.8
-4.2	499.2	2793.5	305.1	-2036.9	2550.9	257.4	2356.8
-5.2	499.2	2930.2	320.0	-2158.6	2672.6	272.3	2493.5
-6.2	499.2	3066.8	335.0	-2280.3	2794.3	287.3	2630.1
-7.2	499.2	3203.4	349.9	-2402.1	2916.1	302.2	2766.7
-8.2	499.2	3340.1	364.9	-2523.4	3037.7	317.5	2903.4
-9.2	499.2	3476.7	380.5	-2644.5	3158.7	333.0	3040.0
-10.2	499.2	3613.4	396.0	-2766.0	3279.9	348.1	3176.7
-11.2	499.2	3750.0	410.9	-2887.7	3401.6	363.1	3313.3
-12.2	499.2	3886.6	425.9	-3009.4	3523.2	378.1	3449.9
-13.2	499.2	4023.3	440.9	-3131.0	3644.9	393.0	3586.6
-14.2	499.2	4159.9	455.9	-3252.7	3766.5	408.0	3723.2
-15.2	499.2	4296.5	470.8	-3374.4	3888.2	423.0	3859.8

-16.2	499.2	4433.2	485.8	-3496.0	4009.9	438.0	3996.5
-17.2	499.2	4569.8	500.8	-3617.7	4131.5	452.9	4133.1
-18.2	499.2	4706.4	515.8	-3739.3	4253.2	467.9	4269.7
-19.2	499.2	4843.1	530.7	-3861.0	4374.9	482.9	4406.4
-20.2	499.2	4979.7	545.7	-3982.7	4496.5	497.8	4543.0
-21.2	499.2	5116.4	560.7	-4104.3	4618.2	512.8	4679.7

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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 2-JUNE-2021                                           TIME: 11:30:41

                        ****************************
                        *  SUMMARY OF RESULTS FOR  *
                        *  CANTILEVER WALL DESIGN  *
                        ****************************

    I.--HEADING
     'SOUTH BATTERY PARK ADJACENT TO JEWISH MESUM

   II.--SUMMARY

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

   WALL BOTTOM ELEV. (FT)     :      -11.88
         PENETRATION (FT)     :       21.38

   MAX. BEND. MOMENT (LB-FT)  :  7.5245E+04
         AT ELEVATION (FT)    :        0.42

   MAX. SCALED DEFL. (LB-IN^3):  2.3409E+10
         AT ELEVATION (FT)    :       13.80

             NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                    ELLASTICITY IN PSI TIMES PILE MOMENT
                    OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                    IN INCHES.
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 2-JUNE-2021 TIME: 11:30:41

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* COMPLETE OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
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I.--HEADING

'SOUTH BATTERY PARK ADJACENT TO JEWISH MESUM

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
13.80	0.0000E+00	0.	2.3409E+10	0.00
13.47+	3.8333E-01	3.	2.2800E+10	21.12
13.47-	3.8333E-01	6893.	2.2800E+10	21.12
12.80	4.6270E+03	6922.	2.1564E+10	64.00
11.80	1.1592E+04	7018.	1.9727E+10	128.00
10.80	1.8684E+04	7178.	1.7909E+10	192.00
10.50	2.0847E+04	7238.	1.7370E+10	211.20
9.80	2.5970E+04	7406.	1.6124E+10	267.07
9.50	2.8204E+04	7490.	1.5597E+10	291.01
8.80	3.3501E+04	7621.	1.4384E+10	85.13
8.51	3.5710E+04	7634.	1.3891E+10	0.00
8.50	3.5790E+04	7634.	1.3873E+10	-3.10
7.80	4.1116E+04	7559.	1.2702E+10	-208.98
6.80	4.8522E+04	7203.	1.1091E+10	-503.09
6.00	5.4100E+04	6713.	9.8615E+09	-723.07
5.80	5.5428E+04	6563.	9.5633E+09	-771.71
4.80	6.1577E+04	5708.	8.1315E+09	-938.38
3.80	6.6789E+04	4687.	6.8061E+09	-1105.04
2.80	7.0895E+04	3498.	5.5958E+09	-1271.70
1.80	7.3730E+04	2143.	4.5079E+09	-1438.37
0.80	7.5126E+04	621.	3.5472E+09	-1605.03
-0.20	7.4917E+04	-1067.	2.7161E+09	-1771.69
-1.20	7.2937E+04	-2922.	2.0142E+09	-1938.35
-2.20	6.9018E+04	-4944.	1.4380E+09	-2105.02
-2.50	6.7443E+04	-5541.	1.2888E+09	-1880.77
-3.20	6.3128E+04	-6752.	9.8082E+08	-1577.90
-3.54	6.0763E+04	-7309.	8.5198E+08	-1732.44
-4.20	5.5564E+04	-8321.	6.3247E+08	-1317.71
-5.20	4.6688E+04	-9326.	3.7995E+08	-692.50
-6.20	3.7120E+04	-9706.	2.0801E+08	-67.30
-7.20	2.7485E+04	-9461.	1.0020E+08	557.91

-8.20	1.8407E+04	-8590.	3.9968E+07	1183.12
-9.20	1.0513E+04	-7094.	1.1711E+07	1808.33
-10.20	4.4271E+03	-4973.	1.8817E+06	2433.54
-11.20	7.7470E+02	-2227.	5.2622E+04	3058.74
-11.88	0.0000E+00	0.	0.0000E+00	3484.38

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES-------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
13.80	0.	0.	0.	0.	0.
13.47	21.	0.	0.	0.	0.
12.80	64.	0.	0.	0.	0.
11.80	128.	0.	0.	0.	0.
10.80	192.	0.	0.	0.	0.
10.50	211.	0.	0.	0.	0.
9.80	256.	0.	0.	11.	128.
9.50	275.	0.	0.	16.	182.
8.80	320.	262.	23.	27.	310.
8.51	339.	370.	32.	31.	363.
8.50	339.	374.	32.	32.	365.
7.80	384.	636.	55.	43.	493.
6.80	448.	1010.	87.	59.	675.
6.00	499.	1293.	112.	71.	821.
5.80	499.	1345.	117.	74.	858.
4.80	499.	1528.	132.	90.	1040.
3.80	499.	1710.	148.	106.	1223.
2.80	499.	1893.	164.	122.	1405.
1.80	499.	2075.	180.	138.	1588.
0.80	499.	2258.	196.	153.	1770.
-0.20	499.	2440.	211.	169.	1952.
-1.20	499.	2623.	227.	185.	2135.
-2.20	499.	2805.	243.	201.	2317.
-2.50	499.	2584.	246.	205.	2154.
-3.20	499.	2302.	268.	225.	1947.
-3.54	499.	2468.	280.	236.	2085.
-4.20	499.	2794.	305.	257.	2357.
-5.20	499.	2930.	320.	272.	2493.
-6.20	499.	3067.	335.	287.	2630.
-7.20	499.	3203.	350.	302.	2767.
-8.20	499.	3340.	365.	318.	2903.
-9.20	499.	3477.	380.	333.	3040.
-10.20	499.	3613.	396.	348.	3177.

-11.20	499.	3750.	411.	363.	3313.
-11.88	499.	3887.	426.	378.	3450.
-13.20	499.	4023.	441.	393.	3587.

ASD Design-Updated-Unfactored.out
PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS
DATE: 20-JULY-2021 TIME: 14:24:28

****
* INPUT DATA *
****

I.--HEADING
'SOUTH BATTERY PARK ADJACENT TO JEWISH MESUM NEW LOADS

II.--CONTROL
CANTILEVER WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

III.--WALL DATA
ELEVATION AT TOP OF WALL = 15.10 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	11.00

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.50

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

V.B.--LEFTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 13.80 (FT)
LEFTSIDE ELEVATION = 6.00 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

NONE

VIII.--HORIZONTAL LOADS

VIII.A.--HORIZONTAL LINE LOADS

ELEVATION (FT)	LINE LOAD (PLF)
15.10	4720.00

VIII.B.--HORIZONTAL DISTRIBUTED LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 20-JULY-2021 TIME: 14:24:31

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**************************
*   SOIL PRESSURES FOR   *
* CANTILEVER WALL DESIGN *
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I.--HEADING

'SOUTH BATTERY PARK ADJACENT TO JEWISH MESUM NEW LOADS

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

				<------NET------> (SOIL + WATER)			
	NET	<---LEFTSIDE--->				<--RIGHTSIDE--->	
ELEV. (FT)	WATER (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
15.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.1	44.8	0.0	0.0	44.8	44.8	0.0	0.0
12.1	108.8	0.0	0.0	108.8	108.8	0.0	0.0
11.1	172.8	0.0	0.0	172.8	172.8	0.0	0.0
11.0	179.2	0.0	0.0	179.2	179.2	0.0	0.0
10.5	211.2	0.0	0.0	219.4	356.9	8.2	145.7
10.1	236.8	238.9	13.4	12.6	485.7	14.7	262.3
10.1	238.4	253.5	14.2	0.0	493.6	15.1	269.4
9.5	275.2	597.2	33.5	-297.5	678.9	24.5	437.1
9.1	300.8	836.1	46.8	-504.2	807.7	31.0	553.7
8.1	364.8	1433.2	80.3	-1021.1	1129.6	47.3	845.1

7.1	428.8	2030.4	113.8	-1538.0	1451.6	63.7	1136.6
6.1	492.8	2627.6	147.2	-2054.8	1773.6	80.0	1428.0
6.0	499.2	2673.6	149.8	-2092.7	1806.6	81.6	1457.1
5.1	499.2	2949.6	165.2	-2354.1	2053.4	96.3	1719.4
4.1	499.2	3241.1	181.6	-2629.2	2328.5	112.7	2010.8
3.1	499.2	3532.5	197.9	-2904.3	2603.6	129.0	2302.3
2.1	499.2	3823.9	214.2	-3179.4	2878.7	145.3	2593.7
1.1	499.2	4115.3	230.6	-3454.5	3153.8	161.6	2885.1
0.1	499.2	4406.8	246.9	-3729.6	3428.9	178.0	3176.6
-0.9	499.2	4698.2	263.2	-4004.7	3704.0	194.3	3468.0
-1.9	499.2	4989.6	279.5	-4279.8	3979.1	210.6	3759.4
-2.5	499.2	2433.6	274.7	-1721.9	2275.9	212.6	2051.4
-2.9	499.2	1793.6	289.3	-1068.6	1834.0	225.8	1624.1
-3.9	499.2	4703.3	349.6	-3932.6	3801.9	271.5	3652.4
-4.9	499.2	4911.5	365.1	-4125.3	3994.6	287.0	3860.5
-5.9	499.2	5119.6	380.6	-4317.9	4187.3	302.5	4068.7
-6.9	499.2	5327.8	396.1	-4510.6	4380.0	317.9	4276.8
-7.9	499.2	5535.9	411.5	-4703.3	4572.6	333.4	4485.0
-8.9	499.2	5744.1	427.0	-4896.0	4765.3	348.9	4693.1
-9.9	499.2	5952.2	442.5	-5088.6	4958.0	364.4	4901.3
-10.9	499.2	6160.4	458.0	-5281.3	5150.6	379.8	5109.4
-11.9	499.2	6368.5	473.4	-5474.0	5343.3	395.3	5317.6
-12.9	499.2	6576.7	488.9	-5666.7	5536.0	410.8	5525.7
-13.9	499.2	6784.8	504.4	-5859.3	5728.7	426.3	5733.9
-14.9	499.2	6992.9	519.9	-6052.0	5921.3	441.7	5942.0
-15.9	499.2	7201.1	535.3	-6244.7	6114.0	457.2	6150.2
-16.9	499.2	7409.2	550.8	-6437.4	6306.7	472.7	6358.3
-17.9	499.2	7617.4	566.3	-6630.0	6499.4	488.2	6566.4
-18.9	499.2	7825.5	581.8	-6822.7	6692.0	503.6	6774.6
-19.9	499.2	8033.7	597.2	-7015.4	6884.7	519.1	6982.7

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE
  FOR THIS ELEVATION.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 20-JULY-2021 TIME: 14:24:32

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****************************
*  SUMMARY OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
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I.--HEADING

'SOUTH BATTERY PARK ADJACENT TO JEWISH MESUM NEW LOADS

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

*****WARNING: STANDARD WEDGE SOLUTION DOES NOT EXIST
AT ALL ELEVATIONS. SEE COMPLETE OUTPUT.

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WALL BOTTOM ELEV. (FT)     :       -3.46
      PENETRATION (FT)     :       13.96

MAX. BEND. MOMENT (LB-FT)  :  3.9444E+04
      AT ELEVATION (FT)    :        5.62

MAX. SCALED DEFL. (LB-IN^3):  6.1040E+09
      AT ELEVATION (FT)    :       15.10

          NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                 ELLASTICITY IN PSI TIMES PILE MOMENT
                 OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                 IN INCHES.
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 20-JULY-2021 TIME: 14:24:32

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* COMPLETE OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
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I.--HEADING

'SOUTH BATTERY PARK ADJACENT TO JEWISH MESUM NEW LOADS

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
15.10	0.0000E+00	4720.	6.1040E+09	0.00
14.10	4.7200E+03	4720.	5.4286E+09	0.00
13.80	6.1360E+03	4720.	5.2272E+09	0.00
13.10	9.4437E+03	4736.	4.7613E+09	44.80
12.10	1.4212E+04	4812.	4.1103E+09	108.80
11.10	1.9090E+04	4953.	3.4839E+09	172.80
11.00	1.9586E+04	4971.	3.4229E+09	179.20
10.50	2.2096E+04	5071.	3.1233E+09	219.36
10.10	2.4136E+04	5117.	2.8905E+09	12.62
10.08	2.4261E+04	5117.	2.8765E+09	0.00
9.50	2.7190E+04	5031.	2.5539E+09	-297.50
9.10	2.9173E+04	4871.	2.3388E+09	-504.24
8.10	3.3706E+04	4108.	1.8375E+09	-1021.10
7.10	3.7218E+04	2829.	1.3942E+09	-1537.96
6.10	3.9191E+04	1033.	1.0151E+09	-2054.82
6.00	3.9284E+04	825.	9.8083E+08	-2092.75
5.10	3.9144E+04	-1176.	7.0334E+08	-2354.10
4.75	3.8587E+04	-2016.	6.1029E+08	-2450.34
4.10	3.6788E+04	-3471.	4.5891E+08	-2023.52
3.10	3.2415E+04	-5166.	2.7776E+08	-1367.03
2.10	2.6675E+04	-6205.	1.5243E+08	-710.53
1.10	2.0224E+04	-6587.	7.3095E+07	-54.03
0.10	1.3720E+04	-6313.	2.8696E+07	602.47
-0.90	7.8174E+03	-5382.	8.0909E+06	1258.97
-1.90	3.1742E+03	-3795.	1.1754E+06	1915.46
-2.50	1.2657E+03	-2527.	1.7431E+05	2309.36
-2.90	4.4644E+02	-1551.	2.0773E+04	2571.96
-3.46	0.0000E+00	0.	0.0000E+00	2941.37

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
15.10	0.	0.	0.	0.	0.
14.10	0.	0.	0.	0.	0.
13.80	0.	0.	0.	0.	0.
13.10	45.	0.	0.	0.	0.
12.10	109.	0.	0.	0.	0.
11.10	173.	0.	0.	0.	0.
11.00	179.	0.	0.	0.	0.
10.50	211.	0.	0.	8.	146.
10.10	237.	239.	13.	15.	262.
10.08	238.	253.	14.	15.	269.
9.50	275.	597.	33.	24.	437.
9.10	301.	836.	47.	31.	554.
8.10	365.	1433.	80.	47.	845.
7.10	429.	2030.	114.	64.	1137.
6.10	493.	2628.	147.	80.	1428.
6.00	499.	2674.	150.	82.	1457.
5.10	499.	2950.	165.	96.	1719.
4.75	499.	3052.	171.	102.	1821.
4.10	499.	3241.	182.	113.	2011.
3.10	499.	3532.	198.	129.	2302.
2.10	499.	3824.	214.	145.	2594.
1.10	499.	4115.	231.	162.	2885.
0.10	499.	4407.	247.	178.	3177.
-0.90	499.	4698.	263.	194.	3468.
-1.90	499.	4990.	280.	211.	3759.
-2.50	499.	2434.	275.	213.	2051.
-2.90	499.	1794.	289.	226.	1624.
-3.46	499.	4703.	350.	272.	3652.
-4.90	499.	4911.	365.	287.	3861.

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE AT THIS ELEVATION.

WP1~WP18-NEW LOADS: For Determination of Required Penetration

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 2-JUNE-2021 TIME: 11:23:40

****
* INPUT DATA *
****

I.--HEADING
'SOUTH BATTERY PARK ADJACENT TO JEWISH MESUM New Loads

II.--CONTROL
CANTILEVER WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

III.--WALL DATA
ELEVATION AT TOP OF WALL = 14.10 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	11.00

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.50

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

V.B.--LEFTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

ASD Design-Updated-Unfactored.out
PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS
DATE: 20-JULY-2021 TIME: 14:29:51

****
* INPUT DATA *
****

I.--HEADING
'SOUTH BATTERY PARK ADJACENT TO JEWISH MESUM NEW LOADS

II.--CONTROL
CANTILEVER WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

III.--WALL DATA
ELEVATION AT TOP OF WALL = 15.10 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	11.00

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.50

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	<--BOTTOM--> SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

V.B.--LEFTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	<--BOTTOM--> SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA
UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 13.80 (FT)
LEFTSIDE ELEVATION = 6.00 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS
NONE

VIII.--HORIZONTAL LOADS

VIII.A.--HORIZONTAL LINE LOADS

ELEVATION (FT)	LINE LOAD (PLF)
15.10	4720.00

VIII.B.--HORIZONTAL DISTRIBUTED LOADS
NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS
DATE: 20-JULY-2021 TIME: 14:29:54

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*   SOIL PRESSURES FOR  *
* CANTILEVER WALL DESIGN *
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I.--HEADING
'SOUTH BATTERY PARK ADJACENT TO JEWISH MESUM NEW LOADS

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

	NET	<---LEFTSIDE--->		<------NET------> (SOIL + WATER)		<--RIGHTSIDE--->	
ELEV. (FT)	WATER (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
15.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.1	44.8	0.0	0.0	44.8	44.8	0.0	0.0
12.1	108.8	0.0	0.0	108.8	108.8	0.0	0.0
11.1	172.8	0.0	0.0	172.8	172.8	0.0	0.0
11.0	179.2	0.0	0.0	179.2	179.2	0.0	0.0
10.5	211.2	0.0	0.0	219.4	296.1	8.2	84.9
10.1	236.8	139.2	13.4	112.3	376.3	14.7	152.9
9.7	263.6	285.2	27.4	0.0	460.3	21.5	224.1
9.5	275.2	348.1	33.5	-48.4	496.5	24.5	254.8
9.1	300.8	487.3	46.8	-155.5	576.7	31.0	322.7
8.1	364.8	835.4	80.3	-423.3	777.1	47.3	492.6

7.1	428.8	1183.5	113.8	-691.0	977.5	63.7	662.5
6.1	492.8	1531.6	147.2	-958.8	1177.9	80.0	832.3
6.0	499.2	1558.4	149.8	-977.5	1198.7	81.6	849.3
5.1	499.2	1719.3	165.2	-1123.7	1336.2	96.3	1002.2
4.1	499.2	1889.1	181.6	-1277.3	1489.7	112.7	1172.1
3.1	499.2	2059.0	197.9	-1430.8	1643.2	129.0	1341.9
2.1	499.2	2228.8	214.2	-1584.3	1796.8	145.3	1511.8
1.1	499.2	2398.7	230.6	-1737.9	1950.3	161.6	1681.7
0.1	499.2	2568.6	246.9	-1891.4	2103.8	178.0	1851.5
-0.9	499.2	2738.4	263.2	-2044.9	2257.4	194.3	2021.4
-1.9	499.2	2908.3	279.5	-2198.5	2410.9	210.6	2191.3
-2.5	499.2	2293.7	274.7	-1582.0	2017.4	212.6	1792.9
-2.9	499.2	2128.2	289.3	-1403.2	1898.9	225.8	1689.0
-3.9	499.2	2887.4	349.6	-2116.7	2391.8	271.5	2242.2
-4.9	499.2	3015.2	365.1	-2229.0	2504.1	287.0	2370.0
-5.9	499.2	3143.0	380.6	-2341.3	2616.4	302.5	2497.8
-6.9	499.2	3270.8	396.1	-2453.6	2728.7	317.9	2625.6
-7.9	499.2	3398.6	411.5	-2566.0	2841.0	333.4	2753.4
-8.9	499.2	3526.4	427.0	-2678.3	2953.4	348.9	2881.2
-9.9	499.2	3654.1	442.5	-2790.6	3065.7	364.4	3009.0
-10.9	499.2	3781.9	458.0	-2902.9	3178.0	379.8	3136.7
-11.9	499.2	3909.7	473.4	-3015.2	3290.3	395.3	3264.5
-12.9	499.2	4037.5	488.9	-3127.5	3402.6	410.8	3392.3
-13.9	499.2	4165.3	504.4	-3239.8	3514.9	426.3	3520.1
-14.9	499.2	4293.1	519.9	-3352.1	3627.2	441.7	3647.9
-15.9	499.2	4420.9	535.3	-3464.4	3739.5	457.2	3775.7
-16.9	499.2	4548.6	550.8	-3576.8	3851.8	472.7	3903.4
-17.9	499.2	4676.4	566.3	-3689.1	3964.2	488.2	4031.2
-18.9	499.2	4804.2	581.8	-3801.4	4076.5	503.6	4159.0
-19.9	499.2	4932.0	597.2	-3913.7	4188.8	519.1	4286.8

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 20-JULY-2021 TIME: 14:29:55

```
****************************
*  SUMMARY OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
****************************
```

I.--HEADING

'SOUTH BATTERY PARK ADJACENT TO JEWISH MESUM NEW LOADS

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

```
WALL BOTTOM ELEV. (FT)     :       -7.58
      PENETRATION (FT)     :       18.08

MAX. BEND. MOMENT (LB-FT)  :  4.8023E+04
      AT ELEVATION (FT)    :        3.21
```

```
MAX. SCALED DEFL. (LB-IN^3):  1.1602E+10
      AT ELEVATION (FT)    :       15.10

          NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                 ELLASTICITY IN PSI TIMES PILE MOMENT
                 OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                 IN INCHES.
```

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 20-JULY-2021 TIME: 14:29:55

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****************************
* COMPLETE OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
****************************
```

I.--HEADING

'SOUTH BATTERY PARK ADJACENT TO JEWISH MESUM NEW LOADS

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
15.10	0.0000E+00	4720.	1.1602E+10	0.00
14.10	4.7200E+03	4720.	1.0565E+10	0.00
13.80	6.1360E+03	4720.	1.0255E+10	0.00
13.10	9.4437E+03	4736.	9.5351E+09	44.80
12.10	1.4212E+04	4812.	8.5219E+09	108.80
11.10	1.9090E+04	4953.	7.5333E+09	172.80
11.00	1.9586E+04	4971.	7.4361E+09	179.20
10.50	2.2096E+04	5071.	6.9554E+09	219.36
10.10	2.4139E+04	5137.	6.5776E+09	112.26
9.68	2.6299E+04	5160.	6.1888E+09	0.00
9.50	2.7231E+04	5156.	6.0237E+09	-48.39
9.10	2.9287E+04	5115.	5.6637E+09	-155.49
8.10	3.4280E+04	4826.	4.8004E+09	-423.25
7.10	3.8849E+04	4269.	3.9962E+09	-691.01
6.10	4.2728E+04	3444.	3.2591E+09	-958.76
6.00	4.3068E+04	3347.	3.1893E+09	-977.52
5.10	4.5664E+04	2401.	2.5956E+09	-1123.72
4.10	4.7478E+04	1201.	2.0110E+09	-1277.26
3.10	4.8015E+04	-153.	1.5081E+09	-1430.80
2.10	4.7121E+04	-1661.	1.0881E+09	-1584.33
1.10	4.4643E+04	-3322.	7.4920E+08	-1737.87
0.65	4.2986E+04	-4112.	6.2322E+08	-1806.35
0.10	4.0447E+04	-5027.	4.8722E+08	-1496.10
-0.90	3.4765E+04	-6243.	2.9493E+08	-936.06
-1.90	2.8147E+04	-6899.	1.6257E+08	-376.02
-2.50	2.3960E+04	-7024.	1.0724E+08	-40.00
-2.90	2.1154E+04	-6995.	7.8798E+07	184.02
-3.90	1.4344E+04	-6531.	3.1606E+07	744.05
-4.90	8.2785E+03	-5507.	9.3074E+06	1304.09
-5.90	3.5170E+03	-3923.	1.5018E+06	1864.13
-6.90	6.1964E+02	-1779.	4.2072E+04	2424.17
-7.58	0.0000E+00	0.	0.0000E+00	2805.13

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES-------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
15.10	0.	0.	0.	0.	0.
14.10	0.	0.	0.	0.	0.
13.80	0.	0.	0.	0.	0.
13.10	45.	0.	0.	0.	0.
12.10	109.	0.	0.	0.	0.
11.10	173.	0.	0.	0.	0.
11.00	179.	0.	0.	0.	0.
10.50	211.	0.	0.	8.	85.
10.10	237.	139.	13.	15.	153.
9.68	264.	285.	27.	22.	224.
9.50	275.	348.	33.	24.	255.
9.10	301.	487.	47.	31.	323.
8.10	365.	835.	80.	47.	493.
7.10	429.	1183.	114.	64.	662.
6.10	493.	1532.	147.	80.	832.
6.00	499.	1558.	150.	82.	849.
5.10	499.	1719.	165.	96.	1002.
4.10	499.	1889.	182.	113.	1172.
3.10	499.	2059.	198.	129.	1342.
2.10	499.	2229.	214.	145.	1512.
1.10	499.	2399.	231.	162.	1682.
0.65	499.	2474.	238.	169.	1757.
0.10	499.	2569.	247.	178.	1852.
-0.90	499.	2738.	263.	194.	2021.
-1.90	499.	2908.	280.	211.	2191.
-2.50	499.	2294.	275.	213.	1793.
-2.90	499.	2128.	289.	226.	1689.
-3.90	499.	2887.	350.	272.	2242.
-4.90	499.	3015.	365.	287.	2370.
-5.90	499.	3143.	381.	302.	2498.
-6.90	499.	3271.	396.	318.	2626.
-7.58	499.	3399.	412.	333.	2753.
-8.90	499.	3526.	427.	349.	2881.

APPENDIX K-2

SHEET PILE WALL ANALYSES
K-2: SHEET PILE DESIGN FOR WP20-WP21

APPENDIX K2: SHEET PILE DESIGN WP20~WP21

Appendix K2 presents the detailed calculation of sheet pile design by software CWALSHT (US Army Corps of Engineers) between working points WP20 and WP21.

SOIL PARAMTERS

Table 1: Generalized Soil Profile for Foundation Design between Sta. 10+00 and Sta.16+00 (WP6~WP21) Based on Borings B-1, B-2 and B-3

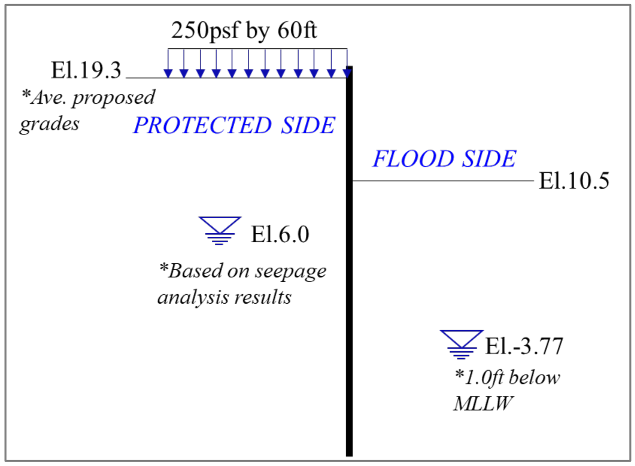
Elevation (ft)	Soil Type	Typical Field SPT Range*		Recommended Key Soil/Rock Parameters
		Field N	N_{60}	
10.5 ~ 3	Fill (medium dense sand, little silt)	12~21	15~27	ϒ=125pcf, ϕ=31.5~34.8° (Ave=33.2°)
3 ~ -2.5				ϒ'=62.6pcf, ϕ=31.5~34.8° (Ave=33.2°)
-2.5 ~ -21.5	Fill (loose to medium dense sand, trace silt)	5~12	6~15	ϒ'=52.6pcf, ϕ=28.9~31.5°(Ave=30.0°)
-21.5 ~ -34.5	Fill (loose to medium dense sand, little silty clay, trace gravel)	8~17	10~22	ϒ'=57.6pcf, ϕ=30~33.4° Ave=31.8°)
-34.5 ~ -38.5	Soft Clay, with little gravel	4	5	ϒ'=44.6pcf, C=600psf
-38.5 ~ -43	Sand (medium dense), with little/some silty clay	10	13	ϒ'=57.6pcf, ϕ=30.9°
<-43	Bedrock-Schist	-	-	ϒ'=87.6pcf, Strain Factor=0.0001, q_u=5000psi, E_{ini}=1.5E+6psi, RQD=75%

*The typical field SPT range is not the actual range of field SPT values, but it is determined based on engineer's judgement.

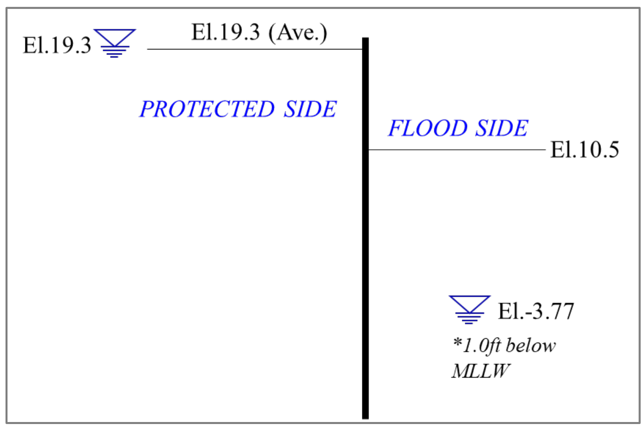
SOFTWARES

CWALSHT (US Army Corps of Engineers).

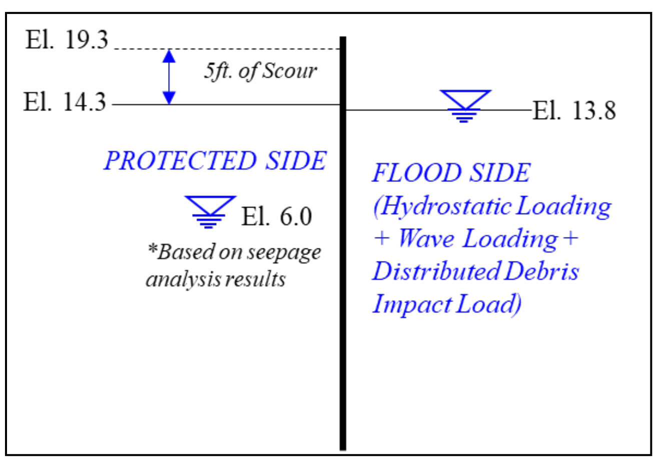
CONTROLLING LOAD CASES:



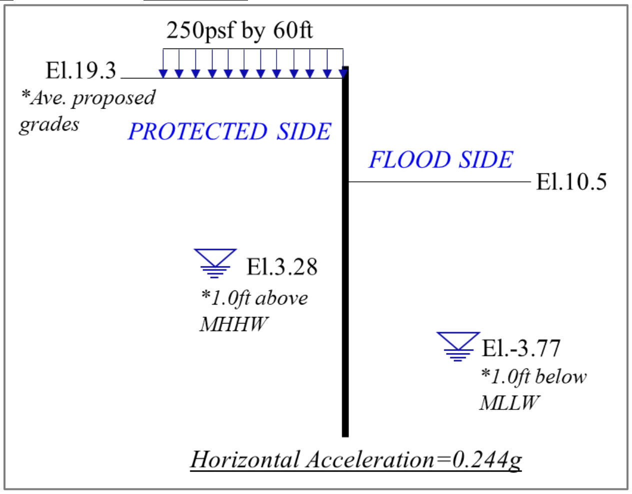
(a) Usual Loading



(b) Unusual Loading-1



(c) Unusual Loading-2



(d) Earthquake Loading

Figure 1: Controlling Load Cases for Floodwall between WP20 and WP21.

For the Load Case of Unusual Loading-2, the design loads provided by AECOM which are summarized as follows were applied to the sheet pile at elevation 10.5 on the flood side:

- Unfactored Moment: 26.4 kip-ft/ft
- Unfactored Shear: 6.27 kip/ft
- Load Acting at EL.10.5 ft (NAVD88)
- Ground Elevation: 10.5 ft (NAVD88)

In order to use the design unfactored shears and moments at +10.5 and at the same time maintaining water level of 13.8 at flood side in the analyses by CWALSHT, a load of 6.09 kips was applied at elevation 14.8. The net result is equal to AECOM shear and moment at EL.10.5.

OTHER PARAMETERS/ASSUMPTIONS

- **For Determination of Depth of Penetration**
  1. Wall friction: 10 degree (Less than 14 degree which is described in Table 3-3 of USACE *EM 1110-2-2504*: Design of Sheet Pile Walls)
  2. Safety factor applied to the active earth pressure=1.0
  3. Safety factor applied to the passive earth pressure=1.5 for Usual Loading, 1.25 for Unusual Loading and 1.1 for Earthquake Loading (Table 5-1 of USACE *EM 1110-2-2504*: Design of Sheet Pile Walls)

- **For Estimation of the Maximum Moment and Shear for Structural Design**
  1. Wall friction: 10 degree (about 1/3 of soil friction angle)
  2. Safety factor applied to the active earth pressure=1.0
  3. Safety factor applied to the passive earth pressure=1.0

SUMMARY OF RESULTS

LOAD CASE	MAXIMUM UNFACTORED MOMENT[1]	MAXIMUM UNFACTORED SHEAR[1]	SCALED DEFLECTION AT TOP OF SHEET PILE[2]	REQUIRED PILE TIP ELEVATION[3]
a-Usual Loading	10.8kips-ft./ft.	5.1kips	1.28×10^9 (lb-in^3)	0.0
b-Unusual Loading-1	22.8kips-ft./ft.	7.1kips	3.89×10^9 (lb-in^3)	-3.5
c-Unusual Loading-2	0.3kips-ft./ft.	0.5kips	1.21×10^7 (lb-in^3)	8.5
d-Earthquake Loading	14.5kips-ft./ft.	6.5kips	2.12×10^9 (lb-in^3)	1.0

Note: [1] These unfactored moment and shear provided here are for structural design and they are calculated using a factor of safety of 1.0 for both active and passive pressures in accordance with Design of Sheet Pile Wall (EM 1110-2-2504) by U.S. Army Corps of Engineers. [2] Divide scaled deflection by the modulus of elasticity in psi times pile moment of inertia in in^4 to obtain deflection in inches. [3] The required pile tip elevation was determined in accordance with Evaluation of I-Walls by U.S, Army Corps of Engineers (ETL 1110-2-575) and FS=1.5, 1.25 and 1.1 were applied to the passive pressures for usual loading, unusual loading and earthquake loading, respectively according to Design of Sheet Pile Walls (EM 1110-2-2504) by U.S. Army Corps of Engineers.

DETTAILED OUTPUT

Please see attachments for the detailed outputs.

WP20~WP21: USUAL LOADING: Mmax, Smax and Deflection for Structural Design

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:31:40

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*  INPUT DATA  *
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```

I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--CONTROL
CANTILEVER WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

III.--WALL DATA
ELEVATION AT TOP OF WALL = 19.30 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	19.30

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.50

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

V.B.--LEFTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH- ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH- ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA
UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 6.00 (FT)
LEFTSIDE ELEVATION = -3.77 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

VII.A.--VERTICAL LINE LOADS
NONE

VII.B.--VERTICAL UNIFORM LOADS
NONE

VII.C.--VERTICAL STRIP LOADS

VII.C.1.--RIGHTSIDE

<-DIST. FROM WALL-> START (FT)	END (FT)	STRIP LOAD (PSF)
0.00	60.00	250.00

VII.C.2.--LEFTSIDE
NONE

VII.D.--VERTICAL RAMP LOADS
NONE

VII.E.--VERTICAL TRIANGULAR LOADS
NONE

VII.F.--VERTICAL VARIABLE LOADS
NONE

VIII.--HORIZONTAL LOADS
NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:31:43

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*************************
*   SOIL PRESSURES FOR  *
* CANTILEVER WALL DESIGN *
*************************
```

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

	NET	<---LEFTSIDE--->		<------NET------> (SOIL + WATER)		<--RIGHTSIDE--->	
ELEV. (FT)	WATER (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
19.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.3	0.0	0.0	0.0	100.4	1791.6	100.4	1791.6
17.3	0.0	0.0	0.0	133.8	2388.7	133.8	2388.7
16.3	0.0	0.0	0.0	167.3	2985.9	167.3	2985.9
15.3	0.0	0.0	0.0	200.7	3583.1	200.7	3583.1
14.3	0.0	0.0	0.0	234.2	4180.3	234.2	4180.3
13.3	0.0	0.0	0.0	267.7	4777.5	267.7	4777.5
12.3	0.0	0.0	0.0	301.1	5374.7	301.1	5374.7
11.3	0.0	0.0	0.0	334.6	5971.9	334.6	5971.9
10.5	0.0	0.0	0.0	361.3	6449.6	361.3	6449.6
10.3	0.0	119.4	6.7	248.6	6562.4	368.0	6569.1
9.9	0.0	382.8	21.4	0.0	6810.9	382.8	6832.4
9.5	0.0	597.2	33.5	-202.4	7013.3	394.8	7046.8
9.3	0.0	716.6	40.1	-315.1	7126.1	401.5	7166.2
8.3	0.0	1313.8	73.6	-878.9	7689.8	434.9	7763.4
7.3	0.0	1911.0	107.1	-1442.6	8253.6	468.4	8360.6
6.3	0.0	2508.2	140.5	-2006.3	8817.3	501.8	8957.8
6.0	0.0	2687.3	150.6	-2177.3	8954.3	510.1	9104.9
5.3	44.8	3105.4	174.0	-2537.3	9211.8	523.3	9341.0

4.3	108.8	3702.6	207.4	-3054.1	9533.8	539.6	9632.4
3.3	172.8	4299.7	240.9	-3571.0	9855.7	556.0	9923.8
2.3	236.8	4896.9	274.3	-4087.8	10177.7	572.3	10215.2
1.3	300.8	5494.1	307.8	-4604.7	10499.7	588.6	10506.7
0.3	364.8	6091.3	341.3	-5121.6	10821.6	604.9	10798.1
-0.7	428.8	6688.5	374.7	-5638.4	11143.6	621.3	11089.5
-1.7	492.8	7285.7	408.2	-6155.3	11465.6	637.6	11380.9
-2.5	544.0	1625.0	352.8	-761.2	2372.2	319.8	2181.0
-2.7	556.8	1648.0	365.9	-767.6	2382.1	323.6	2191.2
-3.7	620.8	7195.4	534.9	-5818.4	10257.4	756.2	10171.5
-3.8	625.3	7219.7	536.7	-5837.2	10261.1	757.2	10172.5
-4.7	625.3	7421.8	551.7	-6024.9	9835.2	771.6	9761.6
-5.7	625.3	7630.0	567.2	-6217.6	9572.3	787.1	9514.3
-6.7	625.3	7838.1	582.7	-6410.3	9766.6	802.6	9724.0
-7.7	625.3	8046.3	598.2	-6602.9	9960.9	818.0	9933.7
-8.7	625.3	8254.4	613.6	-6795.6	10155.1	833.5	10143.5
-9.7	625.3	8462.5	629.1	-6988.3	10349.4	849.0	10353.2
-10.7	625.3	8670.7	644.6	-7180.9	10543.6	864.5	10563.0
-11.7	625.3	8878.8	660.1	-7373.6	10737.9	879.9	10772.7
-12.7	625.3	9087.0	675.5	-7566.3	10932.2	895.4	10982.4
-13.7	625.3	9295.1	691.0	-7759.0	11126.4	910.9	11192.2
-14.7	625.3	9503.3	706.5	-7951.6	11320.7	926.4	11401.9
-15.7	625.3	9711.4	722.0	-8144.3	11515.0	941.8	11611.6
-16.7	625.3	9919.6	737.4	-8337.0	11709.2	957.3	11821.4
-17.7	625.3	10127.7	752.9	-8529.7	11903.5	972.8	12031.1
-18.7	625.3	10335.9	768.4	-8722.3	12097.8	988.3	12240.8
-19.7	625.3	10544.0	783.8	-8915.0	12292.0	1003.7	12450.6

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE
FOR THIS ELEVATION.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:31:43

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****************************
*  SUMMARY OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
****************************
```

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

*****WARNING: STANDARD WEDGE SOLUTION DOES NOT EXIST
AT ALL ELEVATIONS. SEE COMPLETE OUTPUT.

WALL BOTTOM ELEV. (FT) : 3.48
PENETRATION (FT) : 7.02

MAX. BEND. MOMENT (LB-FT) : 1.0806E+04
AT ELEVATION (FT) : 7.22

MAX. SCALED DEFL. (LB-IN^3): 1.2790E+09
AT ELEVATION (FT) : 19.30

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF
ELLASTICITY IN PSI TIMES PILE MOMENT
OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
IN INCHES.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:31:43

****
* COMPLETE OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
19.30	0.0000E+00	0.	1.2790E+09	0.00
18.30	1.6728E+01	50.	1.1604E+09	100.37
17.30	1.2267E+02	167.	1.0418E+09	133.83
16.30	3.6245E+02	318.	9.2348E+08	167.28
15.30	7.6950E+02	502.	8.0578E+08	200.74

14.30	1.3773E+03	719.	6.8945E+08	234.20
13.30	2.2193E+03	970.	5.7553E+08	267.65
12.30	3.3289E+03	1255.	4.6548E+08	301.11
11.30	4.7397E+03	1572.	3.6122E+08	334.57
10.50	6.1076E+03	1851.	2.8362E+08	361.33
10.30	6.4842E+03	1912.	2.6521E+08	248.59
9.86	7.3434E+03	1967.	2.2624E+08	0.00
9.50	8.0451E+03	1930.	1.9633E+08	-202.40
9.30	8.4264E+03	1879.	1.8043E+08	-315.15
8.30	1.0053E+04	1282.	1.1017E+08	-878.88
7.30	1.0801E+04	121.	5.7154E+07	-1442.61
6.30	1.0107E+04	-1604.	2.2595E+07	-2006.34
6.00	9.5330E+03	-2231.	1.5717E+07	-2177.25
5.30	7.4084E+03	-3881.	5.2121E+06	-2537.26
4.89	5.5868E+03	-4971.	2.0776E+06	-2750.32
4.30	2.4909E+03	-5051.	2.7502E+05	2478.78
3.48	0.0000E+00	0.	0.0000E+00	9798.67

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES-------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
19.30	0.	0.	0.	0.	0.
18.30	0.	0.	0.	100.	1792.
17.30	0.	0.	0.	134.	2389.
16.30	0.	0.	0.	167.	2986.
15.30	0.	0.	0.	201.	3583.
14.30	0.	0.	0.	234.	4180.
13.30	0.	0.	0.	268.	4777.
12.30	0.	0.	0.	301.	5375.
11.30	0.	0.	0.	335.	5972.
10.50	0.	0.	0.	361.	6450.
10.30	0.	119.	7.	368.	6569.
9.86	0.	383.	21.	383.	6832.
9.50	0.	597.	33.	395.	7047.
9.30	0.	717.	40.	401.	7166.
8.30	0.	1314.	74.	435.	7763.
7.30	0.	1911.	107.	468.	8361.
6.30	0.	2508.	141.	502.	8958.
6.00	0.	2687.	151.	510.	9105.
5.30	45.	3105.	174.	523.	9341.
4.89	71.	3352.	188.	530.	9461.
4.30	109.	3703.	207.	540.	9632.

3.48	161.	4300.	241.	556.	9924.
2.30	237.	4897.	274.	572.	10215.

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE AT THIS ELEVATION.

WP20~WP21: USUAL LOADING: DETERMINATION OF PILE PENETRATION

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:32:50

****
* INPUT DATA *
****

I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--CONTROL
CANTILEVER WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

III.--WALL DATA
ELEVATION AT TOP OF WALL = 19.30 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	19.30

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.50

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	<--BOTTOM--> SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	<-SAFETY-> <-FACTOR-> PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

V.B.--LEFTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH- ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH- ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 6.00 (FT)
LEFTSIDE ELEVATION = -3.77 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

VII.A.--VERTICAL LINE LOADS
NONE

VII.B.--VERTICAL UNIFORM LOADS
NONE

VII.C.--VERTICAL STRIP LOADS

VII.C.1.--RIGHTSIDE

<-DIST. FROM WALL-> START (FT)	END (FT)	STRIP LOAD (PSF)
0.00	60.00	250.00

VII.C.2.--LEFTSIDE
NONE

VII.D.--VERTICAL RAMP LOADS
NONE

VII.E.--VERTICAL TRIANGULAR LOADS
NONE

VII.F.--VERTICAL VARIABLE LOADS
NONE

VIII.--HORIZONTAL LOADS
NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:33:13

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*   SOIL PRESSURES FOR   *
* CANTILEVER WALL DESIGN *
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

	NET	<---LEFTSIDE--->		<------NET------> (SOIL + WATER)		<--RIGHTSIDE--->	
ELEV. (FT)	WATER (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
19.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.3	0.0	0.0	0.0	100.4	1044.2	100.4	1044.2
17.3	0.0	0.0	0.0	133.8	1392.3	133.8	1392.3
16.3	0.0	0.0	0.0	167.3	1740.4	167.3	1740.4
15.3	0.0	0.0	0.0	200.7	2088.5	200.7	2088.5
14.3	0.0	0.0	0.0	234.2	2436.6	234.2	2436.6
13.3	0.0	0.0	0.0	267.7	2784.7	267.7	2784.7
12.3	0.0	0.0	0.0	301.1	3132.7	301.1	3132.7
11.3	0.0	0.0	0.0	334.6	3480.8	334.6	3480.8
10.5	0.0	0.0	0.0	361.3	3759.3	361.3	3759.3
10.3	0.0	69.6	6.7	298.4	3822.2	368.0	3828.9
9.5	0.0	348.1	33.5	46.7	4073.9	394.8	4107.4
9.4	0.0	399.8	38.4	0.0	4120.6	399.8	4159.0
9.3	0.0	417.7	40.1	-16.2	4136.8	401.5	4177.0
8.3	0.0	765.8	73.6	-330.8	4451.5	434.9	4525.1
7.3	0.0	1113.9	107.1	-645.5	4766.1	468.4	4873.2
6.3	0.0	1461.9	140.5	-960.1	5080.7	501.8	5221.2
6.0	0.0	1566.4	150.6	-1056.3	5156.4	510.1	5307.0
5.3	44.8	1810.0	174.0	-1241.9	5315.4	523.3	5444.6

4.3	108.8	2158.1	207.4	-1509.7	5515.8	539.6	5614.4
3.3	172.8	2506.2	240.9	-1777.4	5716.2	556.0	5784.3
2.3	236.8	2854.3	274.3	-2045.2	5916.6	572.3	5954.2
1.3	300.8	3202.4	307.8	-2312.9	6117.0	588.6	6124.0
0.3	364.8	3550.4	341.3	-2580.7	6317.4	604.9	6293.9
-0.7	428.8	3898.5	374.7	-2848.5	6517.8	621.3	6463.8
-1.7	492.8	4246.6	408.2	-3116.2	6718.3	637.6	6633.6
-2.5	544.0	2346.6	352.8	-1482.8	2372.2	319.8	2181.0
-2.7	556.8	2242.9	365.9	-1362.4	2382.1	323.6	2191.2
-3.7	620.8	4417.3	534.9	-3040.4	6330.3	756.2	6244.4
-3.8	625.3	4432.3	536.7	-3049.8	6341.9	757.2	6253.4
-4.7	625.3	4556.4	551.7	-3159.4	6445.7	771.6	6372.2
-5.7	625.3	4684.1	567.2	-3271.8	6558.0	787.1	6500.0
-6.7	625.3	4811.9	582.7	-3384.1	6670.4	802.6	6627.8
-7.7	625.3	4939.7	598.2	-3496.4	6782.7	818.0	6755.6
-8.7	625.3	5067.5	613.6	-3608.7	6895.0	833.5	6883.3
-9.7	625.3	5195.3	629.1	-3721.0	7007.3	849.0	7011.1
-10.7	625.3	5323.1	644.6	-3833.3	6838.2	864.5	6857.5
-11.7	625.3	5450.8	660.1	-3945.6	6645.7	879.9	6680.5
-12.7	625.3	5578.6	675.5	-4057.9	6735.4	895.4	6785.6
-13.7	625.3	5706.4	691.0	-4170.2	6849.1	910.9	6914.8
-14.7	625.3	5834.2	706.5	-4282.6	6962.9	926.4	7044.1
-15.7	625.3	5962.0	722.0	-4394.9	7076.6	941.8	7173.3
-16.7	625.3	6089.8	737.4	-4507.2	7190.3	957.3	7302.5
-17.7	625.3	6217.6	752.9	-4619.5	7304.1	972.8	7431.7
-18.7	625.3	6345.3	768.4	-4731.8	7417.8	988.3	7560.9
-19.7	625.3	6473.1	783.8	-4844.1	7531.6	1003.7	7690.1

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:33:14

****
* SUMMARY OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

WALL BOTTOM ELEV. (FT) : 0.75
PENETRATION (FT) : 9.75

MAX. BEND. MOMENT (LB-FT) : 1.3356E+04
AT ELEVATION (FT) : 5.73

MAX. SCALED DEFL. (LB-IN^3): 2.2086E+09
AT ELEVATION (FT) : 19.30

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:33:14

****
* COMPLETE OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
19.30	0.0000E+00	0.	2.2086E+09	0.00
18.30	1.6728E+01	50.	2.0284E+09	100.37
17.30	1.2267E+02	167.	1.8483E+09	133.83
16.30	3.6245E+02	318.	1.6684E+09	167.28
15.30	7.6950E+02	502.	1.4891E+09	200.74
14.30	1.3773E+03	719.	1.3112E+09	234.20
13.30	2.2193E+03	970.	1.1358E+09	267.65
12.30	3.3289E+03	1255.	9.6415E+08	301.11
11.30	4.7397E+03	1572.	7.9835E+08	334.57
10.50	6.1076E+03	1851.	6.7150E+08	361.33

10.30	6.4845E+03	1917.	6.4078E+08	298.41
9.50	8.0866E+03	2055.	5.2266E+08	46.71
9.35	8.3920E+03	2058.	5.0168E+08	0.00
9.30	8.4981E+03	2058.	4.9446E+08	-16.22
8.30	1.0495E+04	1884.	3.6282E+08	-330.85
7.30	1.2162E+04	1396.	2.4927E+08	-645.47
6.30	1.3183E+04	593.	1.5665E+08	-960.10
6.00	1.3316E+04	291.	1.3323E+08	-1056.29
5.30	1.3246E+04	-513.	8.6662E+07	-1241.92
4.30	1.2067E+04	-1889.	3.9388E+07	-1509.67
3.30	9.3783E+03	-3533.	1.2748E+07	-1777.43
2.81	7.4249E+03	-4437.	5.9115E+06	-1908.85
2.30	5.0052E+03	-4896.	2.0593E+06	106.32
1.30	8.2166E+02	-2811.	3.7162E+04	4064.19
0.75	0.0000E+00	0.	0.0000E+00	6226.52

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES-------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
19.30	0.	0.	0.	0.	0.
18.30	0.	0.	0.	100.	1044.
17.30	0.	0.	0.	134.	1392.
16.30	0.	0.	0.	167.	1740.
15.30	0.	0.	0.	201.	2088.
14.30	0.	0.	0.	234.	2437.
13.30	0.	0.	0.	268.	2785.
12.30	0.	0.	0.	301.	3133.
11.30	0.	0.	0.	335.	3481.
10.50	0.	0.	0.	361.	3759.
10.30	0.	70.	7.	368.	3829.
9.50	0.	348.	33.	395.	4107.
9.35	0.	400.	38.	400.	4159.
9.30	0.	418.	40.	401.	4177.
8.30	0.	766.	74.	435.	4525.
7.30	0.	1114.	107.	468.	4873.
6.30	0.	1462.	141.	502.	5221.
6.00	0.	1566.	151.	510.	5307.
5.30	45.	1810.	174.	523.	5445.
4.30	109.	2158.	207.	540.	5614.
3.30	173.	2506.	241.	556.	5784.
2.81	204.	2677.	257.	564.	5868.
2.30	237.	2854.	274.	572.	5954.

1.30	301.	3202.	308.	589.	6124.
0.75	336.	3550.	341.	605.	6294.
-0.70	429.	3899.	375.	621.	6464.

WP20~WP21: UNUSUAL LOADING-1: Mmax, Smax and Deflection for Structural Design

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:34:25

****
* INPUT DATA *
****

I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--CONTROL
CANTILEVER WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

III.--WALL DATA
ELEVATION AT TOP OF WALL = 19.30 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	19.30

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.50

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

V.B.--LEFTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH- ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH- ESION (PSF)	<--BOTTOM--> ELEV. (FT)	<--BOTTOM--> SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	<-SAFETY-> <-FACTOR-> PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 19.30 (FT)
LEFTSIDE ELEVATION = -3.77 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

NONE

VIII.--HORIZONTAL LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS
DATE: 25-FEBRUARY-2021 TIME: 12:34:33

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*   SOIL PRESSURES FOR   *
* CANTILEVER WALL DESIGN *
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

				<------NET------>			
	NET	<---LEFTSIDE--->		(SOIL + WATER)		<--RIGHTSIDE--->	
ELEV.	WATER	PASSIVE	ACTIVE	ACTIVE	PASSIVE	ACTIVE	PASSIVE
(FT)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)
19.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.3	64.0	0.0	0.0	80.3	355.4	16.3	291.4
17.3	128.0	0.0	0.0	160.7	710.9	32.7	582.9
16.3	192.0	0.0	0.0	241.0	1066.3	49.0	874.3
15.3	256.0	0.0	0.0	321.3	1421.7	65.3	1165.7
14.3	320.0	0.0	0.0	401.6	1777.1	81.6	1457.1
13.3	384.0	0.0	0.0	482.0	2132.6	98.0	1748.6
12.3	448.0	0.0	0.0	562.3	2488.0	114.3	2040.0
11.3	512.0	0.0	0.0	642.6	2843.4	130.6	2331.4
10.5	563.2	0.0	0.0	706.9	3127.8	143.7	2564.6
10.3	576.0	119.4	6.7	603.5	3192.2	146.9	2622.8
9.5	627.2	597.2	33.5	190.0	3449.7	160.0	2856.0
9.3	640.0	716.6	40.1	86.6	3514.1	163.3	2914.3
9.1	650.7	816.7	45.8	0.0	3568.1	166.0	2963.1
8.3	704.0	1313.8	73.6	-430.2	3836.1	179.6	3205.7
7.3	768.0	1911.0	107.1	-947.1	4158.1	195.9	3497.1
6.3	832.0	2508.2	140.5	-1463.9	4480.0	212.2	3788.6
5.3	896.0	3105.4	174.0	-1980.8	4802.0	228.6	4080.0
4.3	960.0	3702.6	207.4	-2497.7	5124.0	244.9	4371.4
3.3	1024.0	4299.7	240.9	-3014.5	5445.9	261.2	4662.8
2.3	1088.0	4896.9	274.3	-3531.4	5767.9	277.6	4954.3
1.3	1152.0	5494.1	307.8	-4048.2	6089.9	293.9	5245.7
0.3	1216.0	6091.3	341.3	-4565.1	6411.9	310.2	5537.1
-0.7	1280.0	6688.5	374.7	-5082.0	6733.8	326.5	5828.5
-1.7	1344.0	7285.7	408.2	-5598.8	7055.8	342.9	6120.0
-2.5	1395.2	1625.0	352.8	-12.6	2372.2	217.2	1329.8
-2.7	1408.0	1648.0	365.9	-17.5	2382.1	222.5	1340.0
-3.7	1472.0	7195.4	534.9	-5301.3	6614.2	422.0	5677.1
-3.8	1476.5	7219.7	536.7	-5320.1	6631.5	423.1	5691.7
-4.7	1476.5	7421.8	551.7	-5507.8	6810.0	437.5	5885.3
-5.7	1476.5	7630.0	567.2	-5700.5	7002.7	453.0	6093.4
-6.7	1476.5	7838.1	582.7	-5893.2	7195.4	468.5	6301.6
-7.7	1476.5	8046.3	598.2	-6085.8	7388.0	483.9	6509.7
-8.7	1476.5	8254.4	613.6	-6278.5	7580.7	499.4	6717.9
-9.7	1476.5	8462.5	629.1	-6471.2	7773.4	514.9	6926.0
-10.7	1476.5	8670.7	644.6	-6663.9	7966.1	530.4	7134.2
-11.7	1476.5	8878.8	660.1	-6856.5	8158.7	545.8	7342.3
-12.7	1476.5	9087.0	675.5	-7049.2	8351.4	561.3	7550.5
-13.7	1476.5	9295.1	691.0	-7241.9	8544.1	576.8	7758.6
-14.7	1476.5	9503.3	706.5	-7434.6	8736.8	592.3	7966.8
-15.7	1476.5	9711.4	722.0	-7627.2	8929.4	607.7	8174.9
-16.7	1476.5	9919.6	737.4	-7819.9	9122.1	623.2	8383.0
-17.7	1476.5	10127.7	752.9	-8012.6	9314.8	638.7	8591.2
-18.7	1476.5	10335.9	768.4	-8205.3	9507.4	654.1	8799.3

```
-19.7  1476.5   10544.0    783.8   -8397.9    9700.1     669.6    9007.5
        * STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE
          FOR THIS ELEVATION.
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 25-FEBRUARY-2021                                       TIME: 12:34:33

                       ****************************
                       *  SUMMARY OF RESULTS FOR  *
                       *  CANTILEVER WALL DESIGN  *
                       ****************************

    I.--HEADING
     'SOUTH BATTERY PARK FLOODWALL WP18-WP19

   II.--SUMMARY

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        *****WARNING:  STANDARD WEDGE SOLUTION DOES NOT EXIST
                       AT ALL ELEVATIONS.  SEE COMPLETE OUTPUT.

   WALL BOTTOM ELEV. (FT)     :       -0.02
         PENETRATION (FT)     :       10.52

   MAX. BEND. MOMENT (LB-FT)  :  2.2752E+04
         AT ELEVATION (FT)    :        5.40

   MAX. SCALED DEFL. (LB-IN^3):  3.8888E+09
         AT ELEVATION (FT)    :       19.30

             NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                    ELLASTICITY IN PSI TIMES PILE MOMENT
                    OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                    IN INCHES.
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:34:33

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***************************
* COMPLETE OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
***************************
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
19.30	0.0000E+00	0.	3.8888E+09	0.00
18.30	1.3388E+01	40.	3.5828E+09	80.33
17.30	1.0710E+02	161.	3.2769E+09	160.65
16.30	3.6147E+02	361.	2.9711E+09	240.98
15.30	8.5682E+02	643.	2.6661E+09	321.31
14.30	1.6735E+03	1004.	2.3625E+09	401.63
13.30	2.8918E+03	1446.	2.0619E+09	481.96
12.30	4.5920E+03	1968.	1.7664E+09	562.29
11.30	6.8546E+03	2570.	1.4789E+09	642.61
10.50	9.1234E+03	3110.	1.2572E+09	706.88
10.30	9.7589E+03	3241.	1.2033E+09	603.50
9.50	1.2501E+04	3559.	9.9473E+08	190.02
9.30	1.3216E+04	3586.	9.4463E+08	86.64
9.13	1.3818E+04	3594.	9.0335E+08	0.00
8.30	1.6759E+04	3415.	7.0885E+08	-430.22
7.30	1.9873E+04	2726.	5.0196E+08	-947.08
6.30	2.2039E+04	1520.	3.2928E+08	-1463.94
5.30	2.2741E+04	-202.	1.9446E+08	-1980.80
4.30	2.1463E+04	-2441.	9.8665E+07	-2497.66
3.30	1.7687E+04	-5197.	3.9593E+07	-3014.52
3.19	1.7104E+04	-5528.	3.5155E+07	-3070.66
2.30	1.1309E+04	-7079.	1.0678E+07	-409.15
1.30	4.5239E+03	-5995.	1.2474E+06	2576.69
0.30	3.1496E+02	-1925.	4.7033E+03	5562.53
-0.02	0.0000E+00	0.	0.0000E+00	6514.51

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES-------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
19.30	0.	0.	0.	0.	0.
18.30	64.	0.	0.	16.	291.
17.30	128.	0.	0.	33.	583.
16.30	192.	0.	0.	49.	874.
15.30	256.	0.	0.	65.	1166.
14.30	320.	0.	0.	82.	1457.
13.30	384.	0.	0.	98.	1749.
12.30	448.	0.	0.	114.	2040.
11.30	512.	0.	0.	131.	2331.
10.50	563.	0.	0.	144.	2565.
10.30	576.	119.	7.	147.	2623.
9.50	627.	597.	33.	160.	2856.
9.30	640.	717.	40.	163.	2914.
9.13	651.	817.	46.	166.	2963.
8.30	704.	1314.	74.	180.	3206.
7.30	768.	1911.	107.	196.	3497.
6.30	832.	2508.	141.	212.	3789.
5.30	896.	3105.	174.	229.	4080.
4.30	960.	3703.	207.	245.	4371.
3.30	1024.	4300.	241.	261.	4663.
3.19	1031.	4365.	245.	263.	4694.
2.30	1088.	4897.	274.	278.	4954.
1.30	1152.	5494.	308.	294.	5246.
0.30	1216.	6091.	341.	310.	5537.
-0.02	1236.	6688.	375.	327.	5829.
-1.70	1344.	7286.	408.	343.	6120.

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE AT THIS ELEVATION.

WP20~WP21: UNUSUAL LOADING-1: DETERMINATION OF PILE PENETRATION

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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 25-FEBRUARY-2021                                       TIME: 12:35:29

                            ****************
                            *  INPUT DATA  *
                            ****************

     I.--HEADING
    'SOUTH BATTERY PARK FLOODWALL WP18-WP19

    II.--CONTROL
       CANTILEVER WALL DESIGN
       FACTOR OF SAFETY FOR ACTIVE PRESSURES  = 1.00
       FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.25

   III.--WALL DATA
       ELEVATION AT TOP OF WALL    = 19.30 FT.

    IV.--SURFACE POINT DATA

         IV.A.--RIGHTSIDE
            DIST. FROM     ELEVATION
            WALL (FT)         (FT)
                 0.00         19.30

         IV.B.--LEFTSIDE
            DIST. FROM     ELEVATION
            WALL (FT)         (FT)
                 0.00         10.50

     V.--SOIL LAYER DATA

        V.A.--RIGHTSIDE
            LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
            LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT
```

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	<--BOTTOM--> SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

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        V.B.--LEFTSIDE
            LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
```

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH- ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH- ESION (PSF)	<--BOTTOM--> ELEV. (FT)		<-SAFETY-> <-FACTOR-> ACT.	PASS.
							SLOPE (FT/FT)		
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 19.30 (FT)
LEFTSIDE ELEVATION = -3.77 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

NONE

VIII.--HORIZONTAL LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:35:31

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**************************
*   SOIL PRESSURES FOR   *
* CANTILEVER WALL DESIGN *
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

				<------NET------>			
	NET	<---LEFTSIDE--->		(SOIL + WATER)		<--RIGHTSIDE--->	
ELEV. (FT)	WATER (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
19.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.3	64.0	0.0	0.0	80.3	274.1	16.3	210.1
17.3	128.0	0.0	0.0	160.7	548.2	32.7	420.2
16.3	192.0	0.0	0.0	241.0	822.3	49.0	630.3
15.3	256.0	0.0	0.0	321.3	1096.4	65.3	840.4
14.3	320.0	0.0	0.0	401.6	1370.5	81.6	1050.5
13.3	384.0	0.0	0.0	482.0	1644.7	98.0	1260.7
12.3	448.0	0.0	0.0	562.3	1918.8	114.3	1470.8
11.3	512.0	0.0	0.0	642.6	2192.9	130.6	1680.9
10.5	563.2	0.0	0.0	706.9	2412.2	143.7	1849.0
10.3	576.0	86.1	6.7	636.8	2460.3	146.9	1891.0
9.5	627.2	430.6	33.5	356.7	2652.8	160.0	2059.1
9.3	640.0	516.7	40.1	286.6	2700.9	163.3	2101.1
8.5	692.4	869.0	67.5	0.0	2897.9	176.6	2273.0
8.3	704.0	947.2	73.6	-63.6	2941.6	179.6	2311.2
7.3	768.0	1377.8	107.1	-413.8	3182.3	195.9	2521.3
6.3	832.0	1808.3	140.5	-764.1	3422.9	212.2	2731.4
5.3	896.0	2238.9	174.0	-1114.3	3663.6	228.6	2941.5
4.3	960.0	2669.4	207.4	-1464.5	3904.2	244.9	3151.6
3.3	1024.0	3100.0	240.9	-1814.7	4144.9	261.2	3361.8
2.3	1088.0	3530.5	274.3	-2165.0	4385.5	277.6	3571.9
1.3	1152.0	3961.1	307.8	-2515.2	4626.2	293.9	3782.0
0.3	1216.0	4391.6	341.3	-2865.4	4866.8	310.2	3992.1
-0.7	1280.0	4822.2	374.7	-3215.7	5107.5	326.5	4202.2
-1.7	1344.0	5252.7	408.2	-3565.9	5348.1	342.9	4412.3
-2.5	1395.2	1859.4	352.8	-247.0	2372.2	217.2	1329.8
-2.7	1408.0	1670.1	365.9	-39.6	2382.1	222.5	1340.0
-3.7	1472.0	5355.3	534.9	-3461.2	5162.4	422.0	4225.3
-3.8	1476.5	5373.4	536.7	-3473.8	5175.9	423.1	4236.1
-4.7	1476.5	5523.8	551.7	-3609.8	5304.9	437.5	4380.2
-5.7	1476.5	5678.7	567.2	-3749.3	5444.4	453.0	4535.1
-6.7	1476.5	5833.6	582.7	-3888.7	5583.8	468.5	4690.0
-7.7	1476.5	5988.6	598.2	-4028.1	5723.3	483.9	4845.0
-8.7	1476.5	6143.5	613.6	-4167.6	5862.7	499.4	4999.9
-9.7	1476.5	6298.4	629.1	-4307.0	6002.2	514.9	5154.8
-10.7	1476.5	6453.3	644.6	-4446.5	6141.6	530.4	5309.7
-11.7	1476.5	6608.2	660.1	-4585.9	6281.1	545.8	5464.6
-12.7	1476.5	6763.1	675.5	-4725.4	6420.5	561.3	5619.5
-13.7	1476.5	6918.1	691.0	-4864.8	6559.9	576.8	5774.5
-14.7	1476.5	7073.0	706.5	-5004.2	6699.4	592.3	5929.4
-15.7	1476.5	7227.9	722.0	-5143.7	6838.8	607.7	6084.3
-16.7	1476.5	7382.8	737.4	-5283.1	6978.3	623.2	6239.2
-17.7	1476.5	7537.7	752.9	-5422.6	7117.7	638.7	6394.1
-18.7	1476.5	7692.6	768.4	-5562.0	7257.2	654.1	6549.0

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-19.7  1476.5    7847.6    783.8   -5701.5    7396.6     669.6    6704.0
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 25-FEBRUARY-2021                                      TIME: 12:35:32

                       ****************************
                       *  SUMMARY OF RESULTS FOR  *
                       *  CANTILEVER WALL DESIGN  *
                       ****************************

    I.--HEADING
     'SOUTH BATTERY PARK FLOODWALL WP18-WP19

   II.--SUMMARY

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

   WALL BOTTOM ELEV. (FT)     :       -3.31
         PENETRATION (FT)     :       13.81

   MAX. BEND. MOMENT (LB-FT)  :  2.8272E+04
         AT ELEVATION (FT)    :        3.81

   MAX. SCALED DEFL. (LB-IN^3):  6.5601E+09
         AT ELEVATION (FT)    :       19.30

             NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                    ELLASTICITY IN PSI TIMES PILE MOMENT
                    OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                    IN INCHES.
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***************************
* COMPLETE OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
***************************
```

I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
19.30	0.0000E+00	0.	6.5601E+09	0.00
18.30	1.3388E+01	40.	6.1022E+09	80.33
17.30	1.0710E+02	161.	5.6442E+09	160.65
16.30	3.6147E+02	361.	5.1865E+09	240.98
15.30	8.5682E+02	643.	4.7294E+09	321.31
14.30	1.6735E+03	1004.	4.2739E+09	401.63
13.30	2.8918E+03	1446.	3.8213E+09	481.96
12.30	4.5920E+03	1968.	3.3738E+09	562.29
11.30	6.8546E+03	2570.	2.9342E+09	642.61
10.50	9.1234E+03	3110.	2.5910E+09	706.88
10.30	9.7591E+03	3245.	2.5067E+09	636.83
9.50	1.2529E+04	3642.	2.1765E+09	356.65
9.30	1.3264E+04	3706.	2.0960E+09	286.61
8.48	1.6361E+04	3824.	1.7768E+09	0.00
8.30	1.7055E+04	3818.	1.7084E+09	-63.62
7.30	2.0783E+04	3579.	1.3502E+09	-413.85
6.30	2.4097E+04	2990.	1.0278E+09	-764.07
5.30	2.6646E+04	2051.	7.4703E+08	-1114.30
4.30	2.8082E+04	762.	5.1209E+08	-1464.52
3.30	2.8053E+04	-878.	3.2548E+08	-1814.75
2.30	2.6209E+04	-2868.	1.8707E+08	-2164.97
1.69	2.4064E+04	-4242.	1.2552E+08	-2376.89
1.30	2.2217E+04	-5080.	9.3647E+07	-1867.80
0.30	1.6418E+04	-6303.	3.8344E+07	-578.65
-0.70	1.0040E+04	-6237.	1.1327E+07	710.51
-1.70	4.3723E+03	-4882.	1.7611E+06	1999.66
-2.50	1.2163E+03	-2870.	1.1860E+05	3030.99
-2.70	7.0458E+02	-2238.	3.8528E+04	3288.82
-3.31	0.0000E+00	0.	0.0000E+00	4072.72

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES-------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
19.30	0.	0.	0.	0.	0.
18.30	64.	0.	0.	16.	210.
17.30	128.	0.	0.	33.	420.
16.30	192.	0.	0.	49.	630.
15.30	256.	0.	0.	65.	840.
14.30	320.	0.	0.	82.	1051.
13.30	384.	0.	0.	98.	1261.
12.30	448.	0.	0.	114.	1471.
11.30	512.	0.	0.	131.	1681.
10.50	563.	0.	0.	144.	1849.
10.30	576.	86.	7.	147.	1891.
9.50	627.	431.	33.	160.	2059.
9.30	640.	517.	40.	163.	2101.
8.48	692.	869.	68.	177.	2273.
8.30	704.	947.	74.	180.	2311.
7.30	768.	1378.	107.	196.	2521.
6.30	832.	1808.	141.	212.	2731.
5.30	896.	2239.	174.	229.	2942.
4.30	960.	2669.	207.	245.	3152.
3.30	1024.	3100.	241.	261.	3362.
2.30	1088.	3531.	274.	278.	3572.
1.69	1127.	3791.	295.	287.	3699.
1.30	1152.	3961.	308.	294.	3782.
0.30	1216.	4392.	341.	310.	3992.
-0.70	1280.	4822.	375.	327.	4202.
-1.70	1344.	5253.	408.	343.	4412.
-2.50	1395.	1859.	353.	217.	1330.
-2.70	1408.	1670.	366.	222.	1340.
-3.31	1447.	5355.	535.	422.	4225.
-3.77	1476.	5373.	537.	423.	4236.

WP20~WP21: UNUSUAL LOADING-2: Mmax, Smax and Deflection for Structural Design

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 1-JUNE-2021 TIME: 11:23:54

****
* INPUT DATA *
****

I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--CONTROL
CANTILEVER WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

III.--WALL DATA
ELEVATION AT TOP OF WALL = 19.30 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	15.30

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.50

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

V.B.--LEFTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH- ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH- ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 6.00 (FT)
LEFTSIDE ELEVATION = 13.80 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

NONE

VIII.--HORIZONTAL LOADS

VIII.A.--HORIZONTAL LINE LOADS

ELEVATION (FT)	LINE LOAD (PLF)
14.80	6.09

VIII.B.--HORIZONTAL DISTRIBUTED LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 1-JUNE-2021 TIME: 11:23:57

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*   SOIL PRESSURES FOR  *
* CANTILEVER WALL DESIGN *
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I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

	NET	<---LEFTSIDE--->		<------NET------> (SOIL + WATER)		<--RIGHTSIDE--->	
ELEV. (FT)	WATER (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
19.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.8	0.0	0.0	0.0	16.7	298.6	16.7	298.6
14.3	0.0	0.0	0.0	33.5	597.2	33.5	597.2
13.8	0.0	0.0	0.0	50.2	895.8	50.2	895.8
13.3	-32.0	0.0	0.0	34.9	1162.4	66.9	1194.4
12.3	-96.0	0.0	0.0	4.4	1695.6	100.4	1791.6
11.3	-160.0	0.0	0.0	-26.2	2228.7	133.8	2388.7
10.5	-211.2	0.0	0.0	-50.6	2655.3	160.6	2866.5
10.3	-224.0	58.3	3.3	-115.0	2758.7	167.3	2985.9
9.5	-275.2	291.4	16.3	-372.6	3172.2	194.0	3463.7
9.3	-288.0	349.7	19.6	-437.0	3275.5	200.7	3583.1
8.3	-352.0	641.1	35.9	-758.9	3792.4	234.2	4180.3
7.3	-416.0	932.6	52.2	-1080.9	4309.2	267.7	4777.5
6.3	-480.0	1224.0	68.6	-1402.9	4826.1	301.1	5374.7
6.0	-499.2	1311.4	73.5	-1501.3	4949.1	309.3	5521.7
5.3	-499.2	1515.4	84.9	-1692.0	5173.7	322.6	5757.8
4.3	-499.2	1806.8	101.2	-1967.1	5448.8	338.9	6049.3
3.3	-499.2	2098.3	117.6	-2242.2	5723.9	355.2	6340.7
2.3	-499.2	2389.7	133.9	-2517.3	5999.0	371.6	6632.1
1.3	-499.2	2681.1	150.2	-2792.4	6274.1	387.9	6923.5
0.3	-499.2	2972.6	166.5	-3067.5	6549.2	404.2	7215.0
-0.7	-499.2	3264.0	182.9	-3342.6	6824.3	420.5	7506.4
-1.7	-499.2	3555.4	199.2	-3617.7	7099.4	436.9	7797.8
-2.5	-499.2	793.0	172.0	-1007.5	1009.8	284.7	1681.0
-2.7	-499.2	803.2	178.2	-1011.4	1013.8	291.0	1691.2
-3.7	-499.2	3486.3	259.2	-3456.9	6352.1	528.6	7110.5
-4.7	-499.2	3694.4	274.6	-3649.5	6544.8	544.1	7318.6
-5.7	-499.2	3902.6	290.1	-3842.2	6737.5	559.5	7526.8
-6.7	-499.2	4110.7	305.6	-4034.9	6930.1	575.0	7734.9
-7.7	-499.2	4318.9	321.1	-4227.6	7122.8	590.5	7943.1
-8.7	-499.2	4527.0	336.5	-4420.2	7315.5	606.0	8151.2
-9.7	-499.2	4735.2	352.0	-4612.9	7508.2	621.4	8359.4
-10.7	-499.2	4943.3	367.5	-4805.6	7700.8	636.9	8567.5

-11.7	-499.2	5151.5	383.0	-4998.3	7893.5	652.4	8775.7
-12.7	-499.2	5359.6	398.4	-5190.9	8086.2	667.9	8983.8
-13.7	-499.2	5567.7	413.9	-5383.6	8278.9	683.3	9192.0
-14.7	-499.2	5775.9	429.4	-5576.3	8471.5	698.8	9400.1
-15.7	-499.2	5984.0	444.9	-5769.0	8664.2	714.3	9608.3
-16.7	-499.2	6192.2	460.3	-5961.6	8856.9	729.8	9816.4
-17.7	-499.2	6400.3	475.8	-6154.3	9049.6	745.2	10024.6
-18.7	-499.2	6608.5	491.3	-6347.0	9242.2	760.7	10232.7
-19.7	-499.2	6816.6	506.8	-6539.7	9434.9	776.2	10440.9

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE FOR THIS ELEVATION.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 1-JUNE-2021 TIME: 11:23:58

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***************************
*  SUMMARY OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

*****WARNING: STANDARD WEDGE SOLUTION DOES NOT EXIST AT ALL ELEVATIONS. SEE COMPLETE OUTPUT.

```
WALL BOTTOM ELEV. (FT)     :        8.71
      PENETRATION (FT)     :        1.79

MAX. BEND. MOMENT (LB-FT)  :  2.6928E+02
      AT ELEVATION (FT)    :       10.12

MAX. SCALED DEFL. (LB-IN^3):  1.2047E+07
      AT ELEVATION (FT)    :       19.30
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NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 1-JUNE-2021 TIME: 11:23:58

****
* COMPLETE OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
19.30	0.0000E+00	0.	1.2047E+07	0.00
18.30	-6.8212E-13	0.	1.0611E+07	0.00
17.30	-6.8212E-13	0.	9.1756E+06	0.00
16.30	-6.8212E-13	0.	7.7397E+06	0.00
15.30	-6.8212E-13	0.	6.3039E+06	0.00
14.80+	6.9701E-01	4.	5.5859E+06	16.73
14.80-	6.9701E-01	10.	5.5859E+06	16.73
14.30	8.6211E+00	23.	4.8687E+06	33.46
13.80	2.4909E+01	44.	4.1555E+06	50.18
13.30	5.2410E+01	65.	3.4534E+06	34.91
12.30	1.2978E+02	85.	2.1337E+06	4.37
11.30	2.1152E+02	74.	1.0389E+06	-26.17
10.50	2.5953E+02	43.	4.1805E+05	-50.61
10.30	2.6670E+02	26.	3.0585E+05	-115.00
9.50	2.2359E+02	-169.	4.0077E+04	-372.58
9.30	1.8200E+02	-250.	1.5686E+04	-436.97
8.98	7.8002E+01	-406.	9.6710E+02	-540.02
8.71	0.0000E+00	0.	0.0000E+00	3579.01

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

ELEVATION (FT)	WATER PRESSURE (PSF)	<-------------SOIL PRESSURES--------------> <----LEFTSIDE-----> PASSIVE (PSF)	ACTIVE (PSF)	<---RIGHTSIDE----> ACTIVE (PSF)	PASSIVE (PSF)
19.30	0.	0.	0.	0.	0.
18.30	0.	0.	0.	0.	0.
17.30	0.	0.	0.	0.	0.
16.30	0.	0.	0.	0.	0.
15.30	0.	0.	0.	0.	0.
14.80	0.	0.	0.	17.	299.
14.30	0.	0.	0.	33.	597.
13.80	0.	0.	0.	50.	896.
13.30	-32.	0.	0.	67.	1194.
12.30	-96.	0.	0.	100.	1792.
11.30	-160.	0.	0.	134.	2389.
10.50	-211.	0.	0.	161.	2866.
10.30	-224.	58.	3.	167.	2986.
9.50	-275.	291.	16.	194.	3464.
9.30	-288.	350.	20.	201.	3583.
8.98	-308.	443.	25.	211.	3774.
8.71	-326.	641.	36.	234.	4180.
7.30	-416.	933.	52.	268.	4777.

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE AT THIS ELEVATION.

WP20~WP21: UNUSUAL LOADING-2: DETERMINATION OF PILE PENETRATION

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 1-JUNE-2021 TIME: 11:30:30

****
* INPUT DATA *
****

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--CONTROL

CANTILEVER WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.25

III.--WALL DATA

ELEVATION AT TOP OF WALL = 19.30 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	15.30

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.50

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE

LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH- ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH- ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

V.B.--LEFTSIDE

LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH- ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH- ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
125.00	125.00	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
115.00	115.00	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
120.00	120.00	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
107.00	107.00	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
120.00	120.00	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
150.00	150.00	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 6.00 (FT)
LEFTSIDE ELEVATION = 13.80 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

NONE

VIII.--HORIZONTAL LOADS

VIII.A.--HORIZONTAL LINE LOADS

ELEVATION (FT)	LINE LOAD (PLF)
14.80	6.09

VIII.B.--HORIZONTAL DISTRIBUTED LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 1-JUNE-2021 TIME: 11:30:32

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*   SOIL PRESSURES FOR   *
* CANTILEVER WALL DESIGN *
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

				<------NET------>			
	NET	<---LEFTSIDE--->		(SOIL + WATER)		<--RIGHTSIDE--->	
ELEV.	WATER	PASSIVE	ACTIVE	ACTIVE	PASSIVE	ACTIVE	PASSIVE
(FT)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)
19.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.8	0.0	0.0	0.0	16.7	215.3	16.7	215.3
14.3	0.0	0.0	0.0	33.5	430.6	33.5	430.6
13.8	0.0	0.0	0.0	50.2	645.8	50.2	645.8
13.3	-32.0	0.0	0.0	34.9	829.1	66.9	861.1
12.3	-96.0	0.0	0.0	4.4	1195.7	100.4	1291.7
11.3	-160.0	0.0	0.0	-26.2	1562.2	133.8	1722.2
10.5	-211.2	0.0	0.0	-50.6	1855.5	160.6	2066.7
10.3	-224.0	42.0	3.3	-98.7	1925.5	167.3	2152.8
9.5	-275.2	210.1	16.3	-291.3	2205.7	194.0	2497.2
9.3	-288.0	252.1	19.6	-339.4	2275.7	200.7	2583.3
8.3	-352.0	462.2	35.9	-580.0	2625.9	234.2	3013.9
7.3	-416.0	672.4	52.2	-820.7	2976.2	267.7	3444.4
6.3	-480.0	882.5	68.6	-1061.4	3326.4	301.1	3875.0
6.0	-499.2	945.5	73.5	-1135.3	3408.3	309.3	3981.0
5.3	-499.2	1092.6	84.9	-1269.2	3567.1	322.6	4151.2
4.3	-499.2	1302.7	101.2	-1463.0	3760.9	338.9	4361.3
3.3	-499.2	1512.8	117.6	-1656.8	3954.7	355.2	4571.4
2.3	-499.2	1722.9	133.9	-1850.5	4148.5	371.6	4781.5
1.3	-499.2	1933.0	150.2	-2044.3	4342.2	387.9	4991.7
0.3	-499.2	2143.1	166.5	-2238.1	4536.0	404.2	5201.8
-0.7	-499.2	2353.2	182.9	-2431.9	4729.8	420.5	5411.9
-1.7	-499.2	2563.3	199.2	-2625.7	4923.6	436.9	5622.0
-2.5	-499.2	906.1	172.0	-1120.6	1009.8	284.7	1681.0
-2.7	-499.2	811.9	178.2	-1020.1	1013.8	291.0	1691.2
-3.7	-499.2	2594.7	259.2	-2565.3	4533.7	528.6	5292.1
-4.7	-499.2	2749.6	274.6	-2704.8	4673.2	544.1	5447.0
-5.7	-499.2	2904.5	290.1	-2844.2	4812.6	559.5	5601.9
-6.7	-499.2	3059.5	305.6	-2983.6	4952.1	575.0	5756.8
-7.7	-499.2	3214.4	321.1	-3123.1	5091.5	590.5	5911.8
-8.7	-499.2	3369.3	336.5	-3262.5	5230.9	606.0	6066.7
-9.7	-499.2	3524.2	352.0	-3402.0	5370.4	621.4	6221.6
-10.7	-499.2	3679.1	367.5	-3541.4	5509.8	636.9	6376.5

-11.7	-499.2	3834.0	383.0	-3680.9	5649.3	652.4	6531.4
-12.7	-499.2	3989.0	398.4	-3820.3	5788.7	667.9	6686.3
-13.7	-499.2	4143.9	413.9	-3959.7	5928.2	683.3	6841.3
-14.7	-499.2	4298.8	429.4	-4099.2	6067.6	698.8	6996.2
-15.7	-499.2	4453.7	444.9	-4238.6	6207.0	714.3	7151.1
-16.7	-499.2	4608.6	460.3	-4378.1	6346.5	729.8	7306.0
-17.7	-499.2	4763.6	475.8	-4517.5	6485.9	745.2	7460.9
-18.7	-499.2	4918.5	491.3	-4657.0	6625.4	760.7	7615.9
-19.7	-499.2	5073.4	506.8	-4796.4	6764.8	776.2	7770.8

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 1-JUNE-2021 TIME: 11:30:33

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***************************
*  SUMMARY OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
***************************
```

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

```
WALL BOTTOM ELEV. (FT)     :        8.53
      PENETRATION (FT)     :        1.97

MAX. BEND. MOMENT (LB-FT)  :  2.7017E+02
      AT ELEVATION (FT)    :       10.08

MAX. SCALED DEFL. (LB-IN^3):  1.2640E+07
      AT ELEVATION (FT)    :       19.30
```

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 1-JUNE-2021 TIME: 11:30:33

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****************************
* COMPLETE OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
****************************
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
19.30	0.0000E+00	0.	1.2640E+07	0.00
18.30	-6.8212E-13	0.	1.1146E+07	0.00
17.30	-6.8212E-13	0.	9.6524E+06	0.00
16.30	-6.8212E-13	0.	8.1586E+06	0.00
15.30	-6.8212E-13	0.	6.6648E+06	0.00
14.80+	6.9701E-01	4.	5.9179E+06	16.73
14.80-	6.9701E-01	10.	5.9179E+06	16.73
14.30	8.6211E+00	23.	5.1716E+06	33.46
13.80	2.4909E+01	44.	4.4294E+06	50.18
13.30	5.2410E+01	65.	3.6984E+06	34.91
12.30	1.2978E+02	85.	2.3208E+06	4.37
11.30	2.1152E+02	74.	1.1680E+06	-26.17
10.50	2.5953E+02	43.	5.0075E+05	-50.61
10.30	2.6680E+02	28.	3.7695E+05	-98.74
9.50	2.3715E+02	-128.	6.5984E+04	-291.26
9.30	2.0542E+02	-191.	3.1743E+04	-339.39
8.87	8.9591E+01	-358.	1.8591E+03	-442.30
8.53	0.0000E+00	0.	0.0000E+00	2544.79

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

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               <-------------SOIL PRESSURES-------------->
      WATER    <----LEFTSIDE----->     <---RIGHTSIDE---->
```

ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
19.30	0.	0.	0.	0.	0.
18.30	0.	0.	0.	0.	0.
17.30	0.	0.	0.	0.	0.
16.30	0.	0.	0.	0.	0.
15.30	0.	0.	0.	0.	0.
14.80	0.	0.	0.	17.	215.
14.30	0.	0.	0.	33.	431.
13.80	0.	0.	0.	50.	646.
13.30	-32.	0.	0.	67.	861.
12.30	-96.	0.	0.	100.	1292.
11.30	-160.	0.	0.	134.	1722.
10.50	-211.	0.	0.	161.	2067.
10.30	-224.	42.	3.	167.	2153.
9.50	-275.	210.	16.	194.	2497.
9.30	-288.	252.	20.	201.	2583.
8.87	-315.	342.	27.	215.	2767.
8.53	-337.	462.	36.	234.	3014.
7.30	-416.	672.	52.	268.	3444.

WP20~WP21: EARTHQUAKE LOADING: Mmax, Smax and Deflection for Structural Design

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:27:11

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*  INPUT DATA  *
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I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--CONTROL
CANTILEVER WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

III.--WALL DATA
ELEVATION AT TOP OF WALL = 19.30 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	19.30

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.50

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
155.50	155.50	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
143.10	143.10	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
149.28	149.28	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
133.11	133.11	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
149.28	149.28	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
186.60	186.60	45.00	8000.00	15.00	4000.00			DEF	DEF

V.B.--LEFTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH- ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH- ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
94.50	94.50	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
86.94	86.94	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
90.72	90.72	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
80.89	80.89	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
90.72	90.72	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
113.40	113.40	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 3.28 (FT)
LEFTSIDE ELEVATION = -3.77 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

VII.A.--VERTICAL LINE LOADS
NONE

VII.B.--VERTICAL UNIFORM LOADS
NONE

VII.C.--VERTICAL STRIP LOADS

VII.C.1.--RIGHTSIDE

<-DIST. FROM WALL-> START (FT)	END (FT)	STRIP LOAD (PSF)
0.00	60.00	250.00

VII.C.2.--LEFTSIDE
NONE

VII.D.--VERTICAL RAMP LOADS
NONE

VII.E.--VERTICAL TRIANGULAR LOADS
NONE

VII.F.--VERTICAL VARIABLE LOADS
NONE

VIII.--HORIZONTAL LOADS
NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:27:15

****
* SOIL PRESSURES FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

	NET	<---LEFTSIDE--->		<------NET------> (SOIL + WATER)		<--RIGHTSIDE--->	
ELEV. (FT)	WATER (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
19.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.3	0.0	0.0	0.0	108.2	2058.2	108.2	2058.2
17.3	0.0	0.0	0.0	149.7	2847.5	149.7	2847.5
16.3	0.0	0.0	0.0	191.2	3636.8	191.2	3636.8
15.3	0.0	0.0	0.0	232.7	4426.1	232.7	4426.1
14.3	0.0	0.0	0.0	274.2	5215.3	274.2	5215.3
13.3	0.0	0.0	0.0	315.8	6004.6	315.8	6004.6
12.3	0.0	0.0	0.0	357.3	6793.9	357.3	6793.9
11.3	0.0	0.0	0.0	398.8	7583.2	398.8	7583.2
10.5	0.0	0.0	0.0	432.0	8214.6	432.0	8214.6
10.3	0.0	95.9	5.0	344.3	8367.4	440.3	8372.5
9.5	0.0	472.9	24.9	0.0	8967.9	472.9	8992.7
9.5	0.0	479.7	25.2	-6.2	8978.7	473.5	9003.9
9.3	0.0	575.6	30.3	-93.8	9131.5	481.8	9161.8
8.3	0.0	1055.3	55.5	-532.0	9895.5	523.3	9951.0
7.3	0.0	1534.9	80.7	-970.1	10659.6	564.8	10740.3
6.3	0.0	2014.6	105.9	-1408.3	11423.7	606.3	11529.6
5.3	0.0	2494.2	131.2	-1846.4	12187.7	647.8	12318.9
4.3	0.0	2973.9	156.4	-2284.6	12951.9	689.3	13108.3

3.3	0.0	3453.6	181.6	-2723.8	13696.9	729.8	13878.5
3.3	0.0	3463.1	182.1	-2732.7	13709.0	730.5	13891.1
2.3	62.7	3933.2	206.8	-3114.9	14224.4	755.6	14368.5
1.3	126.7	4412.9	232.0	-3506.2	14727.5	780.0	14832.8
0.3	190.7	4892.5	257.3	-3897.4	15230.7	804.4	15297.2
-0.7	254.7	5465.2	283.1	-4377.8	16197.7	832.6	16226.0
-1.7	318.7	5087.5	302.3	-3948.7	12395.5	820.1	12379.1
-2.5	369.9	4327.7	334.9	-3104.2	7961.8	853.6	7926.8
-2.7	382.7	4501.2	350.1	-3226.9	8901.7	891.6	8869.0
-3.7	446.7	5745.7	402.4	-4280.7	14593.3	1018.3	14548.9
-3.8	451.2	5760.6	403.5	-4289.7	14604.9	1019.7	14557.2
-4.7	451.2	5875.3	411.5	-4382.2	14914.6	1041.9	14874.9
-5.7	451.2	5974.1	418.5	-4457.1	15249.3	1065.9	15216.5
-6.7	451.2	6073.2	425.4	-4532.2	15584.0	1089.8	15558.2
-7.7	451.2	6172.3	432.3	-4607.3	15918.7	1113.7	15899.8
-8.7	451.2	6271.3	439.3	-4682.5	16253.4	1137.7	16241.5
-9.7	451.2	6370.4	446.2	-4757.6	16588.1	1161.6	16583.1
-10.7	451.2	6469.5	453.2	-4832.8	16922.8	1185.5	16924.7
-11.7	451.2	6568.6	460.1	-4907.9	17269.6	1209.4	17278.5
-12.7	451.2	6667.7	467.0	-4983.1	17531.1	1233.4	17547.0
-13.7	451.2	6766.7	474.0	-5058.2	17456.3	1257.3	17479.1
-14.7	451.2	6865.8	480.9	-5133.4	17263.8	1281.2	17293.5
-15.7	451.2	6964.9	487.9	-5208.5	17419.4	1305.2	17456.1
-16.7	451.2	7064.0	494.8	-5283.7	17778.0	1329.1	17821.6
-17.7	451.2	7163.1	501.7	-5358.8	18112.7	1353.0	18163.2
-18.7	451.2	7262.1	508.7	-5434.0	18447.4	1377.0	18504.9
-19.7	451.2	7160.3	513.3	-5315.6	18146.2	1393.5	18208.3

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:27:16

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****************************
*  SUMMARY OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
****************************
```

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

```
WALL BOTTOM ELEV. (FT)     :        2.01
      PENETRATION (FT)     :        8.49

MAX. BEND. MOMENT (LB-FT)  :  1.4495E+04
      AT ELEVATION (FT)    :        6.22

MAX. SCALED DEFL. (LB-IN^3):  2.1191E+09
      AT ELEVATION (FT)    :       19.30
```

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:27:16

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****************************
* COMPLETE OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
****************************
```

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
19.30	0.0000E+00	0.	2.1191E+09	0.00
18.30	1.8038E+01	54.	1.9386E+09	108.23
17.30	1.3319E+02	183.	1.7582E+09	149.74
16.30	3.9807E+02	354.	1.5780E+09	191.24
15.30	8.5419E+02	566.	1.3985E+09	232.74
14.30	1.5431E+03	819.	1.2205E+09	274.25
13.30	2.5062E+03	1114.	1.0453E+09	315.75
12.30	3.7850E+03	1451.	8.7437E+08	357.26
11.30	5.4212E+03	1829.	7.1006E+08	398.76
10.50	7.0152E+03	2161.	5.8525E+08	431.96

10.30	7.4554E+03	2239.	5.5519E+08	344.33
9.51	9.2854E+03	2374.	4.4235E+08	0.00
9.50	9.3190E+03	2374.	4.4041E+08	-6.19
9.30	9.7930E+03	2364.	4.1324E+08	-93.82
8.30	1.2037E+04	2051.	2.8820E+08	-531.98
7.30	1.3749E+04	1300.	1.8389E+08	-970.13
6.30	1.4490E+04	111.	1.0319E+08	-1408.29
5.30	1.3824E+04	-1517.	4.7333E+07	-1846.45
4.30	1.1311E+04	-3582.	1.5095E+07	-2284.60
3.30	6.5130E+03	-6086.	2.0725E+06	-2723.75
3.28	6.3907E+03	-6141.	1.9581E+06	-2732.68
3.14	5.4990E+03	-6530.	1.2730E+06	-2787.59
2.30	5.3646E+02	-3511.	6.7111E+03	9982.21
2.01	0.0000E+00	0.	0.0000E+00	14369.43

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES--------------		-------------->	
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
19.30	0.	0.	0.	0.	0.
18.30	0.	0.	0.	108.	2058.
17.30	0.	0.	0.	150.	2848.
16.30	0.	0.	0.	191.	3637.
15.30	0.	0.	0.	233.	4426.
14.30	0.	0.	0.	274.	5215.
13.30	0.	0.	0.	316.	6005.
12.30	0.	0.	0.	357.	6794.
11.30	0.	0.	0.	399.	7583.
10.50	0.	0.	0.	432.	8215.
10.30	0.	96.	5.	440.	8372.
9.51	0.	473.	25.	473.	8993.
9.50	0.	480.	25.	473.	9004.
9.30	0.	576.	30.	482.	9162.
8.30	0.	1055.	55.	523.	9951.
7.30	0.	1535.	81.	565.	10740.
6.30	0.	2015.	106.	606.	11530.
5.30	0.	2494.	131.	648.	12319.
4.30	0.	2974.	156.	689.	13108.
3.30	0.	3454.	182.	730.	13879.
3.28	0.	3463.	182.	730.	13891.
3.14	9.	3531.	186.	734.	13960.
2.30	63.	3933.	207.	756.	14368.
2.01	81.	4413.	232.	780.	14833.

0.30	191.	4893.	257.	804.	15297.

WP20~WP21: EARTHQUAKE LOADING: DETERMINATION OF PENETRATION

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:30:29

****
* INPUT DATA *
****

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--CONTROL

CANTILEVER WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.10

III.--WALL DATA

ELEVATION AT TOP OF WALL = 19.30 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	19.30

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.50

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE

LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
155.50	155.50	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
143.10	143.10	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
149.28	149.28	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
133.11	133.11	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
149.28	149.28	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
186.60	186.60	45.00	8000.00	15.00	4000.00			DEF	DEF

V.B.--LEFTSIDE

LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH- ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH- ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
94.50	94.50	33.20	0.00	10.00	0.00	-2.50	0.00	DEF	DEF
86.94	86.94	30.00	0.00	10.00	0.00	-21.50	0.00	DEF	DEF
90.72	90.72	31.80	0.00	10.00	0.00	-34.50	0.00	DEF	DEF
80.89	80.89	0.00	600.00	0.00	500.00	-38.50	0.00	DEF	DEF
90.72	90.72	30.90	0.00	10.00	0.00	-43.00	0.00	DEF	DEF
113.40	113.40	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 3.28 (FT)
LEFTSIDE ELEVATION = -3.77 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

VII.A.--VERTICAL LINE LOADS

NONE

VII.B.--VERTICAL UNIFORM LOADS

NONE

VII.C.--VERTICAL STRIP LOADS

VII.C.1.--RIGHTSIDE

<-DIST. FROM WALL-> START (FT)	END (FT)	STRIP LOAD (PSF)
0.00	60.00	250.00

VII.C.2.--LEFTSIDE

NONE

VII.D.--VERTICAL RAMP LOADS

NONE

VII.E.--VERTICAL TRIANGULAR LOADS

NONE

VII.F.--VERTICAL VARIABLE LOADS

NONE

VIII.--HORIZONTAL LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:30:31

****
* SOIL PRESSURES FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

	NET	<---LEFTSIDE--->		<------NET------> (SOIL + WATER)		<--RIGHTSIDE--->	
ELEV. (FT)	WATER (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
19.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.3	0.0	0.0	0.0	108.2	1746.1	108.2	1746.1
17.3	0.0	0.0	0.0	149.7	2415.6	149.7	2415.6
16.3	0.0	0.0	0.0	191.2	3085.2	191.2	3085.2
15.3	0.0	0.0	0.0	232.7	3754.8	232.7	3754.8
14.3	0.0	0.0	0.0	274.2	4424.3	274.2	4424.3
13.3	0.0	0.0	0.0	315.8	5093.9	315.8	5093.9
12.3	0.0	0.0	0.0	357.3	5763.5	357.3	5763.5
11.3	0.0	0.0	0.0	398.8	6433.1	398.8	6433.1
10.5	0.0	0.0	0.0	432.0	6968.7	432.0	6968.7
10.3	0.0	81.4	5.0	358.9	7097.6	440.3	7102.6
9.5	0.0	406.9	25.2	66.6	7613.1	473.5	7638.3
9.3	0.0	481.0	29.8	0.0	7730.4	481.0	7760.3
9.3	0.0	488.3	30.3	-6.5	7741.9	481.8	7772.2
8.3	0.0	895.2	55.5	-371.9	8386.3	523.3	8441.8
7.3	0.0	1302.1	80.7	-737.3	9030.6	564.8	9111.4
6.3	0.0	1709.0	105.9	-1102.7	9675.0	606.3	9780.9
5.3	0.0	2115.9	131.2	-1468.2	10319.3	647.8	10450.5
4.3	0.0	2522.8	156.4	-1833.6	10963.8	689.3	11120.2

3.3	0.0	2929.8	181.6	-2200.0	11592.0	729.8	11773.6
3.3	0.0	2937.9	182.1	-2207.4	11602.2	730.5	11784.3
2.3	62.7	3336.7	206.8	-2518.4	12045.1	755.6	12189.2
1.3	126.7	3743.6	232.0	-2836.9	12477.8	780.0	12583.2
0.3	190.7	4150.5	257.3	-3155.4	12910.6	804.4	12977.1
-0.7	254.7	4618.4	283.1	-3531.0	13645.4	832.6	13673.8
-1.7	318.7	4464.4	302.3	-3325.6	11277.9	820.1	11261.5
-2.5	369.9	3997.3	334.9	-2773.7	8352.4	853.6	8317.3
-2.7	382.7	4107.6	350.1	-2833.3	8924.6	891.6	8892.0
-3.7	446.7	4953.4	402.4	-3488.3	12585.0	1018.3	12540.6
-3.8	451.2	4966.9	403.5	-3496.0	12599.2	1019.7	12551.5
-4.7	451.2	5065.8	411.5	-3572.7	12865.1	1041.9	12825.4
-5.7	451.2	5151.0	418.5	-3633.9	13152.7	1065.9	13120.0
-6.7	451.2	5236.4	425.4	-3695.4	13440.3	1089.8	13414.5
-7.7	451.2	5321.8	432.3	-3756.9	13728.0	1113.7	13709.1
-8.7	451.2	5407.3	439.3	-3818.4	14015.6	1137.7	14003.7
-9.7	451.2	5492.7	446.2	-3879.9	14303.2	1161.6	14298.2
-10.7	451.2	5578.1	453.2	-3941.4	14590.8	1185.5	14592.8
-11.7	451.2	5663.5	460.1	-4002.9	14878.5	1209.4	14887.4
-12.7	451.2	5749.0	467.0	-4064.4	15166.1	1233.4	15181.9
-13.7	451.2	5834.4	474.0	-4125.9	15472.4	1257.3	15495.2
-14.7	451.2	5919.8	480.9	-4187.4	15623.1	1281.2	15652.8
-15.7	451.2	6005.3	487.9	-4248.9	15476.8	1305.2	15513.5
-16.7	451.2	6090.7	494.8	-4310.4	15394.2	1329.1	15437.8
-17.7	451.2	6176.1	501.7	-4371.9	15602.3	1353.0	15652.8
-18.7	451.2	6261.5	508.7	-4433.4	15902.2	1377.0	15959.7
-19.7	451.2	6215.0	513.3	-4370.4	15772.3	1393.5	15834.4

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:30:32

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****************************
*  SUMMARY OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
****************************
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY FIXED SURFACE WEDGE METHOD.

WALL BOTTOM ELEV. (FT) : 1.09
PENETRATION (FT) : 9.41

MAX. BEND. MOMENT (LB-FT) : 1.5629E+04
AT ELEVATION (FT) : 5.68

MAX. SCALED DEFL. (LB-IN^3): 2.5509E+09
AT ELEVATION (FT) : 19.30

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF
ELLASTICITY IN PSI TIMES PILE MOMENT
OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
IN INCHES.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS
DATE: 25-FEBRUARY-2021 TIME: 12:30:32

****
* COMPLETE OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP18-WP19

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
19.30	0.0000E+00	0.	2.5509E+09	0.00
18.30	1.8038E+01	54.	2.3428E+09	108.23
17.30	1.3319E+02	183.	2.1348E+09	149.74
16.30	3.9807E+02	354.	1.9270E+09	191.24
15.30	8.5419E+02	566.	1.7199E+09	232.74
14.30	1.5431E+03	819.	1.5144E+09	274.25
13.30	2.5062E+03	1114.	1.3115E+09	315.75
12.30	3.7850E+03	1451.	1.1130E+09	357.26
11.30	5.4212E+03	1829.	9.2112E+08	398.76
10.50	7.0152E+03	2161.	7.7423E+08	431.96

10.30	7.4555E+03	2240.	7.3865E+08	358.88
9.50	9.3311E+03	2410.	6.0180E+08	66.56
9.32	9.7708E+03	2416.	5.7201E+08	0.00
9.30	9.8140E+03	2416.	5.6912E+08	-6.53
8.30	1.2166E+04	2227.	4.1654E+08	-371.93
7.30	1.4146E+04	1672.	2.8493E+08	-737.34
6.30	1.5389E+04	752.	1.7766E+08	-1102.75
5.30	1.5529E+04	-533.	9.6824E+07	-1468.15
4.30	1.4200E+04	-2184.	4.2609E+07	-1833.55
3.30	1.1039E+04	-4201.	1.2668E+07	-2199.96
3.28	1.0954E+04	-4245.	1.2285E+07	-2207.44
2.36	6.0975E+03	-6401.	1.7968E+06	-2498.16
2.30	5.6848E+03	-6536.	1.4856E+06	-1742.45
1.30	2.5289E+02	-2353.	1.6100E+03	10108.34
1.09	0.0000E+00	0.	0.0000E+00	12567.63

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES-------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
19.30	0.	0.	0.	0.	0.
18.30	0.	0.	0.	108.	1746.
17.30	0.	0.	0.	150.	2416.
16.30	0.	0.	0.	191.	3085.
15.30	0.	0.	0.	233.	3755.
14.30	0.	0.	0.	274.	4424.
13.30	0.	0.	0.	316.	5094.
12.30	0.	0.	0.	357.	5763.
11.30	0.	0.	0.	399.	6433.
10.50	0.	0.	0.	432.	6969.
10.30	0.	81.	5.	440.	7103.
9.50	0.	407.	25.	473.	7638.
9.32	0.	481.	30.	481.	7760.
9.30	0.	488.	30.	482.	7772.
8.30	0.	895.	55.	523.	8442.
7.30	0.	1302.	81.	565.	9111.
6.30	0.	1709.	106.	606.	9781.
5.30	0.	2116.	131.	648.	10451.
4.30	0.	2523.	156.	689.	11120.
3.30	0.	2930.	182.	730.	11774.
3.28	0.	2938.	182.	730.	11784.
2.36	59.	3311.	205.	754.	12163.
2.30	63.	3337.	207.	756.	12189.

1.30	127.	3744.	232.	780.	12583.
1.09	140.	4150.	257.	804.	12977.
-0.70	255.	4618.	283.	833.	13674.

APPENDIX K-3

SHEET PILE WALL ANALYSES
K-3: SHEET PILE DESIGN FOR WP21-WP26

Oweis ENGINEERING INC.
INNOVATIVE GEOTECHNICAL ENGINEERING SOLUTIONS

APPENDIX K3: SHEET PILE DESIGN WP21~WP26

Appendix K3 presents the detailed calculation of sheet pile design by software CWALSHT (US Army Corps of Engineers) between working points WP21 and WP26.

SOIL PARAMTERS

Table 1: Generalized Soil Profile for Foundation Design between Sta. 16+00 and Sta.19+50 (WP21~WP25) Based on Borings B-4, B-11 and B-5.

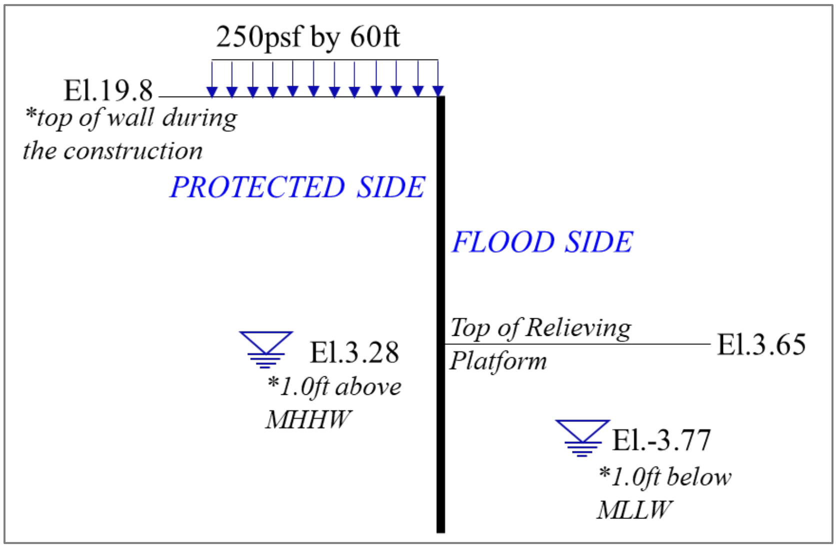
Elevation (ft)	Soil Type	Typical Field SPT Range*		Recommended Key Soil/Rock Parameters
		Field N	N_{60}	
10.5 ~ 3.0	Fill (medium dense sand, trace silt)	8~15	10~19	ϒ=122pcf, φ=30.0~32.6° (Ave=31.2°)
3.0 ~ -7.0	Fill (medium dense sand, trace silt)	12~20	15~26	ϒ'=62.6pcf, φ=31.5~34.5°(Ave=32.9°)
-7.0 ~ -37.0	Fill (loose to medium dense fine sand, trace silt)	7~11	9~14	ϒ'=55.6pcf, φ=29.8~31.2° Ave=30.3°)
-37.0 ~ -44.5	Till (gravel)?	15	19	ϒ'=62.6pcf, φ=32.6°
<-44.5	Bedrock-Schist	-	-	ϒ'=87.6pcf, Strain Factor=0.0001, q_u=5000psi, E=1.5E+6psi, RQD=55%

*The typical field SPT range is not the actual range of field SPT values, but it is determined based on engineer's judgement.

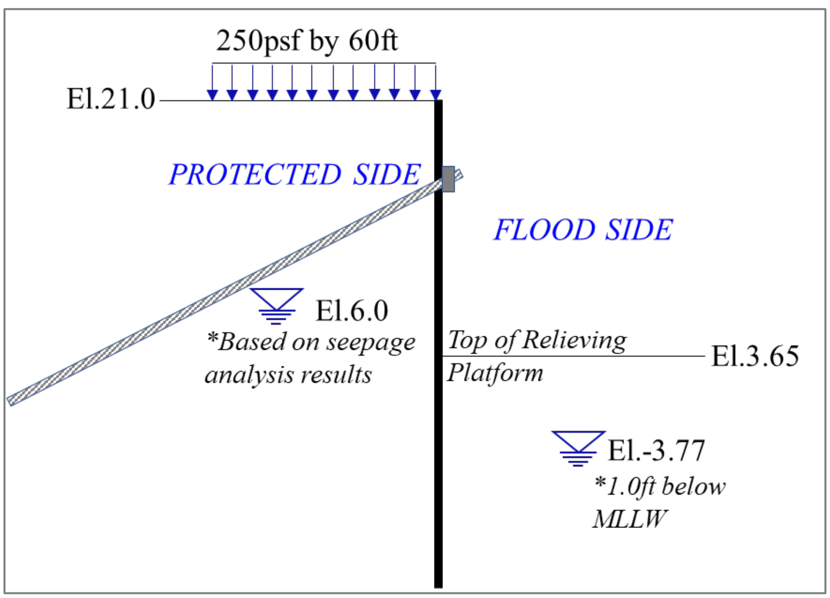
SOFTWARES

CWALSHT (US Army Corps of Engineers) and Shoring Suite.

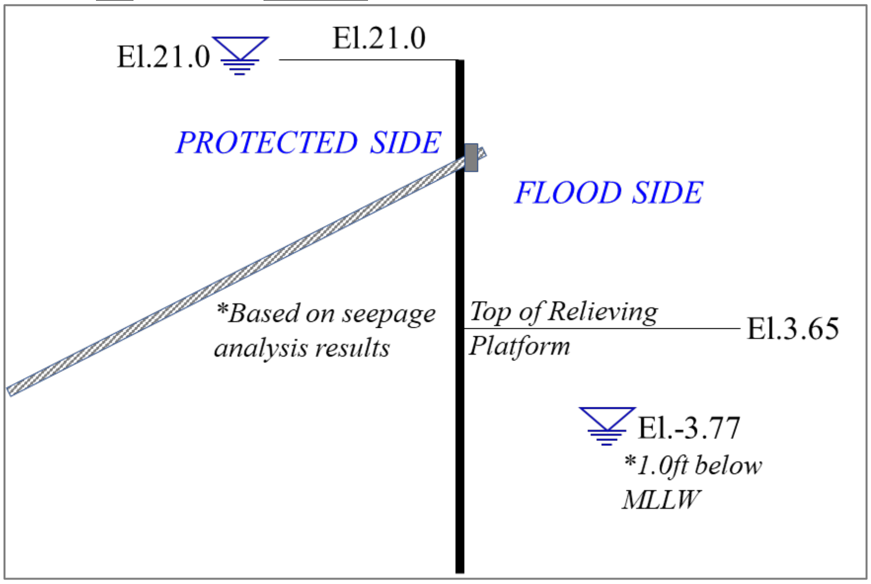
CONTROLLING LOAD CASES:



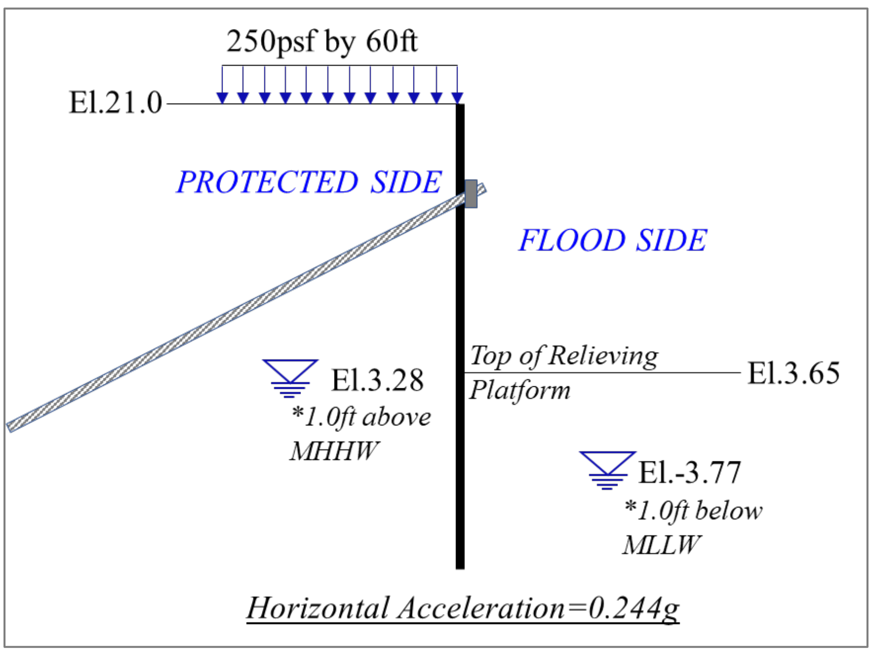
(a) Construction Stage (Cantilever)



(b) Usual Loading (with Tieback at El. 15.5)



(c) Unusual Loading (with Tieback at El. 15.5)



(d) Earthquake Loading (with Tieback at El. 15.5)

Figure 1: Controlling Load Cases for Floodwall between WP21 and WP26.

OTHER PARAMETERS/ASSUMPTIONS

- **For Determination of Depth of Penetration**
  1. Wall friction: 10 degree (Less than 14 degree which is described in Table 3-3 of USACE *EM 1110-2-2504*: Design of Sheet Pile Walls)
  2. Safety factor applied to the active earth pressure=1.0
  3. Safety factor applied to the passive earth pressure=1.25 for the Construction Stage, 1.5 for Usual Loading, 1.25 for Unusual Loading and 1.1 for Earthquake Loading (Table 5-1 of USACE *EM 1110-2-2504*: Design of Sheet Pile Walls)
- **For Estimation of the Maximum Moment and Shear for Structural Design**
  1. Wall friction: 10 degree (about 1/3 of soil friction angle)
  2. Safety factor applied to the active earth pressure=1.0
  3. Safety factor applied to the passive earth pressure=1.0

SUMMARY OF RESULTS

LOAD CASE	MAXIMUM UNFACTORED MOMENT[1]	MAXIMUM UNFACTORED SHEAR[1]	DESIGN ANCHOR FORCE AT EL.15.5	SCALED DEFLECTION AT TOP OF SHEET PILE[2]	REQUIRED PILE TIP ELEVATION[3]
a-Construction Stage	60.6kips-ft./ft.	13.4kips	N/A	2.49×10^{10} (lb-in^3)	-14.0
b-Usual Loading	14.4kips-ft./ft.	3.5kips	4.34kips/ft	6.9×10^{8} (lb-in^3)	-8.5
c-Unusual Loading	45.4kips-ft./ft.	7.4kips	9.7kips/ft	2.27×10^{9} (lb-in^3)	-12.6
d-Earthquake Loading	19.6kips-ft./ft.	4.4kips	5.41kips/ft	1.10×10^{9} (lb-in^3)	-11.9

Note: [1] These unfactored moment and shear provided here are for structural design and they are calculated using a factor of safety of 1.0 for both active and passive pressures in accordance with Design of Sheet Pile Wall (EM 1110-2-2504) by U.S. Army Corps of Engineers. [2] Divide scaled deflection by the modulus of elasticity in psi times pile moment of inertia in in^4 to obtain deflection in inches. For example, the deflection at top the sheet pile during the construction stage with sheet pile NZ26 is: $2.49\times10^{10}/(29\times10^{6}\times419.9)=2.05$ inches. [3] The required pile tip elevation was determined in accordance with Evaluation of I-Walls by U.S, Army Corps of Engineers (ETL 1110-2-575) and FS=1.25, 1.5, 1.25 and 1.1 were applied to the passive pressures for construction stage, usual loading, unusual loading and earthquake loading, respectively according to Design of Sheet Pile Walls (EM 1110-2-2504) by U.S. Army Corps of Engineers.

DETTAILED OUTPUT

Please see attachments for the detailed outputs.

WP21~WP26: CONSTUCTION STAGE: Mmax, Smax and Deflection for Structural Design

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:47:23

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*  INPUT DATA  *
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-CONSTRUCTION STAGE

II.--CONTROL

CANTILEVER WALL DESIGN

FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00

FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

III.--WALL DATA

ELEVATION AT TOP OF WALL = 19.80 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	19.80

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	3.65

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE

LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	<--BOTTOM--> SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
122.00	120.00	31.20	0.00	10.00	0.00	3.00	0.00	DEF	DEF
125.00	123.00	32.90	0.00	10.00	0.00	-7.00	0.00	DEF	DEF
118.00	115.00	30.30	0.00	10.00	0.00	-37.00	0.00	DEF	DEF
125.00	122.00	32.60	0.00	10.00	0.00	-44.50	0.00	DEF	DEF
150.00	145.00	45.00	8000.00	15.00	4000.00			DEF	DEF

V.B.--LEFTSIDE

LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
122.00	120.00	31.20	0.00	10.00	0.00	3.00	0.00	DEF	DEF
125.00	121.00	32.90	0.00	10.00	0.00	-7.00	0.00	DEF	DEF
118.00	113.00	30.30	0.00	10.00	0.00	-37.00	0.00	DEF	DEF
125.00	123.00	32.60	0.00	10.00	0.00	-44.50	0.00	DEF	DEF
150.00	145.00	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 3.28 (FT)
LEFTSIDE ELEVATION = -3.77 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

VII.A.--VERTICAL LINE LOADS

NONE

VII.B.--VERTICAL UNIFORM LOADS

NONE

VII.C.--VERTICAL STRIP LOADS

VII.C.1.--RIGHTSIDE

<-DIST. FROM WALL-> START (FT)	END (FT)	STRIP LOAD (PSF)
0.00	60.00	250.00

VII.C.2.--LEFTSIDE

NONE

VII.D.--VERTICAL RAMP LOADS

NONE

VII.E.--VERTICAL TRIANGULAR LOADS

NONE

VII.F.--VERTICAL VARIABLE LOADS

NONE

VIII.--HORIZONTAL LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:47:37

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*************************
*   SOIL PRESSURES FOR  *
* CANTILEVER WALL DESIGN *
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I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP19-23-CONSTRUCTION STAGE

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

	NET	<---LEFTSIDE--->		<------NET------> (SOIL + WATER)		<--RIGHTSIDE--->	
ELEV. (FT)	WATER (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
19.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.8	0.0	0.0	0.0	107.2	1599.7	107.2	1599.7
17.8	0.0	0.0	0.0	142.0	2118.5	142.0	2118.5
16.8	0.0	0.0	0.0	176.8	2637.3	176.8	2637.3
15.8	0.0	0.0	0.0	211.6	3156.1	211.6	3156.1
14.8	0.0	0.0	0.0	246.4	3675.0	246.4	3675.0
13.8	0.0	0.0	0.0	281.2	4193.8	281.2	4193.8
12.8	0.0	0.0	0.0	315.9	4712.6	315.9	4712.6
11.8	0.0	0.0	0.0	350.7	5231.4	350.7	5231.4
10.8	0.0	0.0	0.0	385.5	5750.2	385.5	5750.2
9.8	0.0	0.0	0.0	420.3	6269.1	420.3	6269.1
8.8	0.0	0.0	0.0	455.1	6787.9	455.1	6787.9
7.8	0.0	0.0	0.0	489.8	7306.7	489.8	7306.7
6.8	0.0	0.0	0.0	524.6	7825.5	524.6	7825.5
5.8	0.0	0.0	0.0	559.4	8344.3	559.4	8344.3
4.8	0.0	0.0	0.0	594.2	8863.2	594.2	8863.2
3.8	0.0	0.0	0.0	629.0	9382.0	629.0	9382.0
3.7	0.0	0.0	0.0	634.2	9459.8	634.2	9459.8
3.3	0.0	192.0	12.9	453.7	9617.5	645.6	9630.4
3.0	17.9	364.4	21.8	388.7	15967.8	735.3	15971.6
2.8	30.7	485.9	27.8	237.0	14862.4	692.1	14859.5

2.7	40.3	566.2	32.6	89.1	10687.8	615.1	10680.1
2.5	52.0	670.1	38.6	0.0	10745.8	618.1	10732.4
1.8	94.7	1050.1	60.5	-326.3	10958.3	629.1	10924.0
0.8	158.7	1619.4	93.3	-815.1	11276.5	645.6	11211.0
-0.2	222.7	2188.7	126.0	-1303.8	11594.7	662.2	11498.0
-1.2	286.7	2758.0	158.8	-1792.6	11912.9	678.7	11785.0
-2.2	350.7	3327.3	191.6	-2281.4	12231.1	695.2	12072.0
-3.2	414.7	3896.6	224.4	-2770.1	12155.1	711.8	11964.7
-3.8	451.2	4186.5	241.1	-3014.1	11937.8	721.2	11727.7
-4.2	451.2	4344.5	250.2	-3165.0	11893.0	728.3	11692.0
-5.2	451.2	4631.5	266.7	-3435.5	12065.6	744.8	11881.1
-6.2	451.2	4918.5	283.3	-3706.0	12300.0	761.3	12132.0
-7.0	451.2	1094.2	256.2	-286.6	2803.6	356.4	2608.6
-7.2	451.2	1105.0	263.1	-297.7	2807.6	356.1	2619.4
-8.2	451.2	4798.2	347.7	-3470.0	11215.7	877.0	11112.2
-9.2	451.2	5021.8	363.9	-3677.4	11424.6	893.2	11337.3
-10.2	451.2	5245.3	380.1	-3884.7	11633.6	909.4	11562.5
-11.2	451.2	5468.9	396.3	-4092.1	11842.5	925.6	11787.6
-12.2	451.2	5692.5	412.5	-4299.4	12051.5	941.8	12012.8
-13.2	451.2	5916.0	428.7	-4506.8	12260.4	958.0	12237.9
-14.2	451.2	6139.6	444.9	-4714.1	12469.3	974.2	12463.0
-15.2	451.2	6363.1	461.1	-4921.5	12678.3	990.4	12688.2
-16.2	451.2	6586.7	477.3	-5128.9	12887.2	1006.6	12913.3
-17.2	451.2	6810.3	493.5	-5336.2	13096.2	1022.8	13138.5
-18.2	451.2	7033.8	509.7	-5543.6	13305.1	1039.0	13363.6
-19.2	451.2	7257.4	525.9	-5750.9	13508.3	1055.2	13583.0
-20.2	451.2	7480.9	542.1	-5958.3	13682.9	1071.4	13773.8
-21.2	451.2	7704.5	558.3	-6165.7	13863.3	1087.6	13970.4
-22.2	451.2	7928.1	574.5	-6373.0	14072.3	1103.8	14195.6
-23.2	451.2	8151.6	590.7	-6580.4	14281.2	1120.0	14420.7
-24.2	451.2	8375.2	606.9	-6787.7	14473.1	1136.2	14628.8
-25.2	451.2	8598.7	623.1	-6995.1	14628.1	1152.4	14800.0
-26.2	451.2	8822.3	639.3	-7202.4	14799.5	1168.6	14987.6
-27.2	451.2	9045.8	655.5	-7409.8	15006.8	1184.8	15211.1
-28.2	451.2	9269.4	671.7	-7617.2	15214.2	1201.0	15434.7
-29.2	451.2	9493.0	687.9	-7824.5	15421.6	1217.2	15658.3
-30.2	451.2	9716.5	704.1	-8031.9	15628.9	1233.4	15881.8
-31.2	451.2	9940.1	720.3	-8239.2	15836.3	1249.6	16105.4
-32.2	451.2	10163.6	736.5	-8446.6	16081.8	1265.8	16367.1
-33.2	451.2	10387.2	752.7	-8654.0	16341.4	1282.0	16642.9
-34.2	451.2	10610.8	768.9	-8861.3	16562.8	1298.2	16880.5
-35.2	451.2	10834.3	785.1	-9068.7	16770.2	1314.4	17104.1
-36.2	451.2	11057.9	801.3	-9276.0	16977.5	1330.6	17327.6
-37.0	451.2	42383.2	1384.3	-39157.4	88132.7	2774.6	89065.9
-37.2	451.2	43956.0	1399.8	-40686.6	91521.4	2818.3	92470.0
-38.2	451.2	12916.7	764.5	-11217.1	19757.8	1248.4	20071.1
-39.2	451.2	13199.4	781.2	-11483.1	20024.4	1265.1	20354.4
-40.2	451.2	13482.1	797.9	-11749.0	20290.9	1281.9	20637.7
-41.2	451.2	13764.7	814.7	-12015.0	20557.5	1298.6	20921.0
-42.2	451.2	14047.4	831.4	-12280.9	20824.1	1315.3	21204.3

-43.2	451.2	14330.1	848.1	-12546.8	21080.4	1332.1	21477.3
-44.2	451.2	14612.8	864.9	-12812.8	21317.1	1348.8	21730.7
-44.5+	451.2	14692.6	869.6	-14241.4	127781.3	0.0	131430.8
-44.5-	451.2	14692.6	869.6	-14241.4	127781.3	0.0	124968.6
-44.5	451.2	20151.9	712.3	-19700.7	131169.7	0.0	131430.8
-44.6+	451.2	182930.7	0.0	-109558.8	147175.9	0.0	146724.7
-44.6-	451.2	37089.4	0.0	-109558.8	147175.9	0.0	146724.7
-45.2	451.2	182930.7	0.0	-182479.5	278865.7	0.0	278414.5

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE FOR THIS ELEVATION.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:47:38

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****************************
*  SUMMARY OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-CONSTRUCTION STAGE

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

*****WARNING: STANDARD WEDGE SOLUTION DOES NOT EXIST AT ALL ELEVATIONS. SEE COMPLETE OUTPUT.

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WALL BOTTOM ELEV. (FT)     :      -10.03
      PENETRATION (FT)     :       13.68

MAX. BEND. MOMENT (LB-FT)  :  6.0557E+04
      AT ELEVATION (FT)    :       -2.52

MAX. SCALED DEFL. (LB-IN^3):  2.4889E+10
      AT ELEVATION (FT)    :       19.80
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NOTE: DIVIDE SCALED DEFLECTION MODULUS OF
ELLASTICITY IN PSI TIMES PILE MOMENT
OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
IN INCHES.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:47:38

****
* COMPLETE OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP19-23-CONSTRUCTION STAGE

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
19.80	0.0000E+00	0.	2.4889E+10	0.00
18.80	1.7874E+01	54.	2.3650E+10	107.24
17.80	1.3092E+02	178.	2.2412E+10	142.03
16.80	3.8599E+02	338.	2.1173E+10	176.81
15.80	8.1786E+02	532.	1.9936E+10	211.59
14.80	1.4613E+03	761.	1.8699E+10	246.37
13.80	2.3512E+03	1025.	1.7466E+10	281.16
12.80	3.5222E+03	1323.	1.6236E+10	315.94
11.80	5.0091E+03	1657.	1.5013E+10	350.72
10.80	6.8468E+03	2025.	1.3798E+10	385.50
9.80	9.0699E+03	2428.	1.2595E+10	420.28
8.80	1.1713E+04	2865.	1.1408E+10	455.07
7.80	1.4812E+04	3338.	1.0241E+10	489.85
6.80	1.8400E+04	3845.	9.0997E+09	524.63
5.80	2.2513E+04	4387.	7.9904E+09	559.41
4.80	2.7186E+04	4964.	6.9201E+09	594.20
3.80	3.2452E+04	5575.	5.8968E+09	628.98
3.65	3.3296E+04	5670.	5.7479E+09	634.19
3.28	3.5433E+04	5871.	5.3863E+09	453.67
3.00	3.7094E+04	5989.	5.1182E+09	388.75
2.80	3.8298E+04	6052.	4.9297E+09	236.95
2.65	3.9208E+04	6076.	4.7901E+09	89.15
2.47	4.0317E+04	6084.	4.6224E+09	0.00
1.80	4.4355E+04	5975.	4.0288E+09	-326.30

0.80	5.0086E+04	5405.	3.2045E+09	-815.07
-0.20	5.5002E+04	4345.	2.4667E+09	-1303.83
-1.20	5.8614E+04	2797.	1.8237E+09	-1792.59
-2.20	6.0433E+04	760.	1.2817E+09	-2281.36
-3.20	5.9971E+04	-1766.	8.4381E+08	-2770.12
-3.77	5.8502E+04	-3414.	6.4065E+08	-3014.12
-4.20	5.6750E+04	-4743.	5.0916E+08	-3165.02
-5.20	5.0380E+04	-8043.	2.7212E+08	-3435.49
-6.20	4.0574E+04	-11614.	1.2164E+08	-3705.96
-7.00	3.0462E+04	-13211.	5.2409E+07	-286.60
-7.20	2.7814E+04	-13269.	4.0813E+07	-297.72
-7.46	2.4310E+04	-13457.	2.8478E+07	-1130.73
-8.20	1.4411E+04	-12944.	7.9615E+06	2520.37
-9.20	3.5517E+03	-7948.	3.7448E+05	7471.60
-10.03	0.0000E+00	0.	0.0000E+00	11598.80

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES-------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
19.80	0.	0.	0.	0.	0.
18.80	0.	0.	0.	107.	1600.
17.80	0.	0.	0.	142.	2119.
16.80	0.	0.	0.	177.	2637.
15.80	0.	0.	0.	212.	3156.
14.80	0.	0.	0.	246.	3675.
13.80	0.	0.	0.	281.	4194.
12.80	0.	0.	0.	316.	4713.
11.80	0.	0.	0.	351.	5231.
10.80	0.	0.	0.	386.	5750.
9.80	0.	0.	0.	420.	6269.
8.80	0.	0.	0.	455.	6788.
7.80	0.	0.	0.	490.	7307.
6.80	0.	0.	0.	525.	7826.
5.80	0.	0.	0.	559.	8344.
4.80	0.	0.	0.	594.	8863.
3.80	0.	0.	0.	629.	9382.
3.65	0.	0.	0.	634.	9460.
3.28	0.	192.	13.	646.	9630.
3.00	18.	364.	22.	735.	15972.
2.80	31.	486.	28.	692.	14859.
2.65	40.	566.	33.	615.	10680.
2.47	52.	670.	39.	618.	10732.

1.80	95.	1050.	60.	629.	10924.
0.80	159.	1619.	93.	646.	11211.
-0.20	223.	2189.	126.	662.	11498.
-1.20	287.	2758.	159.	679.	11785.
-2.20	351.	3327.	192.	695.	12072.
-3.20	415.	3897.	224.	712.	11965.
-3.77	451.	4186.	241.	721.	11728.
-4.20	451.	4344.	250.	728.	11692.
-5.20	451.	4631.	267.	745.	11881.
-6.20	451.	4918.	283.	761.	12132.
-7.00	451.	1094.	256.	356.	2609.
-7.20	451.	1105.	263.	356.	2619.
-7.46	451.	2075.	285.	493.	4850.
-8.20	451.	4798.	348.	877.	11112.
-9.20	451.	5022.	364.	893.	11337.
-10.03	451.	5245.	380.	909.	11562.
-11.20	451.	5469.	396.	926.	11788.

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE AT THIS ELEVATION.

WP21~WP26: CONSTRUCTION STAGE: DETERMINATION OF PENETRATION

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:52:11

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*  INPUT DATA  *
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-CONSTRUCTION STAGE

II.--CONTROL

CANTILEVER WALL DESIGN

FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00

FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.25

III.--WALL DATA

ELEVATION AT TOP OF WALL = 19.80 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	19.80

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	3.65

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE

LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	<--BOTTOM--> SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	<-SAFETY-> <-FACTOR-> PASS.
122.00	120.00	31.20	0.00	10.00	0.00	3.00	0.00	DEF	DEF
125.00	123.00	32.90	0.00	10.00	0.00	-7.00	0.00	DEF	DEF
118.00	115.00	30.30	0.00	10.00	0.00	-37.00	0.00	DEF	DEF
125.00	122.00	32.60	0.00	10.00	0.00	-44.50	0.00	DEF	DEF
150.00	145.00	45.00	8000.00	15.00	4000.00			DEF	DEF

V.B.--LEFTSIDE

LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
122.00	120.00	31.20	0.00	10.00	0.00	3.00	0.00	DEF	DEF
125.00	121.00	32.90	0.00	10.00	0.00	-7.00	0.00	DEF	DEF
118.00	113.00	30.30	0.00	10.00	0.00	-37.00	0.00	DEF	DEF
125.00	123.00	32.60	0.00	10.00	0.00	-44.50	0.00	DEF	DEF
150.00	145.00	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA
UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 3.28 (FT)
LEFTSIDE ELEVATION = -3.77 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

VII.A.--VERTICAL LINE LOADS
NONE

VII.B.--VERTICAL UNIFORM LOADS
NONE

VII.C.--VERTICAL STRIP LOADS

VII.C.1.--RIGHTSIDE

<-DIST. FROM WALL-> START (FT)	END (FT)	STRIP LOAD (PSF)
0.00	60.00	250.00

VII.C.2.--LEFTSIDE
NONE

VII.D.--VERTICAL RAMP LOADS
NONE

VII.E.--VERTICAL TRIANGULAR LOADS
NONE

VII.F.--VERTICAL VARIABLE LOADS
NONE

VIII.--HORIZONTAL LOADS
NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:52:14

****
* SOIL PRESSURES FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP19-23-CONSTRUCTION STAGE

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

	NET	<---LEFTSIDE--->		<------NET------> (SOIL + WATER)		<--RIGHTSIDE--->	
ELEV. (FT)	WATER (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
19.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.8	0.0	0.0	0.0	107.2	1177.7	107.2	1177.7
17.8	0.0	0.0	0.0	142.0	1559.6	142.0	1559.6
16.8	0.0	0.0	0.0	176.8	1941.6	176.8	1941.6
15.8	0.0	0.0	0.0	211.6	2323.5	211.6	2323.5
14.8	0.0	0.0	0.0	246.4	2705.5	246.4	2705.5
13.8	0.0	0.0	0.0	281.2	3087.4	281.2	3087.4
12.8	0.0	0.0	0.0	315.9	3469.4	315.9	3469.4
11.8	0.0	0.0	0.0	350.7	3851.4	350.7	3851.4
10.8	0.0	0.0	0.0	385.5	4233.3	385.5	4233.3
9.8	0.0	0.0	0.0	420.3	4615.3	420.3	4615.3
8.8	0.0	0.0	0.0	455.1	4997.2	455.1	4997.2
7.8	0.0	0.0	0.0	489.8	5379.2	489.8	5379.2
6.8	0.0	0.0	0.0	524.6	5761.1	524.6	5761.1
5.8	0.0	0.0	0.0	559.4	6143.1	559.4	6143.1
4.8	0.0	0.0	0.0	594.2	6525.0	594.2	6525.0
3.8	0.0	0.0	0.0	629.0	6907.0	629.0	6907.0
3.7	0.0	0.0	0.0	634.2	6964.3	634.2	6964.3
3.3	0.0	141.3	12.9	504.3	7077.0	645.6	7089.9
3.0	17.9	263.1	21.8	490.1	9967.0	735.3	9970.8
2.8	30.7	350.1	27.8	372.8	9551.5	692.1	9548.5

2.7	40.3	409.6	32.6	245.7	7734.0	615.1	7726.3
1.9	87.8	715.1	56.9	0.0	7911.2	627.3	7880.3
1.8	94.7	759.7	60.5	-35.9	7937.0	629.1	7902.8
0.8	158.7	1171.5	93.3	-367.2	8175.9	645.6	8110.4
-0.2	222.7	1583.4	126.0	-698.5	8414.7	662.2	8318.0
-1.2	286.7	1995.2	158.8	-1029.8	8653.5	678.7	8525.7
-2.2	350.7	2407.1	191.6	-1361.1	8892.4	695.2	8733.3
-3.2	414.7	2818.9	224.4	-1692.5	9131.2	711.8	8940.9
-3.8	451.2	3028.6	241.1	-1856.3	9269.3	721.2	9059.2
-4.2	451.2	3143.0	250.2	-1963.5	9349.5	728.3	9148.5
-5.2	451.2	3350.6	266.7	-2154.6	9540.6	744.8	9356.1
-6.2	451.2	3558.2	283.3	-2345.7	9731.7	761.3	9563.8
-7.0	451.2	1825.9	256.2	-1018.3	2803.6	356.4	2608.6
-7.2	451.2	1723.2	263.1	-915.9	2807.6	356.1	2619.4
-8.2	451.2	3561.6	347.7	-2233.3	8565.6	877.0	8462.1
-9.2	451.2	3727.5	363.9	-2383.1	8546.6	893.2	8459.3
-10.2	451.2	3893.4	380.1	-2532.8	8698.3	909.4	8627.2
-11.2	451.2	4059.4	396.3	-2682.5	8850.0	925.6	8795.1
-12.2	451.2	4225.3	412.5	-2832.3	9001.8	941.8	8963.1
-13.2	451.2	4391.3	428.7	-2982.0	9153.5	958.0	9131.0
-14.2	451.2	4557.2	444.9	-3131.8	9262.4	974.2	9256.1
-15.2	451.2	4723.1	461.1	-3281.5	9367.6	990.4	9377.5
-16.2	451.2	4889.1	477.3	-3431.2	9514.8	1006.6	9540.9
-17.2	451.2	5055.0	493.5	-3581.0	9664.9	1022.8	9707.2
-18.2	451.2	5220.9	509.7	-3730.7	9815.0	1039.0	9873.5
-19.2	451.2	5386.9	525.9	-3880.5	9965.1	1055.2	10039.8
-20.2	451.2	5552.8	542.1	-4030.2	10115.2	1071.4	10206.1
-21.2	451.2	5718.8	558.3	-4179.9	10265.3	1087.6	10372.4
-22.2	451.2	5884.7	574.5	-4329.7	10415.4	1103.8	10538.7
-23.2	451.2	6050.6	590.7	-4479.4	10565.5	1120.0	10705.0
-24.2	451.2	6216.6	606.9	-4629.2	10710.7	1136.2	10866.4
-25.2	451.2	6382.5	623.1	-4778.9	10838.7	1152.4	11010.6
-26.2	451.2	6548.5	639.3	-4928.6	10971.6	1168.6	11159.7
-27.2	451.2	6714.4	655.5	-5078.4	11121.7	1184.8	11326.0
-28.2	451.2	6880.3	671.7	-5228.1	11271.7	1201.0	11492.2
-29.2	451.2	7046.3	687.9	-5377.8	11421.8	1217.2	11658.5
-30.2	451.2	7212.2	704.1	-5527.6	11571.9	1233.4	11824.8
-31.2	451.2	7378.2	720.3	-5677.3	11722.0	1249.6	11991.1
-32.2	451.2	7544.1	736.5	-5827.1	11872.1	1265.8	12157.4
-33.2	451.2	7710.0	752.7	-5976.8	12022.2	1282.0	12323.7
-34.2	451.2	7876.0	768.9	-6126.5	12179.6	1298.2	12497.3
-35.2	451.2	8041.9	785.1	-6276.3	12362.8	1314.4	12696.7
-36.2	451.2	8207.9	801.3	-6426.0	12538.7	1330.6	12888.8
-37.0	451.2	22638.0	1384.3	-19412.3	42207.2	2774.6	43140.3
-37.2	451.2	23404.4	1399.8	-20134.9	43694.6	2818.3	44643.2
-38.2	451.2	9384.4	764.5	-7684.8	14215.8	1248.4	14529.0
-39.2	451.2	9589.8	781.2	-7873.4	14404.2	1265.1	14734.2
-40.2	451.2	9795.1	797.9	-8062.1	14592.7	1281.9	14939.4
-41.2	451.2	10000.0	814.7	-8250.2	14781.1	1298.6	15144.6
-42.2	451.2	10200.7	831.4	-8434.2	14969.6	1315.3	15349.8

-43.2	451.2	10401.8	848.1	-8618.6	15158.0	1332.1	15555.0
-44.2	451.2	10607.0	864.9	-8807.0	15346.5	1348.8	15760.2
-44.5+	451.2	10664.9	869.6	-10213.7	64157.2	0.0	66057.1
-44.5-	451.2	10664.9	869.6	-10213.7	64157.2	0.0	63094.2
-44.5	451.2	13303.9	712.3	-12852.7	65796.0	0.0	66057.1
-44.6+	451.2	95764.6	0.0	-58373.1	74040.4	0.0	73589.2
-44.6-	451.2	21884.1	0.0	-58373.1	74040.4	0.0	73589.2
-45.2	451.2	95764.6	0.0	-95313.4	138896.3	0.0	138445.1

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:52:15

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***************************
*  SUMMARY OF RESULTS FOR  *
*  CANTILEVER WALL DESIGN  *
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-CONSTRUCTION STAGE

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

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WALL BOTTOM ELEV. (FT)     :      -13.80
      PENETRATION (FT)     :       17.45

MAX. BEND. MOMENT (LB-FT)  :  6.9405E+04
      AT ELEVATION (FT)    :       -4.24

MAX. SCALED DEFL. (LB-IN^3):  3.7121E+10
      AT ELEVATION (FT)    :       19.80
```

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 12:52:15

****
* COMPLETE OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-CONSTRUCTION STAGE

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
19.80	0.0000E+00	0.	3.7121E+10	0.00
18.80	1.7874E+01	54.	3.5440E+10	107.24
17.80	1.3092E+02	178.	3.3760E+10	142.03
16.80	3.8599E+02	338.	3.2080E+10	176.81
15.80	8.1786E+02	532.	3.0400E+10	211.59
14.80	1.4613E+03	761.	2.8722E+10	246.37
13.80	2.3512E+03	1025.	2.7047E+10	281.16
12.80	3.5222E+03	1323.	2.5376E+10	315.94
11.80	5.0091E+03	1657.	2.3711E+10	350.72
10.80	6.8468E+03	2025.	2.2054E+10	385.50
9.80	9.0699E+03	2428.	2.0410E+10	420.28
8.80	1.1713E+04	2865.	1.8781E+10	455.07
7.80	1.4812E+04	3338.	1.7172E+10	489.85
6.80	1.8400E+04	3845.	1.5590E+10	524.63
5.80	2.2513E+04	4387.	1.4039E+10	559.41
4.80	2.7186E+04	4964.	1.2527E+10	594.20
3.80	3.2452E+04	5575.	1.1062E+10	628.98
3.65	3.3296E+04	5670.	1.0847E+10	634.19
3.28	3.5434E+04	5881.	1.0321E+10	504.31
3.00	3.7100E+04	6020.	9.9297E+09	490.09
2.80	3.8313E+04	6106.	9.6529E+09	372.78
2.65	3.9233E+04	6153.	9.4470E+09	245.75
1.91	4.3841E+04	6244.	8.4522E+09	0.00
1.80	4.4517E+04	6242.	8.3104E+09	-35.87
0.80	5.0686E+04	6040.	7.0448E+09	-367.19
-0.20	5.6487E+04	5507.	5.8667E+09	-698.50
-1.20	6.1590E+04	4643.	4.7862E+09	-1029.82
-2.20	6.5663E+04	3448.	3.8119E+09	-1361.13
-3.20	6.8375E+04	1921.	2.9509E+09	-1692.45

-3.77	6.9186E+04	910.	2.5127E+09	-1856.27
-4.20	6.9403E+04	88.	2.2078E+09	-1963.47
-5.20	6.8477E+04	-1971.	1.5844E+09	-2154.57
-6.20	6.5397E+04	-4221.	1.0790E+09	-2345.66
-7.00	6.1412E+04	-5566.	7.5615E+08	-1018.32
-7.20	6.0279E+04	-5760.	6.8624E+08	-915.89
-8.20	5.3841E+04	-7334.	3.9751E+08	-2233.32
-9.20	4.5365E+04	-9643.	2.0152E+08	-2383.06
-10.19	3.4602E+04	-12080.	8.4250E+07	-2531.61
-10.20	3.4506E+04	-12100.	8.3574E+07	-2505.76
-11.20	2.1695E+04	-12980.	2.4940E+07	746.91
-12.20	9.6308E+03	-10607.	3.9038E+06	3999.58
-13.20	1.5660E+03	-4981.	8.5003E+04	7252.25
-13.80	0.0000E+00	0.	0.0000E+00	9219.35

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES	------------->		
	WATER	<----LEFTSIDE	----->	<---RIGHTSIDE	---->
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
19.80	0.	0.	0.	0.	0.
18.80	0.	0.	0.	107.	1178.
17.80	0.	0.	0.	142.	1560.
16.80	0.	0.	0.	177.	1942.
15.80	0.	0.	0.	212.	2324.
14.80	0.	0.	0.	246.	2705.
13.80	0.	0.	0.	281.	3087.
12.80	0.	0.	0.	316.	3469.
11.80	0.	0.	0.	351.	3851.
10.80	0.	0.	0.	386.	4233.
9.80	0.	0.	0.	420.	4615.
8.80	0.	0.	0.	455.	4997.
7.80	0.	0.	0.	490.	5379.
6.80	0.	0.	0.	525.	5761.
5.80	0.	0.	0.	559.	6143.
4.80	0.	0.	0.	594.	6525.
3.80	0.	0.	0.	629.	6907.
3.65	0.	0.	0.	634.	6964.
3.28	0.	141.	13.	646.	7090.
3.00	18.	263.	22.	735.	9971.
2.80	31.	350.	28.	692.	9549.
2.65	40.	410.	33.	615.	7726.
1.91	88.	715.	57.	627.	7880.
1.80	95.	760.	60.	629.	7903.

0.80	159.	1172.	93.	646.	8110.
-0.20	223.	1583.	126.	662.	8318.
-1.20	287.	1995.	159.	679.	8526.
-2.20	351.	2407.	192.	695.	8733.
-3.20	415.	2819.	224.	712.	8941.
-3.77	451.	3029.	241.	721.	9059.
-4.20	451.	3143.	250.	728.	9149.
-5.20	451.	3351.	267.	745.	9356.
-6.20	451.	3558.	283.	761.	9564.
-7.00	451.	1826.	256.	356.	2609.
-7.20	451.	1723.	263.	356.	2619.
-8.20	451.	3562.	348.	877.	8462.
-9.20	451.	3727.	364.	893.	8459.
-10.19	451.	3892.	380.	909.	8626.
-10.20	451.	3893.	380.	909.	8627.
-11.20	451.	4059.	396.	926.	8795.
-12.20	451.	4225.	413.	942.	8963.
-13.20	451.	4391.	429.	958.	9131.
-13.80	451.	4557.	445.	974.	9256.
-15.20	451.	4723.	461.	990.	9378.

WP21~WP26:USUAL LOADING: Mmax, Smax, Tanchor,and Deflection for Structural Design

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 PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                           BY CLASSICAL METHODS
 DATE: 25-FEBRUARY-2021                                       TIME: 13:05:20

                             ****************
                             *  INPUT DATA  *
                             ****************

       I.--HEADING
      'SOUTH BATTERY PARK FLOODWALL WP19-23-USUAL LOADS

      II.--CONTROL
         ANCHORED WALL DESIGN
         FACTOR OF SAFETY FOR ACTIVE PRESSURES  = 1.00
         FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

     III.--WALL DATA
         ELEVATION AT TOP OF WALL    = 21.00 FT.
         ELEVATION AT ANCHOR         = 15.50 FT.

      IV.--SURFACE POINT DATA

           IV.A.--RIGHTSIDE
              DIST. FROM     ELEVATION
              WALL (FT)         (FT)
                   0.00         21.00

           IV.B.--LEFTSIDE
              DIST. FROM     ELEVATION
              WALL (FT)         (FT)
                   0.00          3.65

       V.--SOIL LAYER DATA

          V.A.--RIGHTSIDE
              LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
              LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

                ANGLE OF         ANGLE OF                       <-SAFETY->
  SAT.    MOIST  INTERNAL  COH-     WALL    ADH-    <--BOTTOM--> <-FACTOR->
 WGHT.    WGHT.  FRICTION  ESION  FRICTION  ESION    ELEV.  SLOPE ACT. PASS.
 (PCF)    (PCF)    (DEG)   (PSF)    (DEG)   (PSF)    (FT)  (FT/FT)
122.00  120.00     31.20    0.00    10.00    0.00     3.00   0.00   DEF  DEF
125.00  123.00     32.90    0.00    10.00    0.00    -7.00   0.00   DEF  DEF
118.00  115.00     30.30    0.00    10.00    0.00   -37.00   0.00   DEF  DEF
125.00  122.00     32.60    0.00    10.00    0.00   -44.50   0.00   DEF  DEF
150.00  145.00     45.00 8000.00    15.00 4000.00                   DEF  DEF

          V.B.--LEFTSIDE
              LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE  = DEFAULT
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LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH- ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH- ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
122.00	120.00	31.20	0.00	10.00	0.00	3.00	0.00	DEF	DEF
125.00	121.00	32.90	0.00	10.00	0.00	-7.00	0.00	DEF	DEF
118.00	113.00	30.30	0.00	10.00	0.00	-37.00	0.00	DEF	DEF
125.00	123.00	32.60	0.00	10.00	0.00	-44.50	0.00	DEF	DEF
150.00	145.00	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 6.00 (FT)
LEFTSIDE ELEVATION = -3.77 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

VII.A.--VERTICAL LINE LOADS

NONE

VII.B.--VERTICAL UNIFORM LOADS

NONE

VII.C.--VERTICAL STRIP LOADS

VII.C.1.--RIGHTSIDE

<-DIST. FROM WALL-> START (FT)	END (FT)	STRIP LOAD (PSF)
0.00	60.00	250.00

VII.C.2.--LEFTSIDE

NONE

VII.D.--VERTICAL RAMP LOADS

NONE

VII.E.--VERTICAL TRIANGULAR LOADS

NONE

VII.F.--VERTICAL VARIABLE LOADS

NONE

VIII.--HORIZONTAL LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:05:24

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*   SOIL PRESSURES FOR  *
*  ANCHORED WALL DESIGN *
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-USUAL LOADS

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

	NET	<---LEFTSIDE--->		<------NET------> (SOIL + WATER)	<--RIGHTSIDE--->	
ELEV. (FT)	WATER (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
21.0	0.0	0.0	0.0	0.0	0.0	0.0
20.0	0.0	0.0	0.0	107.2	107.2	1599.7
19.0	0.0	0.0	0.0	142.0	142.0	2118.5
18.0	0.0	0.0	0.0	176.8	176.8	2637.3
17.0	0.0	0.0	0.0	211.6	211.6	3156.1
16.0	0.0	0.0	0.0	246.4	246.4	3675.0
15.5	0.0	0.0	0.0	263.8	263.8	3934.4
15.0	0.0	0.0	0.0	281.2	281.2	4193.8
14.0	0.0	0.0	0.0	315.9	315.9	4712.6
13.0	0.0	0.0	0.0	350.7	350.7	5231.4
12.0	0.0	0.0	0.0	385.5	385.5	5750.2
11.0	0.0	0.0	0.0	420.3	420.3	6269.1
10.0	0.0	0.0	0.0	455.1	455.1	6787.9
9.0	0.0	0.0	0.0	489.8	489.8	7306.7
8.0	0.0	0.0	0.0	524.6	524.6	7825.5
7.0	0.0	0.0	0.0	559.4	559.4	8344.3
6.0	0.0	0.0	0.0	589.7	589.7	8796.1
5.0	64.0	0.0	0.0	675.0	611.0	9113.9
4.0	128.0	0.0	0.0	755.8	627.8	9364.7
3.7	150.4	0.0	0.0	784.1	633.7	9452.5

3.0	192.0	366.7	21.5	519.8	694.5	14268.3
2.7	214.4	570.6	32.7	329.4	685.6	14661.5
2.1	249.5	879.0	50.6	0.0	629.5	11363.0
2.0	256.0	936.3	53.9	-61.1	619.1	10750.7
1.0	320.0	1505.6	86.7	-549.9	635.7	11037.7
0.0	384.0	2074.9	119.5	-1038.7	652.2	11324.7
-1.0	448.0	2644.1	152.3	-1527.4	668.7	11611.7
-2.0	512.0	3213.4	185.1	-2016.2	685.2	11501.9
-3.0	576.0	3782.7	217.8	-2505.0	701.8	11313.9
-3.8	625.3	4196.1	241.7	-2856.3	714.5	11364.1
-4.0	625.3	4287.1	246.9	-2943.5	718.3	11394.6
-5.0	625.3	4574.1	263.4	-3214.0	734.8	11671.0
-6.0	625.3	4861.1	279.9	-3484.5	751.4	11958.4
-7.0	625.3	4342.0	304.1	-2971.4	745.3	8435.9
-8.0	625.3	4272.4	336.3	-2844.4	802.7	7923.4
-9.0	625.3	4977.1	360.7	-3469.2	882.6	11189.6
-10.0	625.3	5200.6	376.9	-3676.6	898.8	11414.7
-11.0	625.3	5424.2	393.1	-3883.9	915.0	11639.9
-12.0	625.3	5647.8	409.3	-4091.3	931.2	11865.0
-13.0	625.3	5871.3	425.5	-4298.6	947.4	12090.1
-14.0	625.3	6094.9	441.7	-4506.0	963.6	12315.3
-15.0	625.3	6318.4	457.9	-4713.3	979.8	12540.4
-16.0	625.3	6542.0	474.1	-4920.7	996.0	12765.6
-17.0	625.3	6765.5	490.3	-5128.1	1012.2	12990.7
-18.0	625.3	6989.1	506.5	-5335.4	1028.4	13215.9
-19.0	625.3	7212.7	522.7	-5542.8	1044.6	13441.0
-20.0	625.3	7436.2	538.9	-5750.1	1060.8	13632.9
-21.0	625.3	7659.8	555.1	-5957.5	1077.0	13823.8
-22.0	625.3	7883.3	571.3	-6164.9	1093.2	14047.8
-23.0	625.3	8106.9	587.5	-6372.2	1109.4	14273.0
-24.0	625.3	8330.5	603.7	-6579.6	1125.6	14470.3
-25.0	625.3	8554.0	619.9	-6786.9	1141.8	14642.0
-26.0	625.3	8777.6	636.1	-6994.3	1158.0	14840.9
-27.0	625.3	9001.1	652.3	-7201.6	1174.2	15064.4
-28.0	625.3	9224.7	668.5	-7409.0	1190.4	15288.0
-29.0	625.3	9448.2	684.7	-7616.4	1206.6	15511.5
-30.0	625.3	9671.8	700.9	-7823.7	1222.8	15735.1
-31.0	625.3	9895.4	717.1	-8031.1	1239.0	15958.7
-32.0	625.3	10118.9	733.3	-8238.4	1255.2	16210.0
-33.0	625.3	10342.5	749.5	-8445.8	1271.4	16485.7
-34.0	625.3	10566.0	765.7	-8653.2	1287.6	16733.8
-35.0	625.3	10789.6	781.9	-8860.5	1303.8	16957.3
-36.0	625.3	11013.2	798.1	-9067.9	1320.0	17180.9
-37.0	625.3	15680.5	857.7	-13584.0	1471.2	27332.0
-38.0	625.3	16618.8	839.4	-14563.0	1430.5	28706.5
-39.0	625.3	13142.9	777.9	-11262.6	1255.0	20183.3
-40.0	625.3	13425.5	794.6	-11528.5	1271.8	20466.6
-41.0	625.3	13708.2	811.3	-11794.4	1288.5	20749.9
-42.0	625.3	13990.9	828.1	-12060.4	1305.2	21033.2
-43.0	625.3	14273.6	844.8	-12326.3	1322.0	21302.6

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-44.0   625.3   14556.2    861.5        -12592.3        1338.7   21560.0
-44.4+  625.3   14667.4    868.1        -14042.1           0.0  258551.4
-44.4-  625.3   14667.4    868.1        -14042.1           0.0  207930.1
-44.5+  625.3   62886.6      0.0        -58686.8           0.0  251046.2
-44.5-  625.3   55737.6      0.0        -58686.8           0.0  251046.2
-44.5   625.3   62886.6      0.0        -62261.3           0.0  258551.4
-45.0   625.3  227821.6      0.0       -227196.4           0.0  371063.5
-46.0   625.3  107212.9      0.0       -106587.7           0.0  123025.7
-47.0   625.3  108941.7      0.0       -108316.4           0.0  124599.7
-48.0   625.3  110642.0      0.0       -110016.7           0.0  126157.5
-49.0   625.3  112315.5      0.0       -111690.2           0.0  127699.7
        * STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE
          FOR THIS ELEVATION.
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 25-FEBRUARY-2021                                    TIME: 13:05:25

                       ****************************
                       *  SUMMARY OF RESULTS FOR  *
                       *   ANCHORED WALL DESIGN   *
                       ****************************

    I.--HEADING
     'SOUTH BATTERY PARK FLOODWALL WP19-23-USUAL LOADS

   II.--SUMMARY

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        *****WARNING:  STANDARD WEDGE SOLUTION DOES NOT EXIST
                       AT ALL ELEVATIONS.  SEE COMPLETE OUTPUT.

   METHOD                           :    FREE EARTH        FIXED EARTH

   WALL BOTTOM ELEVATION (FT)       :         -1.32              -4.38
         PENETRATION (FT)            :         4.97               8.03

   MAXIMUM BENDING MOMENT (LB-FT)   :   -1.4360E+04        -1.0297E+04
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      AT ELEVATION (FT)            :          7.09                8.04

   MAXIMUM SCALED DEFLECTION (LB-IN^3):    6.8251E+08         -4.4429E+08
      AT ELEVATION (FT)            :          7.00               21.00

   ANCHOR FORCE (LB)               :    4.3377E+03          3.8262E+03

            NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                   ELLASTICITY IN PSI TIMES PILE MOMENT
                   OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                   IN INCHES.
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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
                         BY CLASSICAL METHODS
DATE: 25-FEBRUARY-2021                                        TIME: 13:05:25

                       ****************************
                       * COMPLETE OF RESULTS FOR  *
                       *   ANCHORED WALL DESIGN   *
                       *   BY FREE EARTH METHOD   *
                       ****************************
```

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-USUAL LOADS

II.--RESULTS (ANCHOR FORCE= 4338. (LB))

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
21.00	0.0000E+00	0.	-6.6094E+08	0.00
20.00	1.7874E+01	54.	-5.4183E+08	107.24
19.00	1.3092E+02	178.	-4.2268E+08	142.03
18.00	3.8599E+02	338.	-3.0328E+08	176.81
17.00	8.1786E+02	532.	-1.8318E+08	211.59
16.00	1.4613E+03	761.	-6.1643E+07	246.37
15.50+	1.8733E+03	888.	0.0000E+00	263.76
15.50-	1.8733E+03	-3449.	0.0000E+00	263.76
15.00	1.8231E+02	-3313.	6.2299E+07	281.16
14.00	-2.9844E+03	-3015.	1.8644E+08	315.94
13.00	-5.8352E+03	-2681.	3.0547E+08	350.72
12.00	-8.3353E+03	-2313.	4.1447E+08	385.50
11.00	-1.0450E+04	-1910.	5.0912E+08	420.28
10.00	-1.2144E+04	-1473.	5.8577E+08	455.07
9.00	-1.3383E+04	-1000.	6.4150E+08	489.85
8.00	-1.4133E+04	-493.	6.7418E+08	524.63

7.00	-1.4357E+04	49.	6.8251E+08	559.41
6.00	-1.4024E+04	624.	6.6612E+08	589.70
5.00	-1.3091E+04	1256.	6.2557E+08	675.01
4.00	-1.1484E+04	1971.	5.6250E+08	755.82
3.65	-1.0747E+04	2241.	5.3559E+08	784.10
3.00	-9.1431E+03	2665.	4.7970E+08	519.78
2.65	-8.1825E+03	2813.	4.4677E+08	329.36
2.10	-6.6071E+03	2904.	3.9178E+08	0.00
2.00	-6.3117E+03	2901.	3.8117E+08	-61.15
1.00	-3.5232E+03	2595.	2.7172E+08	-549.91
0.00	-1.2847E+03	1801.	1.5611E+08	-1038.67
-1.00	-8.4775E+01	518.	3.8132E+07	-1527.44
-1.32	0.0000E+00	0.	0.0000E+00	-1684.96

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES	--------------	-------------->	
	WATER	<----LEFTSIDE	----->	<---RIGHTSIDE	---->
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
21.00	0.	0.	0.	0.	0.
20.00	0.	0.	0.	107.	1600.
19.00	0.	0.	0.	142.	2119.
18.00	0.	0.	0.	177.	2637.
17.00	0.	0.	0.	212.	3156.
16.00	0.	0.	0.	246.	3675.
15.50	0.	0.	0.	264.	3934.
15.00	0.	0.	0.	281.	4194.
14.00	0.	0.	0.	316.	4713.
13.00	0.	0.	0.	351.	5231.
12.00	0.	0.	0.	386.	5750.
11.00	0.	0.	0.	420.	6269.
10.00	0.	0.	0.	455.	6788.
9.00	0.	0.	0.	490.	7307.
8.00	0.	0.	0.	525.	7826.
7.00	0.	0.	0.	559.	8344.
6.00	0.	0.	0.	590.	8796.
5.00	64.	0.	0.	611.	9114.
4.00	128.	0.	0.	628.	9365.
3.65	150.	0.	0.	634.	9452.
3.00	192.	367.	22.	694.	14268.
2.65	214.	571.	33.	686.	14662.
2.10	249.	879.	51.	630.	11363.
2.00	256.	936.	54.	619.	10751.
1.00	320.	1506.	87.	636.	11038.

0.00	384.	2075.	119.	652.	11325.
-1.00	448.	2644.	152.	669.	11612.
-2.00	512.	3213.	185.	685.	11502.

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE AT THIS ELEVATION.


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***************************
* COMPLETE OF RESULTS FOR  *
*   ANCHORED WALL DESIGN   *
*   BY FIXED EARTH METHOD  *
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I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP19-23-USUAL LOADS

II.--RESULTS (ANCHOR FORCE= 3826. (LB))

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
21.00	0.0000E+00	0.	-4.4429E+08	0.00
20.00	1.7874E+01	54.	-3.6457E+08	107.24
19.00	1.3092E+02	178.	-2.8481E+08	142.03
18.00	3.8599E+02	338.	-2.0480E+08	176.81
17.00	8.1786E+02	532.	-1.2410E+08	211.59
16.00	1.4613E+03	761.	-4.1948E+07	246.37
15.50+	1.8733E+03	888.	0.0000E+00	263.76
15.50-	1.8733E+03	-2938.	0.0000E+00	263.76
15.00	4.3805E+02	-2802.	4.2622E+07	281.16
14.00	-2.2172E+03	-2503.	1.2785E+08	315.94
13.00	-4.5565E+03	-2170.	2.0930E+08	350.72
12.00	-6.5451E+03	-1802.	2.8292E+08	385.50
11.00	-8.1482E+03	-1399.	3.4528E+08	420.28
10.00	-9.3310E+03	-961.	3.9363E+08	455.07
9.00	-1.0059E+04	-489.	4.2592E+08	489.85
8.00	-1.0297E+04	19.	4.4090E+08	524.63
7.00	-1.0010E+04	561.	4.3816E+08	559.41
6.00	-9.1645E+03	1135.	4.1820E+08	589.70
5.00	-7.7202E+03	1768.	3.8249E+08	675.01
4.00	-5.6016E+03	2483.	3.3354E+08	755.82
3.65	-4.6857E+03	2752.	3.1393E+08	784.10

3.00	-2.7496E+03	3176.	2.7502E+08	519.78
2.65	-1.6100E+03	3325.	2.5315E+08	329.36
2.10	2.4578E+02	3415.	2.1831E+08	0.00
2.00	5.9326E+02	3412.	2.1182E+08	-61.15
1.00	3.8932E+03	3106.	1.4964E+08	-549.91
0.00	6.6433E+03	2312.	9.4108E+07	-1038.67
-1.00	8.3547E+03	1029.	4.9905E+07	-1527.44
-2.00	8.5386E+03	-743.	1.9918E+07	-2016.20
-3.00	6.7063E+03	-3003.	4.3957E+06	-2504.97
-3.77	3.6165E+03	-5067.	4.1302E+05	-2856.32
-4.00	2.3747E+03	-5734.	1.0166E+05	-2943.52
-5.00	0.0000E+00	-6863.	0.0000E+00	-3045.51

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES-------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION	PRESSURE	PASSIVE	ACTIVE	ACTIVE	PASSIVE
(FT)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)
21.00	0.	0.	0.	0.	0.
20.00	0.	0.	0.	107.	1600.
19.00	0.	0.	0.	142.	2119.
18.00	0.	0.	0.	177.	2637.
17.00	0.	0.	0.	212.	3156.
16.00	0.	0.	0.	246.	3675.
15.50	0.	0.	0.	264.	3934.
15.00	0.	0.	0.	281.	4194.
14.00	0.	0.	0.	316.	4713.
13.00	0.	0.	0.	351.	5231.
12.00	0.	0.	0.	386.	5750.
11.00	0.	0.	0.	420.	6269.
10.00	0.	0.	0.	455.	6788.
9.00	0.	0.	0.	490.	7307.
8.00	0.	0.	0.	525.	7826.
7.00	0.	0.	0.	559.	8344.
6.00	0.	0.	0.	590.	8796.
5.00	64.	0.	0.	611.	9114.
4.00	128.	0.	0.	628.	9365.
3.65	150.	0.	0.	634.	9452.
3.00	192.	367.	22.	694.	14268.
2.65	214.	571.	33.	686.	14662.
2.10	249.	879.	51.	630.	11363.
2.00	256.	936.	54.	619.	10751.
1.00	320.	1506.	87.	636.	11038.
0.00	384.	2075.	119.	652.	11325.

-1.00	448.	2644.	152.	669.	11612.
-2.00	512.	3213.	185.	685.	11502.
-3.00	576.	3783.	218.	702.	11314.
-3.77	625.	4196.	242.	714.	11364.
-4.00	625.	4287.	247.	718.	11395.
-5.00	625.	4574.	263.	735.	11671.

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE AT THIS ELEVATION.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:06:56

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******************************
* PRELIMINARY DESIGN DATA FOR *
*  FREE EARTH DESIGN IN SAND  *
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-USUAL LOADS

II.--DESIGN PARAMETERS

WALL HEIGHT RATIO (ALPHA) = 0.78
ANCHOR HEIGHT RATIO (BETA) = 0.25

SHEET PILE DATA:

SHEET PILE NAME	<SECTION PROPERTIES> (PER FOOT OF WALL) SECTION MODULUS (IN^3)	MOMENT OF INERTIA (IN^4)	ALLOWABLE STRESS (PSI)	MODULUS OF ELLASTICITY (PSI)
PZ40	60.70	490.80	1.80E+04	2.90E+07
PZ38	46.80	280.80	1.80E+04	2.90E+07
PZ35	48.50	361.20	1.80E+04	2.90E+07
PZ32	38.30	220.40	1.80E+04	2.90E+07
PZ27	30.20	184.20	1.80E+04	2.90E+07
PZ22	18.10	84.40	1.80E+04	2.90E+07
PLZ25	32.80	223.25	1.80E+04	2.90E+07
PLZ23	30.20	203.75	1.80E+04	2.90E+07

III.--PRELIMINARY DESIGN DATA

SHEET PILE NAME	LOG(H^4/EI)	ROWE'S MOMENT REDUCTION COEF.		RATIO OF ALLOWABLE MOMENT TO REDUCED FREE EARTH MOMENT	
		LOOSE	DENSE	LOOSE	DENSE
PZ40	-4.76	1.00*	1.00*	6.34	6.34
PZ38	-4.52	1.00*	1.00*	4.89	4.89
PZ35	-4.63	1.00*	1.00*	5.07	5.07
PZ32	-4.41	1.00*	1.00*	4.00	4.00
PZ27	-4.33	1.00*	1.00*	3.15	3.15
PZ22	-3.99	1.00*	1.00*	1.89	1.89
PLZ25	-4.42	1.00*	1.00*	3.43	3.43
PLZ23	-4.38	1.00*	1.00*	3.15	3.15

* REDUCTION NOT APPLICABLE DUE TO
LOG(H^4/EI) LESS THAN -3.5 OR GREATER THEN -1.5.

WP21~WP26: USUAL LOADING: DETERMINATION OF PENETRATION

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:10:37

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*  INPUT DATA  *
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I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP19-23-USUAL LOADS

II.--CONTROL
ANCHORED WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

III.--WALL DATA
ELEVATION AT TOP OF WALL = 21.00 FT.
ELEVATION AT ANCHOR = 15.50 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	21.00

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	3.65

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	<--BOTTOM--> SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	<-SAFETY-> <-FACTOR-> PASS.
122.00	120.00	31.20	0.00	10.00	0.00	3.00	0.00	DEF	DEF
125.00	123.00	32.90	0.00	10.00	0.00	-7.00	0.00	DEF	DEF
118.00	115.00	30.30	0.00	10.00	0.00	-37.00	0.00	DEF	DEF
125.00	122.00	32.60	0.00	10.00	0.00	-44.50	0.00	DEF	DEF
150.00	145.00	45.00	8000.00	15.00	4000.00			DEF	DEF

V.B.--LEFTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
122.00	120.00	31.20	0.00	10.00	0.00	3.00	0.00	DEF	DEF
125.00	121.00	32.90	0.00	10.00	0.00	-7.00	0.00	DEF	DEF
118.00	113.00	30.30	0.00	10.00	0.00	-37.00	0.00	DEF	DEF
125.00	123.00	32.60	0.00	10.00	0.00	-44.50	0.00	DEF	DEF
150.00	145.00	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 6.00 (FT)
LEFTSIDE ELEVATION = -3.77 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

VII.A.--VERTICAL LINE LOADS

NONE

VII.B.--VERTICAL UNIFORM LOADS

NONE

VII.C.--VERTICAL STRIP LOADS

VII.C.1.--RIGHTSIDE

<-DIST. FROM WALL-> START (FT)	END (FT)	STRIP LOAD (PSF)
0.00	60.00	250.00

VII.C.2.--LEFTSIDE

NONE

VII.D.--VERTICAL RAMP LOADS

NONE

VII.E.--VERTICAL TRIANGULAR LOADS

NONE

VII.F.--VERTICAL VARIABLE LOADS

NONE

VIII.--HORIZONTAL LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:10:40

****
* SOIL PRESSURES FOR *
* ANCHORED WALL DESIGN *
****

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-USUAL LOADS

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

	NET	<---LEFTSIDE--->		<------NET------> (SOIL + WATER)	<--RIGHTSIDE--->	
ELEV.	WATER	PASSIVE	ACTIVE	ACTIVE	ACTIVE	PASSIVE
(FT)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)
21.0	0.0	0.0	0.0	0.0	0.0	0.0
20.0	0.0	0.0	0.0	107.2	107.2	963.7
19.0	0.0	0.0	0.0	142.0	142.0	1276.3
18.0	0.0	0.0	0.0	176.8	176.8	1588.8
17.0	0.0	0.0	0.0	211.6	211.6	1901.4
16.0	0.0	0.0	0.0	246.4	246.4	2213.9
15.5	0.0	0.0	0.0	263.8	263.8	2370.2
15.0	0.0	0.0	0.0	281.2	281.2	2526.5
14.0	0.0	0.0	0.0	315.9	315.9	2839.1
13.0	0.0	0.0	0.0	350.7	350.7	3151.6
12.0	0.0	0.0	0.0	385.5	385.5	3464.2
11.0	0.0	0.0	0.0	420.3	420.3	3776.7
10.0	0.0	0.0	0.0	455.1	455.1	4089.3
9.0	0.0	0.0	0.0	489.8	489.8	4401.8
8.0	0.0	0.0	0.0	524.6	524.6	4714.4
7.0	0.0	0.0	0.0	559.4	559.4	5026.9
6.0	0.0	0.0	0.0	589.7	589.7	5299.1
5.0	64.0	0.0	0.0	675.0	611.0	5490.6
4.0	128.0	0.0	0.0	755.8	627.8	5641.6
3.7	150.4	0.0	0.0	784.1	633.7	5694.5

3.0	192.0	214.3	21.5	672.2	694.5	6981.3
2.7	214.4	332.8	32.7	567.2	685.6	7156.3
2.0	256.0	548.5	53.9	326.6	619.1	6298.3
1.0	320.0	882.0	86.7	73.6	635.7	6466.4
0.7	338.6	979.1	96.2	0.0	640.5	6515.3
0.0	384.0	1215.6	119.5	-179.4	652.2	6634.6
-1.0	448.0	1549.1	152.3	-432.4	668.7	6802.7
-2.0	512.0	1882.6	185.1	-685.4	685.2	6970.8
-3.0	576.0	2216.1	217.8	-938.3	701.8	7139.0
-3.8	625.3	2458.3	241.7	-1118.5	714.5	7268.4
-4.0	625.3	2511.6	246.9	-1168.0	718.3	7307.1
-5.0	625.3	2679.7	263.4	-1319.6	734.8	7475.2
-6.0	625.3	2847.9	279.9	-1471.2	751.4	7643.4
-7.0	625.3	2771.3	304.1	-1400.8	745.3	6657.4
-8.0	625.3	2791.8	336.3	-1363.8	802.7	6480.8
-9.0	625.3	3041.3	360.7	-1533.4	882.6	7213.5
-10.0	625.3	3177.9	376.9	-1653.8	898.8	7064.1
-11.0	625.3	3314.5	393.1	-1774.2	915.0	7144.5
-12.0	625.3	3451.1	409.3	-1894.6	931.2	7282.6
-13.0	625.3	3587.7	425.5	-2015.0	947.4	7420.6
-14.0	625.3	3724.3	441.7	-2135.4	963.6	7558.7
-15.0	625.3	3860.9	457.9	-2255.9	979.8	7696.8
-16.0	625.3	3997.5	474.1	-2376.3	996.0	7834.9
-17.0	625.3	4134.2	490.3	-2496.7	1012.2	7956.0
-18.0	625.3	4270.8	506.5	-2617.1	1028.4	8060.0
-19.0	625.3	4407.4	522.7	-2737.5	1044.6	8180.4
-20.0	625.3	4544.0	538.9	-2857.9	1060.8	8317.4
-21.0	625.3	4680.6	555.1	-2978.3	1077.0	8454.3
-22.0	625.3	4817.2	571.3	-3098.7	1093.2	8591.2
-23.0	625.3	4953.8	587.5	-3219.1	1109.4	8728.2
-24.0	625.3	5090.4	603.7	-3339.5	1125.6	8865.1
-25.0	625.3	5227.0	619.9	-3459.9	1141.8	9002.1
-26.0	625.3	5363.6	636.1	-3580.3	1158.0	9139.0
-27.0	625.3	5500.2	652.3	-3700.7	1174.2	9269.2
-28.0	625.3	5636.8	668.5	-3821.2	1190.4	9390.3
-29.0	625.3	5773.4	684.7	-3941.6	1206.6	9518.2
-30.0	625.3	5910.1	700.9	-4062.0	1222.8	9655.2
-31.0	625.3	6046.7	717.1	-4182.4	1239.0	9792.1
-32.0	625.3	6183.3	733.3	-4302.8	1255.2	9929.0
-33.0	625.3	6319.9	749.5	-4423.2	1271.4	10066.0
-34.0	625.3	6456.5	765.7	-4543.6	1287.6	10202.9
-35.0	625.3	6593.1	781.9	-4664.0	1303.8	10339.9
-36.0	625.3	6729.7	798.1	-4784.4	1320.0	10476.8
-37.0	625.3	8045.9	857.7	-5949.4	1471.2	13028.0
-38.0	625.3	8474.6	839.4	-6418.8	1430.5	13640.2
-39.0	625.3	7738.7	777.9	-5858.4	1255.0	11853.1
-40.0	625.3	7905.1	794.6	-6008.1	1271.8	12019.7
-41.0	625.3	8071.5	811.3	-6157.8	1288.5	12186.2
-42.0	625.3	8238.0	828.1	-6307.5	1305.2	12352.8
-43.0	625.3	8404.4	844.8	-6457.2	1322.0	12519.3

-44.0	625.3	8570.9	861.5	-6606.9	1338.7	12685.9
-44.4+	625.3	8636.3	868.1	-8011.0	0.0	71994.6
-44.4-	625.3	8636.3	868.1	-8011.0	0.0	59326.3
-44.5+	625.3	21885.2	0.0	-20277.8	0.0	70116.4
-44.5-	625.3	19920.9	0.0	-20277.8	0.0	70116.4
-44.5	625.3	21885.2	0.0	-21259.9	0.0	71994.6
-45.0	625.3	71094.7	0.0	-70469.4	0.0	105100.7
-46.0	625.3	45827.9	0.0	-45202.6	0.0	53046.8
-47.0	625.3	46385.3	0.0	-45760.0	0.0	53529.6
-48.0	625.3	46695.3	0.0	-46070.0	0.0	53795.0
-49.0	625.3	46997.7	0.0	-46372.5	0.0	54100.3

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PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
                          BY CLASSICAL METHODS
DATE: 25-FEBRUARY-2021                                        TIME: 13:10:41

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                        *  SUMMARY OF RESULTS FOR  *
                        *   ANCHORED WALL DESIGN   *
                        ****************************

    I.--HEADING
     'SOUTH BATTERY PARK FLOODWALL WP19-23-USUAL LOADS

   II.--SUMMARY

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

   METHOD                            :    FREE EARTH         FIXED EARTH

   WALL BOTTOM ELEVATION (FT)        :         -4.11               -8.37
         PENETRATION (FT)             :         7.76               12.02

   MAXIMUM BENDING MOMENT (LB-FT)    :   -1.8894E+04         -1.4351E+04
         AT ELEVATION (FT)           :          6.19                7.09

   MAXIMUM SCALED DEFLECTION (LB-IN^3):    1.1955E+09          8.2449E+08
         AT ELEVATION (FT)           :          6.00                6.00
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ANCHOR FORCE (LB) : 4.8493E+03 4.3367E+03

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:10:41

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* COMPLETE OF RESULTS FOR  *
*   ANCHORED WALL DESIGN   *
*   BY FREE EARTH METHOD   *
***************************
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-USUAL LOADS

II.--RESULTS (ANCHOR FORCE= 4849. (LB))

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
21.00	0.0000E+00	0.	-1.0406E+09	0.00
20.00	1.7874E+01	54.	-8.5244E+08	107.24
19.00	1.3092E+02	178.	-6.6426E+08	142.03
18.00	3.8599E+02	338.	-4.7583E+08	176.81
17.00	8.1786E+02	532.	-2.8672E+08	211.59
16.00	1.4613E+03	761.	-9.6155E+07	246.37
15.50+	1.8733E+03	888.	0.0000E+00	263.76
15.50-	1.8733E+03	-3961.	0.0000E+00	263.76
15.00	-7.3486E+01	-3825.	9.6792E+07	281.16
14.00	-3.7518E+03	-3526.	2.8948E+08	315.94
13.00	-7.1142E+03	-3193.	4.7573E+08	350.72
12.00	-1.0126E+04	-2825.	6.4973E+08	385.50
11.00	-1.2752E+04	-2422.	8.0630E+08	420.28
10.00	-1.4958E+04	-1984.	9.4088E+08	455.07
9.00	-1.6709E+04	-1512.	1.0497E+09	489.85
8.00	-1.7970E+04	-1004.	1.1297E+09	524.63
7.00	-1.8706E+04	-462.	1.1787E+09	559.41
6.00	-1.8884E+04	112.	1.1955E+09	589.70
5.00	-1.8463E+04	744.	1.1797E+09	675.01
4.00	-1.7367E+04	1460.	1.1322E+09	755.82
3.65	-1.6809E+04	1729.	1.1083E+09	784.10

3.00	-1.5527E+04	2203.	1.0547E+09	672.20
2.65	-1.4717E+04	2420.	1.0211E+09	567.22
2.00	-1.3042E+04	2710.	9.5051E+08	326.61
1.00	-1.0211E+04	2910.	8.2382E+08	73.62
0.71	-9.3616E+03	2921.	7.8341E+08	0.00
0.00	-7.3057E+03	2857.	6.7949E+08	-179.37
-1.00	-4.5803E+03	2551.	5.2252E+08	-432.36
-2.00	-2.2871E+03	1993.	3.5756E+08	-685.35
-3.00	-6.7938E+02	1181.	1.8856E+08	-938.34
-3.77	-6.6176E+01	389.	5.7447E+07	-1118.50
-4.00	-6.7563E+00	126.	1.8247E+07	-1168.02
-4.11	0.0000E+00	0.	0.0000E+00	-1184.25

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<------------SOIL PRESSURES------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
21.00	0.	0.	0.	0.	0.
20.00	0.	0.	0.	107.	964.
19.00	0.	0.	0.	142.	1276.
18.00	0.	0.	0.	177.	1589.
17.00	0.	0.	0.	212.	1901.
16.00	0.	0.	0.	246.	2214.
15.50	0.	0.	0.	264.	2370.
15.00	0.	0.	0.	281.	2526.
14.00	0.	0.	0.	316.	2839.
13.00	0.	0.	0.	351.	3152.
12.00	0.	0.	0.	386.	3464.
11.00	0.	0.	0.	420.	3777.
10.00	0.	0.	0.	455.	4089.
9.00	0.	0.	0.	490.	4402.
8.00	0.	0.	0.	525.	4714.
7.00	0.	0.	0.	559.	5027.
6.00	0.	0.	0.	590.	5299.
5.00	64.	0.	0.	611.	5491.
4.00	128.	0.	0.	628.	5642.
3.65	150.	0.	0.	634.	5695.
3.00	192.	214.	22.	694.	6981.
2.65	214.	333.	33.	686.	7156.
2.00	256.	549.	54.	619.	6298.
1.00	320.	882.	87.	636.	6466.
0.71	339.	979.	96.	640.	6515.
0.00	384.	1216.	119.	652.	6635.

-1.00	448.	1549.	152.	669.	6803.
-2.00	512.	1883.	185.	685.	6971.
-3.00	576.	2216.	218.	702.	7139.
-3.77	625.	2458.	242.	714.	7268.
-4.00	625.	2512.	247.	718.	7307.
-5.00	625.	2680.	263.	735.	7475.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS
DATE: 25-FEBRUARY-2021 TIME: 13:10:41

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* COMPLETE OF RESULTS FOR  *
*   ANCHORED WALL DESIGN   *
*   BY FIXED EARTH METHOD  *
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I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP19-23-USUAL LOADS

II.--RESULTS (ANCHOR FORCE= 4337. (LB))

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
21.00	0.0000E+00	0.	-7.5249E+08	0.00
20.00	1.7874E+01	54.	-6.1673E+08	107.24
19.00	1.3092E+02	178.	-4.8093E+08	142.03
18.00	3.8599E+02	338.	-3.4489E+08	176.81
17.00	8.1786E+02	532.	-2.0815E+08	211.59
16.00	1.4613E+03	761.	-6.9966E+07	246.37
15.50+	1.8733E+03	888.	0.0000E+00	263.76
15.50-	1.8733E+03	-3448.	0.0000E+00	263.76
15.00	1.8281E+02	-3312.	7.0621E+07	281.16
14.00	-2.9829E+03	-3014.	2.1141E+08	315.94
13.00	-5.8327E+03	-2680.	3.4709E+08	350.72
12.00	-8.3318E+03	-2312.	4.7274E+08	385.50
11.00	-1.0445E+04	-1909.	5.8405E+08	420.28
10.00	-1.2139E+04	-1472.	6.7736E+08	455.07
9.00	-1.3377E+04	-999.	7.4977E+08	489.85
8.00	-1.4125E+04	-492.	7.9914E+08	524.63
7.00	-1.4349E+04	50.	8.2417E+08	559.41
6.00	-1.4014E+04	625.	8.2449E+08	589.70
5.00	-1.3080E+04	1257.	8.0067E+08	675.01
4.00	-1.1472E+04	1972.	7.5435E+08	755.82
3.65	-1.0735E+04	2242.	7.3330E+08	784.10

3.00	-9.1199E+03	2715.	6.8832E+08	672.20
2.65	-8.1305E+03	2932.	6.6126E+08	567.22
2.00	-6.1217E+03	3223.	6.0662E+08	326.61
1.00	-2.7779E+03	3423.	5.1439E+08	73.62
0.71	-1.7798E+03	3434.	4.8639E+08	0.00
0.00	6.3953E+02	3370.	4.1737E+08	-179.37
-1.00	3.8776E+03	3064.	3.2143E+08	-432.36
-2.00	6.6833E+03	2505.	2.3213E+08	-685.35
-3.00	8.8037E+03	1693.	1.5428E+08	-938.34
-3.77	9.8116E+03	901.	1.0448E+08	-1118.50
-4.00	9.9889E+03	639.	9.1511E+07	-1168.02
-5.00	1.0018E+04	-605.	4.5832E+07	-1319.63
-6.00	8.7278E+03	-2001.	1.7274E+07	-1471.24
-7.00	6.0032E+03	-3437.	3.5889E+06	-1400.76
-8.00	1.8722E+03	-4819.	7.5259E+04	-1363.84
-9.00	0.0000E+00	-5334.	0.0000E+00	-1426.40

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES-------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
21.00	0.	0.	0.	0.	0.
20.00	0.	0.	0.	107.	964.
19.00	0.	0.	0.	142.	1276.
18.00	0.	0.	0.	177.	1589.
17.00	0.	0.	0.	212.	1901.
16.00	0.	0.	0.	246.	2214.
15.50	0.	0.	0.	264.	2370.
15.00	0.	0.	0.	281.	2526.
14.00	0.	0.	0.	316.	2839.
13.00	0.	0.	0.	351.	3152.
12.00	0.	0.	0.	386.	3464.
11.00	0.	0.	0.	420.	3777.
10.00	0.	0.	0.	455.	4089.
9.00	0.	0.	0.	490.	4402.
8.00	0.	0.	0.	525.	4714.
7.00	0.	0.	0.	559.	5027.
6.00	0.	0.	0.	590.	5299.
5.00	64.	0.	0.	611.	5491.
4.00	128.	0.	0.	628.	5642.
3.65	150.	0.	0.	634.	5695.
3.00	192.	214.	22.	694.	6981.
2.65	214.	333.	33.	686.	7156.

2.00	256.	549.	54.	619.	6298.
1.00	320.	882.	87.	636.	6466.
0.71	339.	979.	96.	640.	6515.
0.00	384.	1216.	119.	652.	6635.
-1.00	448.	1549.	152.	669.	6803.
-2.00	512.	1883.	185.	685.	6971.
-3.00	576.	2216.	218.	702.	7139.
-3.77	625.	2458.	242.	714.	7268.
-4.00	625.	2512.	247.	718.	7307.
-5.00	625.	2680.	263.	735.	7475.
-6.00	625.	2848.	280.	751.	7643.
-7.00	625.	2771.	304.	745.	6657.
-8.00	625.	2792.	336.	803.	6481.
-9.00	625.	3041.	361.	883.	7213.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:10:44

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* PRELIMINARY DESIGN DATA FOR *
*  FREE EARTH DESIGN IN SAND  *
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-USUAL LOADS

II.--DESIGN PARAMETERS

WALL HEIGHT RATIO (ALPHA) = 0.69
ANCHOR HEIGHT RATIO (BETA) = 0.22

SHEET PILE DATA:

SHEET PILE NAME	<SECTION PROPERTIES> (PER FOOT OF WALL) SECTION MODULUS (IN^3)	MOMENT OF INERTIA (IN^4)	ALLOWABLE STRESS (PSI)	MODULUS OF ELLASTICITY (PSI)
PZ40	60.70	490.80	2.40E+04	2.90E+07
PZ38	46.80	280.80	2.40E+04	2.90E+07
PZ35	48.50	361.20	2.40E+04	2.90E+07

PZ32	38.30	220.40	2.40E+04	2.90E+07
PZ27	30.20	184.20	2.40E+04	2.90E+07
PZ22	18.10	84.40	2.40E+04	2.90E+07
PLZ25	32.80	223.25	2.40E+04	2.90E+07
PLZ23	30.20	203.75	2.40E+04	2.90E+07

III.--PRELIMINARY DESIGN DATA

SHEET PILE NAME	LOG(H^4/EI)	ROWE'S MOMENT REDUCTION COEF.		RATIO OF ALLOWABLE MOMENT TO REDUCED FREE EARTH MOMENT	
		LOOSE	DENSE	LOOSE	DENSE
PZ40	-4.55	1.00*	1.00*	6.43	6.43
PZ38	-4.31	1.00*	1.00*	4.95	4.95
PZ35	-4.42	1.00*	1.00*	5.13	5.13
PZ32	-4.21	1.00*	1.00*	4.05	4.05
PZ27	-4.13	1.00*	1.00*	3.20	3.20
PZ22	-3.79	1.00*	1.00*	1.92	1.92
PLZ25	-4.21	1.00*	1.00*	3.47	3.47
PLZ23	-4.17	1.00*	1.00*	3.20	3.20

* REDUCTION NOT APPLICABLE DUE TO
LOG(H^4/EI) LESS THAN -3.5 OR GREATER THEN -1.5.

WP21~WP26: UNUSUAL LOADING: Mmax,Smax,Tanchor and Deflection for Structural Design

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:12:45

****
* INPUT DATA *
****

I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP19-23-UNUSUAL LOADS

II.--CONTROL
ANCHORED WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

III.--WALL DATA
ELEVATION AT TOP OF WALL = 21.00 FT.
ELEVATION AT ANCHOR = 15.50 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	21.00

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	3.65

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
122.00	120.00	31.20	0.00	10.00	0.00	3.00	0.00	DEF	DEF
125.00	123.00	32.90	0.00	10.00	0.00	-7.00	0.00	DEF	DEF
118.00	115.00	30.30	0.00	10.00	0.00	-37.00	0.00	DEF	DEF
125.00	122.00	32.60	0.00	10.00	0.00	-44.50	0.00	DEF	DEF
150.00	145.00	45.00	8000.00	15.00	4000.00			DEF	DEF

V.B.--LEFTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
122.00	120.00	31.20	0.00	10.00	0.00	3.00	0.00	DEF	DEF
125.00	121.00	32.90	0.00	10.00	0.00	-7.00	0.00	DEF	DEF
118.00	113.00	30.30	0.00	10.00	0.00	-37.00	0.00	DEF	DEF
125.00	123.00	32.60	0.00	10.00	0.00	-44.50	0.00	DEF	DEF
150.00	145.00	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA
UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 21.00 (FT)
LEFTSIDE ELEVATION = -3.77 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS
NONE

VIII.--HORIZONTAL LOADS
NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS
DATE: 25-FEBRUARY-2021 TIME: 13:12:58

****
* SOIL PRESSURES FOR *
* ANCHORED WALL DESIGN *
****

I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP19-23-UNUSUAL LOADS

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

				<------NET------>		
	NET	<---LEFTSIDE--->		(SOIL + WATER)	<--RIGHTSIDE--->	
ELEV.	WATER	PASSIVE	ACTIVE	ACTIVE	ACTIVE	PASSIVE
(FT)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)
21.0	0.0	0.0	0.0	0.0	0.0	0.0
20.0	64.0	0.0	0.0	80.8	16.8	250.8
19.0	128.0	0.0	0.0	161.6	33.6	501.5
18.0	192.0	0.0	0.0	242.4	50.4	752.3
17.0	256.0	0.0	0.0	323.2	67.2	1003.1
16.0	320.0	0.0	0.0	404.1	84.1	1253.8
15.5	352.0	0.0	0.0	444.5	92.5	1379.2
15.0	384.0	0.0	0.0	484.9	100.9	1504.6
14.0	448.0	0.0	0.0	565.7	117.7	1755.3
13.0	512.0	0.0	0.0	646.5	134.5	2006.1
12.0	576.0	0.0	0.0	727.3	151.3	2256.9
11.0	640.0	0.0	0.0	808.1	168.1	2507.6
10.0	704.0	0.0	0.0	888.9	184.9	2758.4
9.0	768.0	0.0	0.0	969.7	201.7	3009.2
8.0	832.0	0.0	0.0	1050.5	218.5	3259.9
7.0	896.0	0.0	0.0	1131.4	235.4	3510.7
6.0	960.0	0.0	0.0	1212.2	252.2	3761.4
5.0	1024.0	0.0	0.0	1293.0	269.0	4012.2
4.0	1088.0	0.0	0.0	1373.8	285.8	4263.0
3.7	1110.4	0.0	0.0	1402.1	291.7	4350.7
3.0	1152.0	366.7	21.5	1105.7	320.4	6403.8
2.7	1174.4	570.6	32.7	923.1	319.3	6639.5
2.0	1216.0	936.3	53.9	579.1	299.4	5198.9
1.0	1280.0	1505.6	86.7	90.4	315.9	5485.9
0.8	1291.8	1610.8	92.8	0.0	319.0	5539.0
0.0	1344.0	2074.9	119.5	-398.4	332.5	5772.9
-1.0	1408.0	2644.1	152.3	-887.2	349.0	6059.9
-2.0	1472.0	3213.4	185.1	-1375.9	365.5	6346.9
-3.0	1536.0	3782.7	217.8	-1864.7	382.0	6633.9
-3.8	1585.3	4196.1	241.7	-2216.0	394.8	6854.9
-4.0	1585.3	4287.1	246.9	-2303.2	398.6	6920.9
-5.0	1585.3	4574.1	263.4	-2573.7	415.1	7207.9
-6.0	1585.3	4861.1	279.9	-2844.2	431.6	7494.9
-7.0	1585.3	4342.0	304.1	-2314.2	442.5	5657.6
-8.0	1585.3	4272.4	336.3	-2204.3	482.8	5429.9
-9.0	1585.3	4977.1	360.7	-2863.2	528.6	7294.6
-10.0	1585.3	5200.6	376.9	-3070.6	544.8	7518.2
-11.0	1585.3	5424.2	393.1	-3277.9	561.0	7741.8
-12.0	1585.3	5647.8	409.3	-3485.3	577.2	7965.3
-13.0	1585.3	5871.3	425.5	-3692.6	593.4	8188.9
-14.0	1585.3	6094.9	441.7	-3900.0	609.6	8412.4
-15.0	1585.3	6318.4	457.9	-4107.3	625.8	8636.0
-16.0	1585.3	6542.0	474.1	-4314.7	642.0	8859.5
-17.0	1585.3	6765.5	490.3	-4522.1	658.2	9083.1
-18.0	1585.3	6989.1	506.5	-4729.4	674.4	9306.7

-19.0	1585.3	7212.7	522.7	-4936.8	690.6	9530.2
-20.0	1585.3	7436.2	538.9	-5144.1	706.8	9753.8
-21.0	1585.3	7659.8	555.1	-5351.5	723.0	9977.3
-22.0	1585.3	7883.3	571.3	-5558.9	739.2	10200.9
-23.0	1585.3	8106.9	587.5	-5766.2	755.4	10424.5
-24.0	1585.3	8330.5	603.7	-5973.6	771.6	10648.0
-25.0	1585.3	8554.0	619.9	-6180.9	787.8	10871.6
-26.0	1585.3	8777.6	636.1	-6388.3	804.0	11095.1
-27.0	1585.3	9001.1	652.3	-6595.6	820.2	11318.7
-28.0	1585.3	9224.7	668.5	-6803.0	836.4	11542.2
-29.0	1585.3	9448.2	684.7	-7010.4	852.6	11765.8
-30.0	1585.3	9671.8	700.9	-7217.7	868.8	11989.4
-31.0	1585.3	9895.4	717.1	-7425.1	885.0	12212.9
-32.0	1585.3	10118.9	733.3	-7632.4	901.2	12436.5
-33.0	1585.3	10342.5	749.5	-7839.8	917.4	12660.0
-34.0	1585.3	10566.0	765.7	-8047.2	933.6	12883.6
-35.0	1585.3	10789.6	781.9	-8254.5	949.8	13107.2
-36.0	1585.3	11013.2	798.1	-8461.9	966.0	13330.7
-37.0	1585.3	15680.5	857.7	-13037.0	1058.3	20132.1
-38.0	1585.3	16618.8	839.4	-14000.8	1032.7	21208.6
-39.0	1585.3	13142.9	777.9	-10626.2	931.4	15737.0
-40.0	1585.3	13425.5	794.6	-10892.1	948.1	16019.6
-41.0	1585.3	13708.2	811.3	-11158.1	964.9	16302.3
-42.0	1585.3	13990.9	828.1	-11424.0	981.6	16585.0
-43.0	1585.3	14273.6	844.8	-11690.0	998.3	16867.7
-44.0	1585.3	14556.2	861.5	-11955.9	1015.0	17150.3
-44.2+	1585.3	14614.2	864.9	-13028.9	0.0	195439.8
-44.2-	1585.3	14614.2	864.9	-13028.9	0.0	90226.2
-44.3+	1585.3	116307.8	0.0	-84351.4	0.0	132595.1
-44.3-	1585.3	55565.6	0.0	-84351.4	0.0	132595.1
-44.5	1585.3	116307.8	0.0	-114722.5	0.0	195439.8
-45.0	1585.3	227821.6	0.0	-226236.4	0.0	286323.5
-46.0	1585.3	107212.9	0.0	-105627.7	0.0	112303.5
-47.0	1585.3	108941.7	0.0	-107356.4	0.0	113715.2
-48.0	1585.3	110642.0	0.0	-109056.7	0.0	115231.2
-49.0	1585.3	112315.5	0.0	-110730.2	0.0	116733.0

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE
FOR THIS ELEVATION.

DATE: 25-FEBRUARY-2021 TIME: 13:12:59

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***************************
*  SUMMARY OF RESULTS FOR  *
*   ANCHORED WALL DESIGN   *
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-UNUSUAL LOADS

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

*****WARNING: STANDARD WEDGE SOLUTION DOES NOT EXIST
AT ALL ELEVATIONS. SEE COMPLETE OUTPUT.

METHOD	:	FREE EARTH	FIXED EARTH
WALL BOTTOM ELEVATION (FT)	:	-3.96	-8.27
PENETRATION (FT)	:	7.61	11.92
MAXIMUM BENDING MOMENT (LB-FT)	:	-3.6359E+04	-2.7817E+04
AT ELEVATION (FT)	:	6.41	7.27
MAXIMUM SCALED DEFLECTION (LB-IN^3)	:	2.2682E+09	1.5752E+09
AT ELEVATION (FT)	:	6.00	7.00
ANCHOR FORCE (LB)	:	8.6016E+03	7.6157E+03

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF
ELLASTICITY IN PSI TIMES PILE MOMENT
OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
IN INCHES.

DATE: 25-FEBRUARY-2021 TIME: 13:12:59

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***************************
* COMPLETE OF RESULTS FOR  *
*   ANCHORED WALL DESIGN   *
*   BY FREE EARTH METHOD   *
***************************
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I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP19-23-UNUSUAL LOADS

II.--RESULTS (ANCHOR FORCE= 8602. (LB))

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
21.00	0.0000E+00	0.	-2.0405E+09	0.00
20.00	1.3469E+01	40.	-1.6706E+09	80.81
19.00	1.0775E+02	162.	-1.3006E+09	161.62
18.00	3.6365E+02	364.	-9.3040E+08	242.43
17.00	8.6199E+02	646.	-5.5956E+08	323.25
16.00	1.6836E+03	1010.	-1.8719E+08	404.06
15.50+	2.2408E+03	1222.	0.0000E+00	444.46
15.50-	2.2408E+03	-7379.	0.0000E+00	444.46
15.00	-1.3916E+03	-7147.	1.8785E+08	484.87
14.00	-8.2827E+03	-6622.	5.6024E+08	565.68
13.00	-1.4608E+04	-6016.	9.1840E+08	646.49
12.00	-2.0287E+04	-5329.	1.2514E+09	727.30
11.00	-2.5239E+04	-4561.	1.5495E+09	808.11
10.00	-2.9382E+04	-3713.	1.8040E+09	888.93
9.00	-3.2637E+04	-2783.	2.0079E+09	969.74
8.00	-3.4922E+04	-1773.	2.1556E+09	1050.55
7.00	-3.6156E+04	-682.	2.2431E+09	1131.36
6.00	-3.6259E+04	490.	2.2682E+09	1212.17
5.00	-3.5150E+04	1742.	2.2309E+09	1292.98
4.00	-3.2748E+04	3076.	2.1330E+09	1373.79
3.65	-3.1586E+04	3561.	2.0852E+09	1402.08
3.00	-2.8996E+04	4376.	1.9787E+09	1105.71
2.65	-2.7400E+04	4731.	1.9126E+09	923.09
2.00	-2.4154E+04	5220.	1.7745E+09	579.13
1.00	-1.8726E+04	5554.	1.5287E+09	90.37
0.82	-1.7698E+04	5563.	1.4794E+09	0.00
0.00	-1.3208E+04	5400.	1.2504E+09	-398.40
-1.00	-8.0884E+03	4758.	9.4933E+08	-887.16
-2.00	-3.8558E+03	3626.	6.3413E+08	-1375.93
-3.00	-9.9913E+02	2006.	3.1206E+08	-1864.69
-3.77	-4.2173E+01	435.	6.2569E+07	-2216.04
-3.96	0.0000E+00	0.	0.0000E+00	-2289.22

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

<-------------SOIL PRESSURES-------------->

	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION	PRESSURE	PASSIVE	ACTIVE	ACTIVE	PASSIVE
(FT)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)
21.00	0.	0.	0.	0.	0.
20.00	64.	0.	0.	17.	251.
19.00	128.	0.	0.	34.	502.
18.00	192.	0.	0.	50.	752.
17.00	256.	0.	0.	67.	1003.
16.00	320.	0.	0.	84.	1254.
15.50	352.	0.	0.	92.	1379.
15.00	384.	0.	0.	101.	1505.
14.00	448.	0.	0.	118.	1755.
13.00	512.	0.	0.	134.	2006.
12.00	576.	0.	0.	151.	2257.
11.00	640.	0.	0.	168.	2508.
10.00	704.	0.	0.	185.	2758.
9.00	768.	0.	0.	202.	3009.
8.00	832.	0.	0.	219.	3260.
7.00	896.	0.	0.	235.	3511.
6.00	960.	0.	0.	252.	3761.
5.00	1024.	0.	0.	269.	4012.
4.00	1088.	0.	0.	286.	4263.
3.65	1110.	0.	0.	292.	4351.
3.00	1152.	367.	22.	320.	6404.
2.65	1174.	571.	33.	319.	6639.
2.00	1216.	936.	54.	299.	5199.
1.00	1280.	1506.	87.	316.	5486.
0.82	1292.	1611.	93.	319.	5539.
0.00	1344.	2075.	119.	332.	5773.
-1.00	1408.	2644.	152.	349.	6060.
-2.00	1472.	3213.	185.	366.	6347.
-3.00	1536.	3783.	218.	382.	6634.
-3.77	1585.	4196.	242.	395.	6855.
-4.00	1585.	4287.	247.	399.	6921.

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE AT THIS ELEVATION.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:12:59

****
* COMPLETE OF RESULTS FOR *
* ANCHORED WALL DESIGN *
* BY FIXED EARTH METHOD *

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I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP19-23-UNUSUAL LOADS

II.--RESULTS (ANCHOR FORCE= 7616. (LB))

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
21.00	0.0000E+00	0.	-1.4955E+09	0.00
20.00	1.3469E+01	40.	-1.2247E+09	80.81
19.00	1.0775E+02	162.	-9.5378E+08	161.62
18.00	3.6365E+02	364.	-6.8269E+08	242.43
17.00	8.6199E+02	646.	-4.1094E+08	323.25
16.00	1.6836E+03	1010.	-1.3764E+08	404.06
15.50+	2.2408E+03	1222.	0.0000E+00	444.46
15.50-	2.2408E+03	-6393.	0.0000E+00	444.46
15.00	-8.9864E+02	-6161.	1.3834E+08	484.87
14.00	-6.8038E+03	-5636.	4.1257E+08	565.68
13.00	-1.2143E+04	-5030.	6.7512E+08	646.49
12.00	-1.6836E+04	-4343.	9.1678E+08	727.30
11.00	-2.0802E+04	-3575.	1.1295E+09	808.11
10.00	-2.3960E+04	-2727.	1.3063E+09	888.93
9.00	-2.6228E+04	-1797.	1.4419E+09	969.74
8.00	-2.7527E+04	-787.	1.5323E+09	1050.55
7.00	-2.7776E+04	304.	1.5752E+09	1131.36
6.00	-2.6893E+04	1476.	1.5704E+09	1212.17
5.00	-2.4798E+04	2728.	1.5192E+09	1292.98
4.00	-2.1409E+04	4062.	1.4254E+09	1373.79
3.65	-1.9903E+04	4547.	1.3835E+09	1402.08
3.00	-1.6672E+04	5362.	1.2948E+09	1105.71
2.65	-1.4731E+04	5717.	1.2418E+09	923.09
2.00	-1.0844E+04	6206.	1.1355E+09	579.13
1.00	-4.4304E+03	6540.	9.5756E+08	90.37
0.82	-3.2202E+03	6549.	9.2349E+08	0.00
0.00	2.0736E+03	6386.	7.7199E+08	-398.40
-1.00	8.1793E+03	5744.	5.8994E+08	-887.16
-2.00	1.3398E+04	4612.	4.2191E+08	-1375.93
-3.00	1.7240E+04	2992.	2.7682E+08	-1864.69
-3.77	1.8957E+04	1421.	1.8499E+08	-2216.04
-4.00	1.9224E+04	901.	1.6126E+08	-2303.25
-5.00	1.8928E+04	-1538.	7.8587E+07	-2573.72
-6.00	1.6059E+04	-4247.	2.8252E+07	-2844.19
-7.00	1.0478E+04	-6826.	5.2689E+06	-2314.25
-8.00	2.5139E+03	-9085.	5.2763E+04	-2204.29
-9.00	0.0000E+00	-9699.	0.0000E+00	-2380.73

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF
ELLASTICITY IN PSI TIMES PILE MOMENT

OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES-------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
21.00	0.	0.	0.	0.	0.
20.00	64.	0.	0.	17.	251.
19.00	128.	0.	0.	34.	502.
18.00	192.	0.	0.	50.	752.
17.00	256.	0.	0.	67.	1003.
16.00	320.	0.	0.	84.	1254.
15.50	352.	0.	0.	92.	1379.
15.00	384.	0.	0.	101.	1505.
14.00	448.	0.	0.	118.	1755.
13.00	512.	0.	0.	134.	2006.
12.00	576.	0.	0.	151.	2257.
11.00	640.	0.	0.	168.	2508.
10.00	704.	0.	0.	185.	2758.
9.00	768.	0.	0.	202.	3009.
8.00	832.	0.	0.	219.	3260.
7.00	896.	0.	0.	235.	3511.
6.00	960.	0.	0.	252.	3761.
5.00	1024.	0.	0.	269.	4012.
4.00	1088.	0.	0.	286.	4263.
3.65	1110.	0.	0.	292.	4351.
3.00	1152.	367.	22.	320.	6404.
2.65	1174.	571.	33.	319.	6639.
2.00	1216.	936.	54.	299.	5199.
1.00	1280.	1506.	87.	316.	5486.
0.82	1292.	1611.	93.	319.	5539.
0.00	1344.	2075.	119.	332.	5773.
-1.00	1408.	2644.	152.	349.	6060.
-2.00	1472.	3213.	185.	366.	6347.
-3.00	1536.	3783.	218.	382.	6634.
-3.77	1585.	4196.	242.	395.	6855.
-4.00	1585.	4287.	247.	399.	6921.
-5.00	1585.	4574.	263.	415.	7208.
-6.00	1585.	4861.	280.	432.	7495.
-7.00	1585.	4342.	304.	442.	5658.
-8.00	1585.	4272.	336.	483.	5430.
-9.00	1585.	4977.	361.	529.	7295.

*   STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE
AT THIS ELEVATION.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:13:01

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******************************
* PRELIMINARY DESIGN DATA FOR *
*  FREE EARTH DESIGN IN SAND  *
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I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP19-23-UNUSUAL LOADS

II.--DESIGN PARAMETERS

WALL HEIGHT RATIO (ALPHA) = 0.70
ANCHOR HEIGHT RATIO (BETA) = 0.22

SHEET PILE DATA:

SHEET PILE NAME	<SECTION PROPERTIES> (PER FOOT OF WALL) SECTION MODULUS (IN^3)	MOMENT OF INERTIA (IN^4)	ALLOWABLE STRESS (PSI)	MODULUS OF ELLASTICITY (PSI)
PZ40	60.70	490.80	2.40E+04	2.90E+07
PZ38	46.80	280.80	2.40E+04	2.90E+07
PZ35	48.50	361.20	2.40E+04	2.90E+07
PZ32	38.30	220.40	2.40E+04	2.90E+07
PZ27	30.20	184.20	2.40E+04	2.90E+07
PZ22	18.10	84.40	2.40E+04	2.90E+07
PLZ25	32.80	223.25	2.40E+04	2.90E+07
PLZ23	30.20	203.75	2.40E+04	2.90E+07

III.--PRELIMINARY DESIGN DATA

SHEET PILE NAME	LOG(H^4/EI)	ROWE'S MOMENT REDUCTION COEF.		RATIO OF ALLOWABLE MOMENT TO REDUCED FREE EARTH MOMENT	
		LOOSE	DENSE	LOOSE	DENSE
PZ40	-4.56	1.00*	1.00*	3.34	3.34
PZ38	-4.32	1.00*	1.00*	2.57	2.57
PZ35	-4.43	1.00*	1.00*	2.67	2.67
PZ32	-4.22	1.00*	1.00*	2.11	2.11

PZ27	-4.14	1.00*	1.00*	1.66	1.66
PZ22	-3.80	1.00*	1.00*	1.00	1.00
PLZ25	-4.22	1.00*	1.00*	1.80	1.80
PLZ23	-4.18	1.00*	1.00*	1.66	1.66

* REDUCTION NOT APPLICABLE DUE TO
LOG(H^4/EI) LESS THAN -3.5 OR GREATER THEN -1.5.

WP21~WP26:UNUSUAL LOADING: DETERMINATION OF PENETRATION

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:15:08

****
* INPUT DATA *
****

I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP19-23-UNUSUAL LOADS

II.--CONTROL
ANCHORED WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.25

III.--WALL DATA
ELEVATION AT TOP OF WALL = 21.00 FT.
ELEVATION AT ANCHOR = 15.50 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	21.00

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	3.65

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	<--BOTTOM--> SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
122.00	120.00	31.20	0.00	10.00	0.00	3.00	0.00	DEF	DEF
125.00	123.00	32.90	0.00	10.00	0.00	-7.00	0.00	DEF	DEF
118.00	115.00	30.30	0.00	10.00	0.00	-37.00	0.00	DEF	DEF
125.00	122.00	32.60	0.00	10.00	0.00	-44.50	0.00	DEF	DEF
150.00	145.00	45.00	8000.00	15.00	4000.00			DEF	DEF

V.B.--LEFTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
122.00	120.00	31.20	0.00	10.00	0.00	3.00	0.00	DEF	DEF
125.00	121.00	32.90	0.00	10.00	0.00	-7.00	0.00	DEF	DEF
118.00	113.00	30.30	0.00	10.00	0.00	-37.00	0.00	DEF	DEF
125.00	123.00	32.60	0.00	10.00	0.00	-44.50	0.00	DEF	DEF
150.00	145.00	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 21.00 (FT)
LEFTSIDE ELEVATION = -3.77 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

NONE

VIII.--HORIZONTAL LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:15:20

****
* SOIL PRESSURES FOR *
* ANCHORED WALL DESIGN *
****

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-UNUSUAL LOADS

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

		<---LEFTSIDE--->		<------NET------> (SOIL + WATER)	<--RIGHTSIDE--->	
ELEV. (FT)	NET WATER (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
21.0	0.0	0.0	0.0	0.0	0.0	0.0
20.0	64.0	0.0	0.0	80.8	16.8	184.6
19.0	128.0	0.0	0.0	161.6	33.6	369.2
18.0	192.0	0.0	0.0	242.4	50.4	553.8
17.0	256.0	0.0	0.0	323.2	67.2	738.4
16.0	320.0	0.0	0.0	404.1	84.1	923.1
15.5	352.0	0.0	0.0	444.5	92.5	1015.4
15.0	384.0	0.0	0.0	484.9	100.9	1107.7
14.0	448.0	0.0	0.0	565.7	117.7	1292.3
13.0	512.0	0.0	0.0	646.5	134.5	1476.9
12.0	576.0	0.0	0.0	727.3	151.3	1661.5
11.0	640.0	0.0	0.0	808.1	168.1	1846.1
10.0	704.0	0.0	0.0	888.9	184.9	2030.7
9.0	768.0	0.0	0.0	969.7	201.7	2215.3
8.0	832.0	0.0	0.0	1050.5	218.5	2399.9
7.0	896.0	0.0	0.0	1131.4	235.4	2584.5
6.0	960.0	0.0	0.0	1212.2	252.2	2769.2
5.0	1024.0	0.0	0.0	1293.0	269.0	2953.8
4.0	1088.0	0.0	0.0	1373.8	285.8	3138.4
3.7	1110.4	0.0	0.0	1402.1	291.7	3203.0
3.0	1152.0	264.8	21.5	1207.6	320.4	4189.6
2.7	1174.4	411.6	32.7	1082.2	319.3	4340.3
2.0	1216.0	677.3	53.9	838.1	299.4	3761.1
1.0	1280.0	1089.2	86.7	506.8	315.9	3968.7
0.0	1344.0	1501.0	119.5	175.4	332.5	4176.3
-0.5	1377.9	1719.1	136.9	0.0	341.2	4286.2
-1.0	1408.0	1912.9	152.3	-155.9	349.0	4383.9
-2.0	1472.0	2324.7	185.1	-487.2	365.5	4591.6
-3.0	1536.0	2736.6	217.8	-818.5	382.0	4799.2
-3.8	1585.3	3035.6	241.7	-1055.5	394.8	4959.0
-4.0	1585.3	3101.4	246.9	-1117.6	398.6	5006.8
-5.0	1585.3	3309.0	263.4	-1308.7	415.1	5214.4
-6.0	1585.3	3516.7	279.9	-1499.8	431.6	5422.0
-7.0	1585.3	3332.2	304.1	-1304.5	442.5	4643.4
-8.0	1585.3	3327.7	336.3	-1259.6	482.8	4546.3
-9.0	1585.3	3694.3	360.7	-1580.4	528.6	5414.5
-10.0	1585.3	3860.2	376.9	-1730.2	544.8	5580.5
-11.0	1585.3	4026.2	393.1	-1879.9	561.0	5746.4
-12.0	1585.3	4192.1	409.3	-2029.6	577.2	5912.4
-13.0	1585.3	4358.1	425.5	-2179.4	593.4	6078.3
-14.0	1585.3	4524.0	441.7	-2329.1	609.6	6244.2
-15.0	1585.3	4689.9	457.9	-2478.9	625.8	6410.2
-16.0	1585.3	4855.9	474.1	-2628.6	642.0	6576.1
-17.0	1585.3	5021.8	490.3	-2778.3	658.2	6742.1
-18.0	1585.3	5187.8	506.5	-2928.1	674.4	6908.0

-19.0	1585.3	5353.7	522.7	-3077.8	690.6	7073.9
-20.0	1585.3	5519.6	538.9	-3227.6	706.8	7239.9
-21.0	1585.3	5685.6	555.1	-3377.3	723.0	7405.8
-22.0	1585.3	5851.5	571.3	-3527.0	739.2	7571.8
-23.0	1585.3	6017.5	587.5	-3676.8	755.4	7737.7
-24.0	1585.3	6183.4	603.7	-3826.5	771.6	7903.6
-25.0	1585.3	6349.3	619.9	-3976.3	787.8	8069.6
-26.0	1585.3	6515.3	636.1	-4126.0	804.0	8235.5
-27.0	1585.3	6681.2	652.3	-4275.7	820.2	8401.5
-28.0	1585.3	6847.2	668.5	-4425.5	836.4	8567.4
-29.0	1585.3	7013.1	684.7	-4575.2	852.6	8733.3
-30.0	1585.3	7179.0	700.9	-4725.0	868.8	8899.3
-31.0	1585.3	7345.0	717.1	-4874.7	885.0	9065.2
-32.0	1585.3	7510.9	733.3	-5024.4	901.2	9231.2
-33.0	1585.3	7676.9	749.5	-5174.2	917.4	9397.1
-34.0	1585.3	7842.8	765.7	-5323.9	933.6	9563.0
-35.0	1585.3	8008.7	781.9	-5473.7	949.8	9729.0
-36.0	1585.3	8174.7	798.1	-5623.4	966.0	9894.9
-37.0	1585.3	10456.2	857.7	-7812.6	1058.3	13162.7
-38.0	1585.3	11050.4	839.4	-8432.4	1032.7	13839.1
-39.0	1585.3	9548.7	777.9	-7032.0	931.4	11433.4
-40.0	1585.3	9754.1	794.6	-7220.7	948.1	11636.3
-41.0	1585.3	9959.4	811.3	-7409.3	964.9	11836.3
-42.0	1585.3	10160.6	828.1	-7593.7	981.6	12038.6
-43.0	1585.3	10361.2	844.8	-7777.6	998.3	12243.7
-44.0	1585.3	10566.0	861.5	-7965.6	1015.0	12448.9
-44.2+	1585.3	10608.0	864.9	-9022.7	0.0	93583.3
-44.2-	1585.3	10608.0	864.9	-9022.7	0.0	45703.7
-44.3+	1585.3	58222.1	0.0	-42416.7	0.0	64984.5
-44.3-	1585.3	29781.9	0.0	-42416.7	0.0	64984.5
-44.5	1585.3	58222.1	0.0	-56636.8	0.0	93583.3
-45.0	1585.3	114042.8	0.0	-112457.5	0.0	139130.7
-46.0	1585.3	64702.3	0.0	-63117.0	0.0	68114.4
-47.0	1585.3	65414.2	0.0	-63828.9	0.0	68561.6
-48.0	1585.3	66263.5	0.0	-64678.3	0.0	69342.7
-49.0	1585.3	67101.2	0.0	-65515.9	0.0	70117.6

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                      ***************************
                      *  SUMMARY OF RESULTS FOR  *
                      *   ANCHORED WALL DESIGN   *
                      ***************************

    I.--HEADING
     'SOUTH BATTERY PARK FLOODWALL WP19-23-UNUSUAL LOADS

   II.--SUMMARY

        RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

        LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

   METHOD                           :    FREE EARTH         FIXED EARTH

   WALL BOTTOM ELEVATION (FT)       :         -6.72              -12.58
         PENETRATION (FT)            :        10.37               16.23

   MAXIMUM BENDING MOMENT (LB-FT)   :   -4.4549E+04         -3.5916E+04
         AT ELEVATION (FT)          :          5.69                6.45

   MAXIMUM SCALED DEFLECTION (LB-IN^3):    3.5345E+09          2.6359E+09
         AT ELEVATION (FT)          :          5.00                5.00

   ANCHOR FORCE (LB)                :    9.4681E+03          8.5528E+03

             NOTE:  DIVIDE SCALED DEFLECTION MODULUS OF
                    ELLASTICITY IN PSI TIMES PILE MOMENT
                    OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
                    IN INCHES.



PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
                         BY CLASSICAL METHODS
DATE: 25-FEBRUARY-2021                                       TIME: 13:15:21

                      ***************************
                      * COMPLETE OF RESULTS FOR  *
                      *   ANCHORED WALL DESIGN   *
                      *   BY FREE EARTH METHOD   *
                      ***************************

     I.--HEADING
     'SOUTH BATTERY PARK FLOODWALL WP19-23-UNUSUAL LOADS

    II.--RESULTS (ANCHOR FORCE= 9468. (LB))
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ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
21.00	0.0000E+00	0.	-2.8746E+09	0.00
20.00	1.3469E+01	40.	-2.3530E+09	80.81
19.00	1.0775E+02	162.	-1.8314E+09	161.62
18.00	3.6365E+02	364.	-1.3096E+09	242.43
17.00	8.6199E+02	646.	-7.8706E+08	323.25
16.00	1.6836E+03	1010.	-2.6302E+08	404.06
15.50+	2.2408E+03	1222.	0.0000E+00	444.46
15.50-	2.2408E+03	-8246.	0.0000E+00	444.46
15.00	-1.8248E+03	-8013.	2.6365E+08	484.87
14.00	-9.5824E+03	-7488.	7.8689E+08	565.68
13.00	-1.6774E+04	-6882.	1.2937E+09	646.49
12.00	-2.3320E+04	-6195.	1.7715E+09	727.30
11.00	-2.9138E+04	-5428.	2.2092E+09	808.11
10.00	-3.4148E+04	-4579.	2.5967E+09	888.93
9.00	-3.8269E+04	-3650.	2.9252E+09	969.74
8.00	-4.1420E+04	-2640.	3.1878E+09	1050.55
7.00	-4.3521E+04	-1549.	3.3790E+09	1131.36
6.00	-4.4490E+04	-377.	3.4951E+09	1212.17
5.00	-4.4248E+04	876.	3.5345E+09	1292.98
4.00	-4.2712E+04	2209.	3.4976E+09	1373.79
3.65	-4.1854E+04	2695.	3.4671E+09	1402.08
3.00	-3.9820E+04	3543.	3.3871E+09	1207.62
2.65	-3.8508E+04	3944.	3.3319E+09	1082.16
2.00	-3.5734E+04	4568.	3.2080E+09	838.07
1.00	-3.0802E+04	5240.	2.9673E+09	506.76
0.00	-2.5363E+04	5581.	2.6734E+09	175.44
-0.53	-2.2391E+04	5628.	2.4994E+09	0.00
-1.00	-1.9749E+04	5591.	2.3357E+09	-155.88
-2.00	-1.4291E+04	5270.	1.9639E+09	-487.19
-3.00	-9.3207E+03	4617.	1.5673E+09	-818.51
-3.77	-6.0318E+03	3895.	1.2504E+09	-1055.54
-4.00	-5.1644E+03	3645.	1.1544E+09	-1117.57
-5.00	-2.1096E+03	2432.	7.3251E+08	-1308.67
-6.00	-3.6359E+02	1028.	3.0677E+08	-1499.77
-6.72	0.0000E+00	0.	0.0000E+00	-1359.33

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES-------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION	PRESSURE	PASSIVE	ACTIVE	ACTIVE	PASSIVE

(FT)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)
21.00	0.	0.	0.	0.	0.
20.00	64.	0.	0.	17.	185.
19.00	128.	0.	0.	34.	369.
18.00	192.	0.	0.	50.	554.
17.00	256.	0.	0.	67.	738.
16.00	320.	0.	0.	84.	923.
15.50	352.	0.	0.	92.	1015.
15.00	384.	0.	0.	101.	1108.
14.00	448.	0.	0.	118.	1292.
13.00	512.	0.	0.	134.	1477.
12.00	576.	0.	0.	151.	1661.
11.00	640.	0.	0.	168.	1846.
10.00	704.	0.	0.	185.	2031.
9.00	768.	0.	0.	202.	2215.
8.00	832.	0.	0.	219.	2400.
7.00	896.	0.	0.	235.	2585.
6.00	960.	0.	0.	252.	2769.
5.00	1024.	0.	0.	269.	2954.
4.00	1088.	0.	0.	286.	3138.
3.65	1110.	0.	0.	292.	3203.
3.00	1152.	265.	22.	320.	4190.
2.65	1174.	412.	33.	319.	4340.
2.00	1216.	677.	54.	299.	3761.
1.00	1280.	1089.	87.	316.	3969.
0.00	1344.	1501.	119.	332.	4176.
-0.53	1378.	1719.	137.	341.	4286.
-1.00	1408.	1913.	152.	349.	4384.
-2.00	1472.	2325.	185.	366.	4592.
-3.00	1536.	2737.	218.	382.	4799.
-3.77	1585.	3036.	242.	395.	4959.
-4.00	1585.	3101.	247.	399.	5007.
-5.00	1585.	3309.	263.	415.	5214.
-6.00	1585.	3517.	280.	432.	5422.
-7.00	1585.	3332.	304.	442.	4643.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS
DATE: 25-FEBRUARY-2021 TIME: 13:15:21

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* COMPLETE OF RESULTS FOR  *
*   ANCHORED WALL DESIGN   *
*   BY FIXED EARTH METHOD  *
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I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP19-23-UNUSUAL LOADS

II.--RESULTS (ANCHOR FORCE= 8553. (LB))

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
21.00	0.0000E+00	0.	-2.2441E+09	0.00
20.00	1.3469E+01	40.	-1.8372E+09	80.81
19.00	1.0775E+02	162.	-1.4302E+09	161.62
18.00	3.6365E+02	364.	-1.0230E+09	242.43
17.00	8.6199E+02	646.	-6.1510E+08	323.25
16.00	1.6836E+03	1010.	-2.0570E+08	404.06
15.50+	2.2408E+03	1222.	0.0000E+00	444.46
15.50-	2.2408E+03	-7331.	0.0000E+00	444.46
15.00	-1.3672E+03	-7098.	2.0636E+08	484.87
14.00	-8.2095E+03	-6573.	6.1582E+08	565.68
13.00	-1.4486E+04	-5967.	1.0112E+09	646.49
12.00	-2.0116E+04	-5280.	1.3816E+09	727.30
11.00	-2.5019E+04	-4512.	1.7174E+09	808.11
10.00	-2.9114E+04	-3664.	2.0100E+09	888.93
9.00	-3.2320E+04	-2734.	2.2525E+09	969.74
8.00	-3.4556E+04	-1724.	2.4392E+09	1050.55
7.00	-3.5741E+04	-633.	2.5664E+09	1131.36
6.00	-3.5795E+04	538.	2.6320E+09	1212.17
5.00	-3.4637E+04	1791.	2.6359E+09	1292.98
4.00	-3.2186E+04	3124.	2.5802E+09	1373.79
3.65	-3.1008E+04	3610.	2.5473E+09	1402.08
3.00	-2.8379E+04	4458.	2.4690E+09	1207.62
2.65	-2.6747E+04	4859.	2.4181E+09	1082.16
2.00	-2.3377E+04	5483.	2.3089E+09	838.07
1.00	-1.7530E+04	6156.	2.1086E+09	506.76
0.00	-1.1177E+04	6497.	1.8781E+09	175.44
-0.53	-7.7200E+03	6543.	1.7475E+09	0.00
-1.00	-4.6473E+03	6506.	1.6283E+09	-155.88
-2.00	1.7259E+03	6185.	1.3704E+09	-487.19
-3.00	7.6120E+03	5532.	1.1155E+09	-818.51
-3.77	1.1606E+04	4811.	9.2753E+08	-1055.54
-4.00	1.2684E+04	4561.	8.7353E+08	-1117.57
-5.00	1.6654E+04	3348.	6.5336E+08	-1308.67
-6.00	1.9315E+04	1943.	4.6178E+08	-1499.77
-7.00	2.0541E+04	541.	3.0337E+08	-1304.48
-8.00	2.0437E+04	-741.	1.8026E+08	-1259.60
-9.00	1.9013E+04	-2161.	9.2286E+07	-1580.42
-10.00	1.6037E+04	-3816.	3.6938E+07	-1730.16
-11.00	1.1331E+04	-5621.	9.0533E+06	-1879.90
-12.00	4.7449E+03	-7576.	4.7750E+05	-2029.64
-13.00	0.0000E+00	-8779.	0.0000E+00	-2116.57

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF
ELLASTICITY IN PSI TIMES PILE MOMENT
OF INERTIA IN IN^4 TO OBTAIN DEFLECTION
IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
21.00	0.	0.	0.	0.	0.
20.00	64.	0.	0.	17.	185.
19.00	128.	0.	0.	34.	369.
18.00	192.	0.	0.	50.	554.
17.00	256.	0.	0.	67.	738.
16.00	320.	0.	0.	84.	923.
15.50	352.	0.	0.	92.	1015.
15.00	384.	0.	0.	101.	1108.
14.00	448.	0.	0.	118.	1292.
13.00	512.	0.	0.	134.	1477.
12.00	576.	0.	0.	151.	1661.
11.00	640.	0.	0.	168.	1846.
10.00	704.	0.	0.	185.	2031.
9.00	768.	0.	0.	202.	2215.
8.00	832.	0.	0.	219.	2400.
7.00	896.	0.	0.	235.	2585.
6.00	960.	0.	0.	252.	2769.
5.00	1024.	0.	0.	269.	2954.
4.00	1088.	0.	0.	286.	3138.
3.65	1110.	0.	0.	292.	3203.
3.00	1152.	265.	22.	320.	4190.
2.65	1174.	412.	33.	319.	4340.
2.00	1216.	677.	54.	299.	3761.
1.00	1280.	1089.	87.	316.	3969.
0.00	1344.	1501.	119.	332.	4176.
-0.53	1378.	1719.	137.	341.	4286.
-1.00	1408.	1913.	152.	349.	4384.
-2.00	1472.	2325.	185.	366.	4592.
-3.00	1536.	2737.	218.	382.	4799.
-3.77	1585.	3036.	242.	395.	4959.
-4.00	1585.	3101.	247.	399.	5007.
-5.00	1585.	3309.	263.	415.	5214.
-6.00	1585.	3517.	280.	432.	5422.
-7.00	1585.	3332.	304.	442.	4643.
-8.00	1585.	3328.	336.	483.	4546.
-9.00	1585.	3694.	361.	529.	5415.
-10.00	1585.	3860.	377.	545.	5580.
-11.00	1585.	4026.	393.	561.	5746.
-12.00	1585.	4192.	409.	577.	5912.

-13.00	1585.	4358.	425.	593.	6078.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:15:23

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******************************
* PRELIMINARY DESIGN DATA FOR *
*  FREE EARTH DESIGN IN SAND  *
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-UNUSUAL LOADS

II.--DESIGN PARAMETERS

WALL HEIGHT RATIO (ALPHA) = 0.63
ANCHOR HEIGHT RATIO (BETA) = 0.20

SHEET PILE DATA:

SHEET PILE NAME	<SECTION PROPERTIES> (PER FOOT OF WALL) SECTION MODULUS (IN^3)	MOMENT OF INERTIA (IN^4)	ALLOWABLE STRESS (PSI)	MODULUS OF ELLASTICITY (PSI)
PZ40	60.70	490.80	2.40E+04	2.90E+07
PZ38	46.80	280.80	2.40E+04	2.90E+07
PZ35	48.50	361.20	2.40E+04	2.90E+07
PZ32	38.30	220.40	2.40E+04	2.90E+07
PZ27	30.20	184.20	2.40E+04	2.90E+07
PZ22	18.10	84.40	2.40E+04	2.90E+07
PLZ25	32.80	223.25	2.40E+04	2.90E+07
PLZ23	30.20	203.75	2.40E+04	2.90E+07

III.--PRELIMINARY DESIGN DATA

SHEET PILE NAME	LOG(H^4/EI)	ROWE'S MOMENT REDUCTION COEF.		RATIO OF ALLOWABLE MOMENT TO REDUCED FREE EARTH MOMENT	
		LOOSE	DENSE	LOOSE	DENSE
PZ40	-4.38	1.00*	1.00*	2.73	2.73

PZ38	-4.14	1.00*	1.00*	2.10	2.10
PZ35	-4.25	1.00*	1.00*	2.18	2.18
PZ32	-4.03	1.00*	1.00*	1.72	1.72
PZ27	-3.96	1.00*	1.00*	1.36	1.36
PZ22	-3.62	1.00*	1.00*	0.81	0.81
PLZ25	-4.04	1.00*	1.00*	1.47	1.47
PLZ23	-4.00	1.00*	1.00*	1.36	1.36

* REDUCTION NOT APPLICABLE DUE TO
LOG(H^4/EI) LESS THAN -3.5 OR GREATER THEN -1.5.

WP21~WP26: EARTHQUAKE LOADING: Mmax,Smax,Tanchor and Deflection for Structural Design

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:20:58

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*  INPUT DATA  *
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I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP19-23-SEISMIC LOADS

II.--CONTROL
ANCHORED WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.00

III.--WALL DATA
ELEVATION AT TOP OF WALL = 21.00 FT.
ELEVATION AT ANCHOR = 15.50 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	21.00

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	3.65

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
151.77	149.28	31.20	0.00	10.00	0.00	3.00	0.00	DEF	DEF
155.50	153.00	32.90	0.00	10.00	0.00	-7.00	0.00	DEF	DEF
146.79	143.10	30.30	0.00	10.00	0.00	-37.00	0.00	DEF	DEF
155.50	151.77	32.60	0.00	10.00	0.00	-44.50	0.00	DEF	DEF
186.60	180.38	45.00	8000.00	15.00	4000.00			DEF	DEF

V.B.--LEFTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
92.23	90.72	31.20	0.00	10.00	0.00	3.00	0.00	DEF	DEF
94.50	91.50	32.90	0.00	10.00	0.00	-7.00	0.00	DEF	DEF
89.20	85.50	30.30	0.00	10.00	0.00	-37.00	0.00	DEF	DEF
94.50	93.00	32.60	0.00	10.00	0.00	-44.50	0.00	DEF	DEF
113.40	109.70	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 3.28 (FT)
LEFTSIDE ELEVATION = -3.77 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

VII.A.--VERTICAL LINE LOADS
NONE

VII.B.--VERTICAL UNIFORM LOADS
NONE

VII.C.--VERTICAL STRIP LOADS

VII.C.1.--RIGHTSIDE

<-DIST. FROM WALL-> START (FT)	END (FT)	STRIP LOAD (PSF)
0.00	60.00	250.00

VII.C.2.--LEFTSIDE
NONE

VII.D.--VERTICAL RAMP LOADS
NONE

VII.E.--VERTICAL TRIANGULAR LOADS
NONE

VII.F.--VERTICAL VARIABLE LOADS
NONE

VIII.--HORIZONTAL LOADS
NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:21:11

****
* SOIL PRESSURES FOR *
* ANCHORED WALL DESIGN *
****

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-SEISMIC LOADS

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

	NET	<---LEFTSIDE--->		<------NET------> (SOIL + WATER)	<--RIGHTSIDE--->	
ELEV.	WATER	PASSIVE	ACTIVE	ACTIVE	ACTIVE	PASSIVE
(FT)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)
21.0	0.0	0.0	0.0	0.0	0.0	0.0
20.0	0.0	0.0	0.0	115.7	115.7	1726.3
19.0	0.0	0.0	0.0	159.0	159.0	2371.7
18.0	0.0	0.0	0.0	202.3	202.3	3017.1
17.0	0.0	0.0	0.0	245.5	245.5	3662.5
16.0	0.0	0.0	0.0	288.8	288.8	4307.9
15.5	0.0	0.0	0.0	310.4	310.4	4630.6
15.0	0.0	0.0	0.0	332.1	332.1	4953.3
14.0	0.0	0.0	0.0	375.3	375.3	5598.7
13.0	0.0	0.0	0.0	418.6	418.6	6244.2
12.0	0.0	0.0	0.0	461.9	461.9	6889.6
11.0	0.0	0.0	0.0	505.2	505.2	7535.0
10.0	0.0	0.0	0.0	548.4	548.4	8180.4
9.0	0.0	0.0	0.0	591.7	591.7	8825.8
8.0	0.0	0.0	0.0	635.0	635.0	9471.2
7.0	0.0	0.0	0.0	678.2	678.2	10116.6
6.0	0.0	0.0	0.0	721.5	721.5	10762.0
5.0	0.0	0.0	0.0	764.8	764.8	11407.4
4.0	0.0	0.0	0.0	808.0	808.0	12052.9
3.7	0.0	0.0	0.0	823.2	823.2	12278.8

3.3	0.0	145.1	9.7	692.6	837.8	12496.4
3.0	17.9	270.2	16.5	633.5	885.7	16518.8
2.7	40.3	431.4	24.7	502.3	893.4	18854.8
2.0	81.9	707.9	40.8	189.9	815.9	14167.9
1.4	117.5	947.2	54.5	0.0	829.7	14407.2
1.0	145.9	1138.4	65.6	-151.8	840.7	14598.4
0.0	209.9	1568.9	90.4	-493.5	865.5	15028.9
-1.0	273.9	1999.4	115.1	-835.2	890.3	15459.4
-2.0	337.9	2429.9	139.9	-1176.9	915.1	15603.8
-3.0	401.9	2860.4	164.7	-1518.6	939.9	15459.5
-3.8	451.2	3166.5	182.4	-1756.3	959.0	15569.0
-4.0	451.2	3224.9	185.7	-1809.0	964.7	15668.1
-5.0	451.2	3368.4	194.0	-1927.7	989.5	16099.3
-6.0	451.2	3511.9	202.2	-2046.4	1014.3	16530.4
-7.0	451.2	3068.3	215.5	-1603.5	1013.7	12008.3
-8.0	451.2	2963.0	234.5	-1417.6	1094.2	11350.2
-9.0	451.2	3425.2	248.2	-1773.8	1200.1	15602.4
-10.0	451.2	3529.5	255.8	-1853.3	1225.0	15947.5
-11.0	451.2	3633.8	263.3	-1932.8	1249.8	16292.7
-12.0	451.2	3738.1	270.9	-2012.3	1274.6	16637.9
-13.0	451.2	3842.5	278.4	-2091.8	1299.5	16983.1
-14.0	451.2	3946.8	286.0	-2171.3	1324.3	17328.3
-15.0	451.2	4051.1	293.6	-2250.8	1349.1	17673.4
-16.0	451.2	4155.4	301.1	-2330.3	1374.0	17968.2
-17.0	451.2	4259.8	308.7	-2409.8	1398.8	18247.9
-18.0	451.2	4364.1	316.2	-2489.2	1423.7	18576.6
-19.0	451.2	4468.4	323.8	-2568.7	1448.5	18919.4
-20.0	451.2	4572.8	331.4	-2648.2	1473.3	19262.1
-21.0	451.2	4677.1	338.9	-2727.7	1498.2	19604.9
-22.0	451.2	4781.4	346.5	-2807.2	1523.0	19929.1
-23.0	451.2	4885.7	354.0	-2886.7	1547.8	20236.9
-24.0	451.2	4990.1	361.6	-2966.2	1572.7	20563.3
-25.0	451.2	5094.4	369.2	-3045.7	1597.5	20906.1
-26.0	451.2	5198.7	376.7	-3125.2	1622.4	21248.8
-27.0	451.2	5303.0	384.3	-3204.7	1647.2	21591.6
-28.0	451.2	5407.4	391.8	-3284.2	1672.0	21934.3
-29.0	451.2	5511.7	399.4	-3363.6	1696.9	22277.1
-30.0	451.2	5616.0	407.0	-3443.1	1721.7	22619.8
-31.0	451.2	5720.4	414.5	-3522.6	1746.5	22962.6
-32.0	451.2	5824.7	422.1	-3602.1	1771.4	23333.1
-33.0	451.2	5929.0	429.6	-3681.6	1796.2	23728.0
-34.0	451.2	6033.3	437.2	-3761.1	1821.0	24095.3
-35.0	451.2	6137.7	444.8	-3840.6	1845.9	24438.0
-36.0	451.2	6242.0	452.3	-3920.1	1870.7	24780.8
-37.0	451.2	9071.6	488.8	-6545.1	2075.4	38994.5
-38.0	451.2	9582.3	477.2	-7112.1	2019.1	40944.3
-39.0	451.2	7386.3	437.2	-5151.9	1783.1	29063.6
-40.0	451.2	7527.6	445.5	-5268.2	1808.2	29487.6
-41.0	451.2	7668.9	453.9	-5384.4	1833.3	29911.7
-42.0	451.2	7810.3	462.3	-5500.7	1858.4	30335.7

-43.0	451.2	7951.6	470.6	-5616.9	1883.5	30759.7
-44.0	451.2	8092.9	479.0	-5733.1	1908.6	31183.7
-44.1+	451.2	353493.6	0.0	-209439.5	1735.5	88157.4
-44.1-	451.2	69758.7	0.0	-209439.5	1735.5	88157.4
-44.5	451.2	353493.6	0.0	-352103.5	939.0	350303.7
-44.7+	451.2	347462.4	0.0	-347011.2	0.0	494032.0
-44.7-	451.2	347462.4	0.0	-347011.2	0.0	393558.7
-45.0	451.2	92005.4	0.0	-91554.2	0.0	494032.0
-46.0	451.2	92597.4	0.0	-92146.2	0.0	144477.6
-47.0	451.2	93881.5	0.0	-93430.3	0.0	146503.9
-48.0	451.2	95136.8	0.0	-94685.6	0.0	148513.9
-49.0	451.2	96364.8	0.0	-95913.6	0.0	150508.4

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE FOR THIS ELEVATION.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:21:12

****
* SUMMARY OF RESULTS FOR *
*   ANCHORED WALL DESIGN   *
****

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-SEISMIC LOADS

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

*****WARNING: STANDARD WEDGE SOLUTION DOES NOT EXIST AT ALL ELEVATIONS. SEE COMPLETE OUTPUT.

METHOD	:	FREE EARTH	FIXED EARTH
WALL BOTTOM ELEVATION (FT)	:	-2.93	-6.74
PENETRATION (FT)	:	6.58	10.39

MAXIMUM BENDING MOMENT (LB-FT)	:	-1.9559E+04	-1.4714E+04
AT ELEVATION (FT)	:	6.73	7.60
MAXIMUM SCALED DEFLECTION (LB-IN^3)	:	1.0948E+09	7.4825E+08
AT ELEVATION (FT)	:	7.00	7.00
ANCHOR FORCE (LB)	:	5.4033E+03	4.8225E+03

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:21:12

****
* COMPLETE OF RESULTS FOR *
* ANCHORED WALL DESIGN *
* BY FREE EARTH METHOD *
****

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-SEISMIC LOADS

II.--RESULTS (ANCHOR FORCE= 5403. (LB))

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
21.00	0.0000E+00	0.	-1.0082E+09	0.00
20.00	1.9289E+01	58.	-8.2605E+08	115.73
19.00	1.4223E+02	195.	-6.4387E+08	159.00
18.00	4.2418E+02	376.	-4.6142E+08	202.27
17.00	9.0839E+02	600.	-2.7820E+08	245.54
16.00	1.6381E+03	867.	-9.3388E+07	288.81
15.50+	2.1086E+03	1017.	0.0000E+00	310.44
15.50-	2.1086E+03	-4387.	0.0000E+00	310.44
15.00	-4.4986E+01	-4226.	9.4107E+07	332.08
14.00	-4.0977E+03	-3872.	2.8138E+08	375.35
13.00	-7.7751E+03	-3475.	4.6162E+08	418.61
12.00	-1.1034E+04	-3035.	6.2849E+08	461.88
11.00	-1.3831E+04	-2552.	7.7636E+08	505.15
10.00	-1.6123E+04	-2025.	9.0040E+08	548.42
9.00	-1.7866E+04	-1455.	9.9666E+08	591.69

8.00	-1.9018E+04	-841.	1.0621E+09	634.96
7.00	-1.9534E+04	-185.	1.0948E+09	678.23
6.00	-1.9373E+04	515.	1.0939E+09	721.50
5.00	-1.8490E+04	1258.	1.0596E+09	764.77
4.00	-1.6842E+04	2045.	9.9338E+08	808.04
3.65	-1.6076E+04	2330.	9.6319E+08	823.18
3.28	-1.5161E+04	2611.	9.2758E+08	692.64
3.00	-1.4403E+04	2796.	8.9823E+08	633.46
2.65	-1.3389E+04	2995.	8.5882E+08	502.28
2.00	-1.1358E+04	3220.	7.7828E+08	189.91
1.44	-9.5488E+03	3273.	7.0278E+08	0.00
1.00	-8.1000E+03	3239.	6.3873E+08	-151.80
0.00	-4.9939E+03	2916.	4.8516E+08	-493.50
-1.00	-2.3813E+03	2252.	3.2289E+08	-835.21
-2.00	-6.0391E+02	1246.	1.5638E+08	-1176.91
-2.93	0.0000E+00	0.	0.0000E+00	-1495.53

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES-------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
21.00	0.	0.	0.	0.	0.
20.00	0.	0.	0.	116.	1726.
19.00	0.	0.	0.	159.	2372.
18.00	0.	0.	0.	202.	3017.
17.00	0.	0.	0.	246.	3663.
16.00	0.	0.	0.	289.	4308.
15.50	0.	0.	0.	310.	4631.
15.00	0.	0.	0.	332.	4953.
14.00	0.	0.	0.	375.	5599.
13.00	0.	0.	0.	419.	6244.
12.00	0.	0.	0.	462.	6890.
11.00	0.	0.	0.	505.	7535.
10.00	0.	0.	0.	548.	8180.
9.00	0.	0.	0.	592.	8826.
8.00	0.	0.	0.	635.	9471.
7.00	0.	0.	0.	678.	10117.
6.00	0.	0.	0.	721.	10762.
5.00	0.	0.	0.	765.	11407.
4.00	0.	0.	0.	808.	12053.
3.65	0.	0.	0.	823.	12279.
3.28	0.	145.	10.	838.	12496.
3.00	18.	270.	17.	886.	16519.

2.65	40.	431.	25.	893.	18855.
2.00	82.	708.	41.	816.	14168.
1.44	117.	947.	55.	830.	14407.
1.00	146.	1138.	66.	841.	14598.
0.00	210.	1569.	90.	866.	15029.
-1.00	274.	1999.	115.	890.	15459.
-2.00	338.	2430.	140.	915.	15604.
-3.00	402.	2860.	165.	940.	15459.

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE AT THIS ELEVATION.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:21:12

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****************************
* COMPLETE OF RESULTS FOR  *
*   ANCHORED WALL DESIGN   *
*   BY FIXED EARTH METHOD  *
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I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP19-23-SEISMIC LOADS

II.--RESULTS (ANCHOR FORCE= 4823. (LB))

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
21.00	0.0000E+00	0.	-7.1744E+08	0.00
20.00	1.9289E+01	58.	-5.8817E+08	115.73
19.00	1.4223E+02	195.	-4.5885E+08	159.00
18.00	4.2418E+02	376.	-3.2926E+08	202.27
17.00	9.0839E+02	600.	-1.9891E+08	245.54
16.00	1.6381E+03	867.	-6.6957E+07	288.81
15.50+	2.1086E+03	1017.	0.0000E+00	310.44
15.50-	2.1086E+03	-3806.	0.0000E+00	310.44
15.00	2.4545E+02	-3645.	6.7697E+07	332.08
14.00	-3.2264E+03	-3291.	2.0265E+08	375.35
13.00	-6.3230E+03	-2894.	3.3208E+08	418.61
12.00	-9.0009E+03	-2454.	4.5065E+08	461.88
11.00	-1.1217E+04	-1971.	5.5372E+08	505.15
10.00	-1.2928E+04	-1444.	6.3749E+08	548.42
9.00	-1.4090E+04	-874.	6.9900E+08	591.69
8.00	-1.4661E+04	-260.	7.3625E+08	634.96

7.00	-1.4597E+04	396.	7.4825E+08	678.23
6.00	-1.3854E+04	1096.	7.3513E+08	721.50
5.00	-1.2390E+04	1839.	6.9817E+08	764.77
4.00	-1.0162E+04	2625.	6.3991E+08	808.04
3.65	-9.1930E+03	2911.	6.1516E+08	823.18
3.28	-8.0626E+03	3191.	5.8688E+08	692.64
3.00	-7.1426E+03	3377.	5.6420E+08	633.46
2.65	-5.9246E+03	3576.	5.3451E+08	502.28
2.00	-3.5162E+03	3801.	4.7625E+08	189.91
1.44	-1.3843E+03	3854.	4.2433E+08	0.00
1.00	3.2258E+02	3820.	3.8224E+08	-151.80
0.00	4.0095E+03	3497.	2.8877E+08	-493.50
-1.00	7.2030E+03	2833.	2.0216E+08	-835.21
-2.00	9.5613E+03	1827.	1.2788E+08	-1176.91
-3.00	1.0743E+04	479.	6.9947E+07	-1518.62
-3.77	1.0638E+04	-782.	3.7827E+07	-1756.32
-4.00	1.0411E+04	-1192.	3.0361E+07	-1809.03
-5.00	8.2948E+03	-3060.	8.5055E+06	-1927.74
-6.00	4.2509E+03	-5047.	7.0626E+05	-2046.45
-7.00	0.0000E+00	-6436.	0.0000E+00	-1719.66

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES-------------->			
		<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	WATER PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
21.00	0.	0.	0.	0.	0.
20.00	0.	0.	0.	116.	1726.
19.00	0.	0.	0.	159.	2372.
18.00	0.	0.	0.	202.	3017.
17.00	0.	0.	0.	246.	3663.
16.00	0.	0.	0.	289.	4308.
15.50	0.	0.	0.	310.	4631.
15.00	0.	0.	0.	332.	4953.
14.00	0.	0.	0.	375.	5599.
13.00	0.	0.	0.	419.	6244.
12.00	0.	0.	0.	462.	6890.
11.00	0.	0.	0.	505.	7535.
10.00	0.	0.	0.	548.	8180.
9.00	0.	0.	0.	592.	8826.
8.00	0.	0.	0.	635.	9471.
7.00	0.	0.	0.	678.	10117.
6.00	0.	0.	0.	721.	10762.
5.00	0.	0.	0.	765.	11407.

4.00	0.	0.	0.	808.	12053.
3.65	0.	0.	0.	823.	12279.
3.28	0.	145.	10.	838.	12496.
3.00	18.	270.	17.	886.	16519.
2.65	40.	431.	25.	893.	18855.
2.00	82.	708.	41.	816.	14168.
1.44	117.	947.	55.	830.	14407.
1.00	146.	1138.	66.	841.	14598.
0.00	210.	1569.	90.	866.	15029.
-1.00	274.	1999.	115.	890.	15459.
-2.00	338.	2430.	140.	915.	15604.
-3.00	402.	2860.	165.	940.	15459.
-3.77	451.	3166.	182.	959.	15569.
-4.00	451.	3225.	186.	965.	15668.
-5.00	451.	3368.	194.	989.	16099.
-6.00	451.	3512.	202.	1014.	16530.
-7.00	451.	3068.	216.	1014.	12008.

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE AT THIS ELEVATION.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:21:14

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* PRELIMINARY DESIGN DATA FOR *
*  FREE EARTH DESIGN IN SAND  *
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-SEISMIC LOADS

II.--DESIGN PARAMETERS

WALL HEIGHT RATIO (ALPHA) = 0.72

ANCHOR HEIGHT RATIO (BETA) = 0.23

SHEET PILE DATA:

<SECTION PROPERTIES>

(PER FOOT OF WALL)

SHEET PILE NAME	SECTION MODULUS (IN^3)	MOMENT OF INERTIA (IN^4)	ALLOWABLE STRESS (PSI)	MODULUS OF ELLASTICITY (PSI)
PZ40	60.70	490.80	2.40E+04	2.90E+07
PZ38	46.80	280.80	2.40E+04	2.90E+07
PZ35	48.50	361.20	2.40E+04	2.90E+07
PZ32	38.30	220.40	2.40E+04	2.90E+07
PZ27	30.20	184.20	2.40E+04	2.90E+07
PZ22	18.10	84.40	2.40E+04	2.90E+07
PLZ25	32.80	223.25	2.40E+04	2.90E+07
PLZ23	30.20	203.75	2.40E+04	2.90E+07

III.--PRELIMINARY DESIGN DATA

SHEET PILE NAME	LOG(H^4/EI)	ROWE'S MOMENT REDUCTION COEF.		RATIO OF ALLOWABLE MOMENT TO REDUCED FREE EARTH MOMENT	
		LOOSE	DENSE	LOOSE	DENSE
PZ40	-4.64	1.00*	1.00*	6.21	6.21
PZ38	-4.39	1.00*	1.00*	4.79	4.79
PZ35	-4.50	1.00*	1.00*	4.96	4.96
PZ32	-4.29	1.00*	1.00*	3.92	3.92
PZ27	-4.21	1.00*	1.00*	3.09	3.09
PZ22	-3.87	1.00*	1.00*	1.85	1.85
PLZ25	-4.30	1.00*	1.00*	3.35	3.35
PLZ23	-4.26	1.00*	1.00*	3.09	3.09

* REDUCTION NOT APPLICABLE DUE TO
LOG(H^4/EI) LESS THAN -3.5 OR GREATER THEN -1.5.

WP21~WP26: EARTHQUAKE LOADING: DETERMINATION OF PENETRATION

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:22:55

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*  INPUT DATA  *
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I.--HEADING
'SOUTH BATTERY PARK FLOODWALL WP19-23-SEISMIC LOADS

II.--CONTROL
ANCHORED WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.00
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.10

III.--WALL DATA
ELEVATION AT TOP OF WALL = 21.00 FT.
ELEVATION AT ANCHOR = 15.50 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	21.00

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	3.65

V.--SOIL LAYER DATA

V.A.--RIGHTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT
LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH-ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH-ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
151.77	149.28	31.20	0.00	10.00	0.00	3.00	0.00	DEF	DEF
155.50	153.00	32.90	0.00	10.00	0.00	-7.00	0.00	DEF	DEF
146.79	143.10	30.30	0.00	10.00	0.00	-37.00	0.00	DEF	DEF
155.50	151.77	32.60	0.00	10.00	0.00	-44.50	0.00	DEF	DEF
186.60	180.38	45.00	8000.00	15.00	4000.00			DEF	DEF

V.B.--LEFTSIDE
LEVEL 2 FACTOR OF SAFETY FOR ACTIVE PRESSURE = DEFAULT

LEVEL 2 FACTOR OF SAFETY FOR PASSIVE PRESSURE = DEFAULT

SAT. WGHT. (PCF)	MOIST WGHT. (PCF)	ANGLE OF INTERNAL FRICTION (DEG)	COH- ESION (PSF)	ANGLE OF WALL FRICTION (DEG)	ADH- ESION (PSF)	<--BOTTOM--> ELEV. (FT)	SLOPE (FT/FT)	<-SAFETY-> <-FACTOR-> ACT.	PASS.
92.23	90.72	31.20	0.00	10.00	0.00	3.00	0.00	DEF	DEF
94.50	91.50	32.90	0.00	10.00	0.00	-7.00	0.00	DEF	DEF
89.20	85.50	30.30	0.00	10.00	0.00	-37.00	0.00	DEF	DEF
94.50	93.00	32.60	0.00	10.00	0.00	-44.50	0.00	DEF	DEF
113.40	109.70	45.00	8000.00	15.00	4000.00			DEF	DEF

VI.--WATER DATA

UNIT WEIGHT = 64.00 (PCF)
RIGHTSIDE ELEVATION = 3.28 (FT)
LEFTSIDE ELEVATION = -3.77 (FT)
NO SEEPAGE

VII.--VERTICAL SURCHARGE LOADS

VII.A.--VERTICAL LINE LOADS

NONE

VII.B.--VERTICAL UNIFORM LOADS

NONE

VII.C.--VERTICAL STRIP LOADS

VII.C.1.--RIGHTSIDE

<-DIST. FROM WALL-> START (FT)	END (FT)	STRIP LOAD (PSF)
0.00	60.00	250.00

VII.C.2.--LEFTSIDE

NONE

VII.D.--VERTICAL RAMP LOADS

NONE

VII.E.--VERTICAL TRIANGULAR LOADS

NONE

VII.F.--VERTICAL VARIABLE LOADS

NONE

VIII.--HORIZONTAL LOADS

NONE

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:23:09

****
* SOIL PRESSURES FOR *
* ANCHORED WALL DESIGN *
****

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-SEISMIC LOADS

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

	NET	<---LEFTSIDE--->		<------NET------> (SOIL + WATER)	<--RIGHTSIDE--->	
ELEV. (FT)	WATER (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
21.0	0.0	0.0	0.0	0.0	0.0	0.0
20.0	0.0	0.0	0.0	115.7	115.7	1500.5
19.0	0.0	0.0	0.0	159.0	159.0	2061.5
18.0	0.0	0.0	0.0	202.3	202.3	2622.5
17.0	0.0	0.0	0.0	245.5	245.5	3183.6
16.0	0.0	0.0	0.0	288.8	288.8	3744.6
15.5	0.0	0.0	0.0	310.4	310.4	4025.1
15.0	0.0	0.0	0.0	332.1	332.1	4305.6
14.0	0.0	0.0	0.0	375.3	375.3	4866.6
13.0	0.0	0.0	0.0	418.6	418.6	5427.6
12.0	0.0	0.0	0.0	461.9	461.9	5988.6
11.0	0.0	0.0	0.0	505.2	505.2	6549.6
10.0	0.0	0.0	0.0	548.4	548.4	7110.6
9.0	0.0	0.0	0.0	591.7	591.7	7671.6
8.0	0.0	0.0	0.0	635.0	635.0	8232.6
7.0	0.0	0.0	0.0	678.2	678.2	8793.6
6.0	0.0	0.0	0.0	721.5	721.5	9354.6
5.0	0.0	0.0	0.0	764.8	764.8	9915.6
4.0	0.0	0.0	0.0	808.0	808.0	10476.7
3.7	0.0	0.0	0.0	823.2	823.2	10673.0

3.3	0.0	126.1	9.7	711.6	837.8	10862.2
3.0	17.9	233.4	16.5	670.2	885.7	13794.0
2.7	40.3	371.5	24.7	562.2	893.4	15531.9
2.0	81.9	610.4	40.8	287.4	815.9	12220.9
1.0	145.9	981.6	65.6	5.0	840.7	12587.2
1.0	147.1	988.2	66.0	0.0	841.2	12593.8
0.0	209.9	1352.8	90.4	-277.4	865.5	12958.4
-1.0	273.9	1724.0	115.1	-559.7	890.3	13329.6
-2.0	337.9	2095.2	139.9	-842.1	915.1	13700.8
-3.0	401.9	2466.3	164.7	-1124.5	939.9	14072.0
-3.8	451.2	2730.2	182.4	-1320.1	959.0	14357.8
-4.0	451.2	2780.6	185.7	-1364.7	964.7	14302.3
-5.0	451.2	2904.3	194.0	-1463.7	989.5	14024.4
-6.0	451.2	3028.1	202.2	-1562.6	1014.3	14351.7
-7.0	451.2	2727.3	215.5	-1262.4	1013.7	11001.7
-8.0	451.2	2653.4	234.5	-1108.0	1094.2	10442.8
-9.0	451.2	2987.7	248.2	-1336.4	1200.1	13562.4
-10.0	451.2	3078.7	255.8	-1402.6	1225.0	13862.5
-11.0	451.2	3169.7	263.3	-1468.7	1249.8	14162.5
-12.0	451.2	3260.7	270.9	-1534.9	1274.6	14462.5
-13.0	451.2	3351.7	278.4	-1601.1	1299.5	14762.5
-14.0	451.2	3442.7	286.0	-1667.2	1324.3	15062.5
-15.0	451.2	3533.7	293.6	-1733.4	1349.1	15362.5
-16.0	451.2	3624.7	301.1	-1799.6	1374.0	15662.5
-17.0	451.2	3715.7	308.7	-1865.7	1398.8	15962.6
-18.0	451.2	3806.7	316.2	-1931.9	1423.7	16262.6
-19.0	451.2	3897.7	323.8	-1998.0	1448.5	16562.6
-20.0	451.2	3988.7	331.4	-2064.2	1473.3	16862.6
-21.0	451.2	4079.7	338.9	-2130.4	1498.2	17162.6
-22.0	451.2	4170.8	346.5	-2196.5	1523.0	17447.6
-23.0	451.2	4261.8	354.0	-2262.7	1547.8	17719.3
-24.0	451.2	4352.8	361.6	-2328.9	1572.7	18006.1
-25.0	451.2	4443.8	369.2	-2395.0	1597.5	18306.1
-26.0	451.2	4534.8	376.7	-2461.2	1622.4	18606.1
-27.0	451.2	4625.8	384.3	-2527.4	1647.2	18906.1
-28.0	451.2	4716.8	391.8	-2593.5	1672.0	19206.1
-29.0	451.2	4807.8	399.4	-2659.7	1696.9	19506.1
-30.0	451.2	4898.8	407.0	-2725.9	1721.7	19806.2
-31.0	451.2	4989.8	414.5	-2792.0	1746.5	20106.2
-32.0	451.2	5080.8	422.1	-2858.2	1771.4	20428.7
-33.0	451.2	5171.8	429.6	-2924.4	1796.2	20771.1
-34.0	451.2	5262.8	437.2	-2990.5	1821.0	21091.0
-35.0	451.2	5353.8	444.8	-3056.7	1845.9	21382.0
-36.0	451.2	5444.8	452.3	-3122.9	1870.7	21644.2
-37.0	451.2	7520.0	488.8	-4993.5	2075.4	31091.2
-38.0	451.2	7936.5	477.2	-5466.2	2019.1	32667.3
-39.0	451.2	6384.2	437.2	-4149.9	1783.1	25100.6
-40.0	451.2	6506.4	445.5	-4247.0	1808.2	25466.9
-41.0	451.2	6628.6	453.9	-4344.0	1833.3	25833.1
-42.0	451.2	6750.7	462.3	-4441.1	1858.4	26199.4

-43.0	451.2	6872.9	470.6	-4538.2	1883.5	26565.7
-44.0	451.2	6995.0	479.0	-4635.2	1908.6	26931.9
-44.1+	451.2	247406.7	0.0	-146475.0	1735.5	66351.5
-44.1-	451.2	49916.7	0.0	-146475.0	1735.5	66351.5
-44.5	451.2	247406.7	0.0	-246016.5	939.0	247727.9
-44.7+	451.2	245345.7	0.0	-244894.5	0.0	350483.1
-44.7-	451.2	245345.7	0.0	-244894.5	0.0	278652.0
-45.0	451.2	72685.2	0.0	-72234.0	0.0	350483.1
-46.0	451.2	73622.3	0.0	-73171.1	0.0	115343.6
-47.0	451.2	74540.3	0.0	-74089.1	0.0	116855.6
-48.0	451.2	75438.1	0.0	-74986.9	0.0	118355.9
-49.0	451.2	76316.7	0.0	-75865.5	0.0	119845.1

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE FOR THIS ELEVATION.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:23:10

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****************************
*  SUMMARY OF RESULTS FOR  *
*   ANCHORED WALL DESIGN   *
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-SEISMIC LOADS

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

LEFTSIDE SOIL PRESSURES DETERMINED BY SWEEP SEARCH WEDGE METHOD.

*****WARNING: STANDARD WEDGE SOLUTION DOES NOT EXIST AT ALL ELEVATIONS. SEE COMPLETE OUTPUT.

METHOD	:	FREE EARTH	FIXED EARTH
WALL BOTTOM ELEVATION (FT)	:	-3.83	-8.20
PENETRATION (FT)	:	7.48	11.85

MAXIMUM BENDING MOMENT (LB-FT)	:	-2.1162E+04	-1.6236E+04
AT ELEVATION (FT)	:	6.47	7.31
MAXIMUM SCALED DEFLECTION (LB-IN^3)	:	1.2982E+09	9.0616E+08
AT ELEVATION (FT)	:	6.00	7.00
ANCHOR FORCE (LB)	:	5.5835E+03	5.0116E+03

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:23:10

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****************************
* COMPLETE OF RESULTS FOR  *
*   ANCHORED WALL DESIGN   *
*   BY FREE EARTH METHOD   *
****************************
```

I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-SEISMIC LOADS

II.--RESULTS (ANCHOR FORCE= 5583. (LB))

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
21.00	0.0000E+00	0.	-1.1522E+09	0.00
20.00	1.9289E+01	58.	-9.4390E+08	115.73
19.00	1.4223E+02	195.	-7.3553E+08	159.00
18.00	4.2418E+02	376.	-5.2689E+08	202.27
17.00	9.0839E+02	600.	-3.1749E+08	245.54
16.00	1.6381E+03	867.	-1.0648E+08	288.81
15.50+	2.1086E+03	1017.	0.0000E+00	310.44
15.50-	2.1086E+03	-4567.	0.0000E+00	310.44
15.00	-1.3503E+02	-4406.	1.0720E+08	332.08
14.00	-4.3679E+03	-4052.	3.2049E+08	375.35
13.00	-8.2253E+03	-3655.	5.2628E+08	418.61
12.00	-1.1664E+04	-3215.	7.1793E+08	461.88
11.00	-1.4641E+04	-2732.	8.8948E+08	505.15
10.00	-1.7113E+04	-2205.	1.0358E+09	548.42
9.00	-1.9036E+04	-1635.	1.1526E+09	591.69

8.00	-2.0368E+04	-1021.	1.2367E+09	634.96
7.00	-2.1065E+04	-365.	1.2856E+09	678.23
6.00	-2.1083E+04	335.	1.2982E+09	721.50
5.00	-2.0380E+04	1078.	1.2745E+09	764.77
4.00	-1.8913E+04	1865.	1.2157E+09	808.04
3.65	-1.8210E+04	2150.	1.1872E+09	823.18
3.28	-1.7361E+04	2434.	1.1530E+09	711.62
3.00	-1.6652E+04	2627.	1.1243E+09	670.23
2.65	-1.5694E+04	2843.	1.0853E+09	562.20
2.00	-1.3746E+04	3119.	1.0042E+09	287.44
1.00	-1.0530E+04	3265.	8.6047E+08	5.05
0.98	-1.0472E+04	3266.	8.5772E+08	0.00
0.00	-7.3095E+03	3129.	6.9850E+08	-277.35
-1.00	-4.3659E+03	2711.	5.2386E+08	-559.75
-2.00	-1.9821E+03	2010.	3.4160E+08	-842.14
-3.00	-4.4044E+02	1026.	1.5579E+08	-1124.54
-3.77	-2.7470E+00	85.	1.2013E+07	-1320.07
-3.83	0.0000E+00	0.	0.0000E+00	-1332.56

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES-------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION (FT)	PRESSURE (PSF)	PASSIVE (PSF)	ACTIVE (PSF)	ACTIVE (PSF)	PASSIVE (PSF)
21.00	0.	0.	0.	0.	0.
20.00	0.	0.	0.	116.	1501.
19.00	0.	0.	0.	159.	2062.
18.00	0.	0.	0.	202.	2623.
17.00	0.	0.	0.	246.	3184.
16.00	0.	0.	0.	289.	3745.
15.50	0.	0.	0.	310.	4025.
15.00	0.	0.	0.	332.	4306.
14.00	0.	0.	0.	375.	4867.
13.00	0.	0.	0.	419.	5428.
12.00	0.	0.	0.	462.	5989.
11.00	0.	0.	0.	505.	6550.
10.00	0.	0.	0.	548.	7111.
9.00	0.	0.	0.	592.	7672.
8.00	0.	0.	0.	635.	8233.
7.00	0.	0.	0.	678.	8794.
6.00	0.	0.	0.	721.	9355.
5.00	0.	0.	0.	765.	9916.
4.00	0.	0.	0.	808.	10477.
3.65	0.	0.	0.	823.	10673.

3.28	0.	126.	10.	838.	10862.
3.00	18.	233.	17.	886.	13794.
2.65	40.	372.	25.	893.	15532.
2.00	82.	610.	41.	816.	12221.
1.00	146.	982.	66.	841.	12587.
0.98	147.	988.	66.	841.	12594.
0.00	210.	1353.	90.	866.	12958.
-1.00	274.	1724.	115.	890.	13330.
-2.00	338.	2095.	140.	915.	13701.
-3.00	402.	2466.	165.	940.	14072.
-3.77	451.	2730.	182.	959.	14358.
-4.00	451.	2781.	186.	965.	14302.

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE AT THIS ELEVATION.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHOREDOR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:23:10

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****************************
* COMPLETE OF RESULTS FOR  *
*   ANCHORED WALL DESIGN   *
*   BY FIXED EARTH METHOD  *
****************************
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-SEISMIC LOADS

II.--RESULTS (ANCHOR FORCE= 5012. (LB))

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
21.00	0.0000E+00	0.	-8.4126E+08	0.00
20.00	1.9289E+01	58.	-6.8947E+08	115.73
19.00	1.4223E+02	195.	-5.3764E+08	159.00
18.00	4.2418E+02	376.	-3.8554E+08	202.27
17.00	9.0839E+02	600.	-2.3268E+08	245.54
16.00	1.6381E+03	867.	-7.8213E+07	288.81
15.50+	2.1086E+03	1017.	0.0000E+00	310.44
15.50-	2.1086E+03	-3995.	0.0000E+00	310.44
15.00	1.5092E+02	-3834.	7.8946E+07	332.08
14.00	-3.5100E+03	-3480.	2.3623E+08	375.35
13.00	-6.7956E+03	-3083.	3.8751E+08	418.61
12.00	-9.6625E+03	-2643.	5.2710E+08	461.88

11.00	-1.2068E+04	-2160.	6.5007E+08	505.15
10.00	-1.3968E+04	-1633.	7.5225E+08	548.42
9.00	-1.5319E+04	-1063.	8.3038E+08	591.69
8.00	-1.6079E+04	-450.	8.8212E+08	634.96
7.00	-1.6204E+04	207.	9.0616E+08	678.23
6.00	-1.5650E+04	907.	9.0231E+08	721.50
5.00	-1.4375E+04	1650.	8.7151E+08	764.77
4.00	-1.2336E+04	2436.	8.1599E+08	808.04
3.65	-1.1433E+04	2722.	7.9132E+08	823.18
3.28	-1.0372E+04	3006.	7.6262E+08	711.62
3.00	-9.5034E+03	3199.	7.3926E+08	670.23
2.65	-8.3448E+03	3415.	7.0826E+08	562.20
2.00	-6.0256E+03	3691.	6.4621E+08	287.44
1.00	-2.2378E+03	3837.	5.4278E+08	5.05
0.98	-2.1693E+03	3837.	5.4088E+08	0.00
0.00	1.5550E+03	3701.	4.3549E+08	-277.35
-1.00	5.0704E+03	3283.	3.3085E+08	-559.75
-2.00	8.0262E+03	2582.	2.3489E+08	-842.14
-3.00	1.0140E+04	1598.	1.5268E+08	-1124.54
-3.77	1.1018E+04	657.	1.0108E+08	-1320.07
-4.00	1.1134E+04	348.	8.7826E+07	-1364.74
-5.00	1.0783E+04	-1066.	4.2018E+07	-1463.68
-6.00	8.9691E+03	-2579.	1.4631E+07	-1562.61
-7.00	5.6589E+03	-3991.	2.5245E+06	-1262.42
-8.00	1.0620E+03	-5177.	1.2464E+04	-1108.03
-9.00	0.0000E+00	-5404.	0.0000E+00	-1153.89

NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<-------------SOIL PRESSURES------------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION	PRESSURE	PASSIVE	ACTIVE	ACTIVE	PASSIVE
(FT)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)
21.00	0.	0.	0.	0.	0.
20.00	0.	0.	0.	116.	1501.
19.00	0.	0.	0.	159.	2062.
18.00	0.	0.	0.	202.	2623.
17.00	0.	0.	0.	246.	3184.
16.00	0.	0.	0.	289.	3745.
15.50	0.	0.	0.	310.	4025.
15.00	0.	0.	0.	332.	4306.
14.00	0.	0.	0.	375.	4867.
13.00	0.	0.	0.	419.	5428.
12.00	0.	0.	0.	462.	5989.
11.00	0.	0.	0.	505.	6550.

10.00	0.	0.	0.	548.	7111.
9.00	0.	0.	0.	592.	7672.
8.00	0.	0.	0.	635.	8233.
7.00	0.	0.	0.	678.	8794.
6.00	0.	0.	0.	721.	9355.
5.00	0.	0.	0.	765.	9916.
4.00	0.	0.	0.	808.	10477.
3.65	0.	0.	0.	823.	10673.
3.28	0.	126.	10.	838.	10862.
3.00	18.	233.	17.	886.	13794.
2.65	40.	372.	25.	893.	15532.
2.00	82.	610.	41.	816.	12221.
1.00	146.	982.	66.	841.	12587.
0.98	147.	988.	66.	841.	12594.
0.00	210.	1353.	90.	866.	12958.
-1.00	274.	1724.	115.	890.	13330.
-2.00	338.	2095.	140.	915.	13701.
-3.00	402.	2466.	165.	940.	14072.
-3.77	451.	2730.	182.	959.	14358.
-4.00	451.	2781.	186.	965.	14302.
-5.00	451.	2904.	194.	989.	14024.
-6.00	451.	3028.	202.	1014.	14352.
-7.00	451.	2727.	216.	1014.	11002.
-8.00	451.	2653.	235.	1094.	10443.
-9.00	451.	2988.	248.	1200.	13562.

* STANDARD WEDGE SOLUTION DOES NOT EXIST FOR INDICATED PRESSURE AT THIS ELEVATION.

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS

DATE: 25-FEBRUARY-2021 TIME: 13:23:12

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******************************
* PRELIMINARY DESIGN DATA FOR *
*  FREE EARTH DESIGN IN SAND  *
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I.--HEADING

'SOUTH BATTERY PARK FLOODWALL WP19-23-SEISMIC LOADS

II.--DESIGN PARAMETERS

WALL HEIGHT RATIO (ALPHA) = 0.70
ANCHOR HEIGHT RATIO (BETA) = 0.22

SHEET PILE DATA:

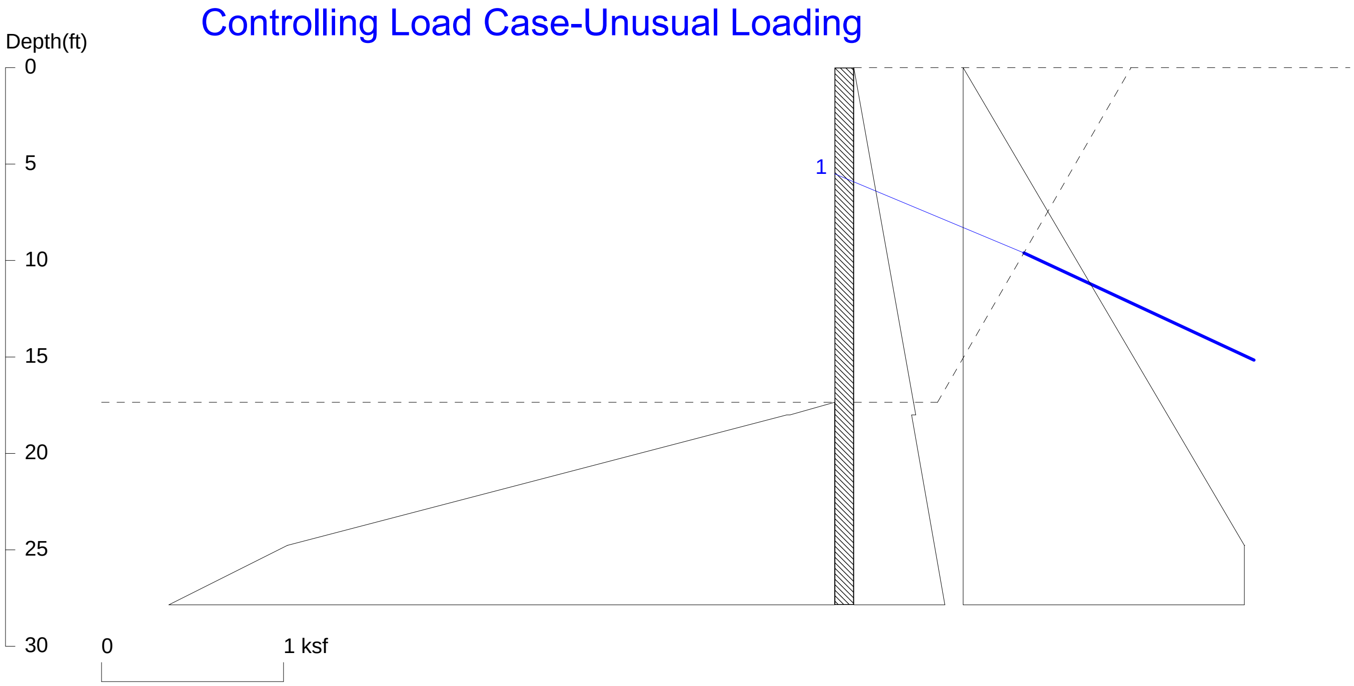
SHEET PILE NAME	<SECTION PROPERTIES> (PER FOOT OF WALL) SECTION MODULUS (IN^3)	MOMENT OF INERTIA (IN^4)	ALLOWABLE STRESS (PSI)	MODULUS OF ELLASTICITY (PSI)
PZ40	60.70	490.80	2.40E+04	2.90E+07
PZ38	46.80	280.80	2.40E+04	2.90E+07
PZ35	48.50	361.20	2.40E+04	2.90E+07
PZ32	38.30	220.40	2.40E+04	2.90E+07
PZ27	30.20	184.20	2.40E+04	2.90E+07
PZ22	18.10	84.40	2.40E+04	2.90E+07
PLZ25	32.80	223.25	2.40E+04	2.90E+07
PLZ23	30.20	203.75	2.40E+04	2.90E+07

III.--PRELIMINARY DESIGN DATA

SHEET PILE NAME	LOG(H^4/EI)	ROWE'S MOMENT REDUCTION COEF.		RATIO OF ALLOWABLE MOMENT TO REDUCED FREE EARTH MOMENT	
		LOOSE	DENSE	LOOSE	DENSE
PZ40	-4.57	1.00*	1.00*	5.74	5.74
PZ38	-4.33	1.00*	1.00*	4.42	4.42
PZ35	-4.44	1.00*	1.00*	4.58	4.58
PZ32	-4.23	1.00*	1.00*	3.62	3.62
PZ27	-4.15	1.00*	1.00*	2.85	2.85
PZ22	-3.81	1.00*	1.00*	1.71	1.71
PLZ25	-4.23	1.00*	1.00*	3.10	3.10
PLZ23	-4.19	1.00*	1.00*	2.85	2.85

* REDUCTION NOT APPLICABLE DUE TO
LOG(H^4/EI) LESS THAN -3.5 OR GREATER THEN -1.5.

Anchor Design for Sheeting in Wagner Park between WP21~WP26



<ShoringSuite> CIVILTECH SOFTWARE USA www.civiltech.com

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File: C:\Documents and Settings\SGao\Desktop\Anchor Design-Wagner Park\Anchor Wall in Wagner Park.sh8

Wall Height=17.4 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=10.50 Min. Pile Length=27.85
MOMENT IN PILE: Max. Moment=45.34 per Pile Spacing=1.0 at Depth=15.34

PILE SELECTION:
Request Min. Section Modulus = 22.9 in3/ft=1231.06 cm3/m, Fy= 36 ksi = 248 MPa, Fb/Fy=0.66
-> Piles meet Min. Section Requirements: Top Deflection is shown in (in)
SZ350 (-0.76) AZ13 (-0.65) SZ375 (-0.71) FSP6L (-0.15) AZ14 (-0.60)
SZ222 (-0.55) SZ24 (-0.51) SZ24A (-0.51) SZ25 (-0.52) CZ114D (-0.47)
3N(M) (-0.56) PLZ23 (-0.46) PZ27 (-0.51) BZ16.4 (-0.52)

BRACE FORCE: Strut, Tieback, Plate Anchor, Deadman, Sheet Pile as Anchor

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	L_free	Fixed Length
1. Tieback	5.5	25.0	8.0	84.6	76.6	35.7	9.7	23.4

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	17.35	0.328	0.018920
*	Below	Base		
17.35	0.328	18.00	0.341	0.018920
18.00	0.318	28.00	0.503	0.018528
*	Water	Pres.		
0.000	0.000	24.77	1.546	0.062400
24.77	1.546	156.1	1.546	0.000000

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		

17.35	0.000	18.00	0.246	0.378005
18.00	0.263	24.77	3.008	0.405468
24.77	3.008	28.00	3.692	0.211506

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	17.35	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

APPENDIX K-4

SHEET PILE WALL ANALYSES
K-4: GLOBAL STABILITY ANALYSES

APPENDIX K4-GLOBAL STABILITY ANALYSIS FOR I-TYPE WALL

This appendix presents the global stability analyses performed for the proposed sheet pile wall (I-Type Wall) in accordance with Design of Sheet Pile Walls (EM 1110-2504) and Evaluation of I-Walls (ETL 1110-2-575) by U.S. Army Corps of Engineers.

Two analyses were performed:

- For floodwall near MJH: Soil Properties -Table 10, Tip Elevation: -12.0
- For floodwall in Wagner Park: Soil Properties-Table 11, Tip Elevation: -14.0

The grades on both sides of the wall and water level considered in the analyses are presented in the following Figures 1 and 2.

Based on the analyses, the calculated factor of safety of the global stability for the two cases are 4.55 and 2.52, respectively which are higher than the acceptable factor of safety of 1.5 according to Engineering and Design Manual-Slope Stability by U.S. Army Corps of Engineers (EM 1110-2-1902). Therefore, it is concluded here that the proposed I-type wall is adequate against the deep-seated mode of failure described in Engineering and Design Manual-Design of Sheet Pile Walls by U.S. Army Corps of Engineers (EM 1110-2-2504). See the attachment for the detailed calculations.

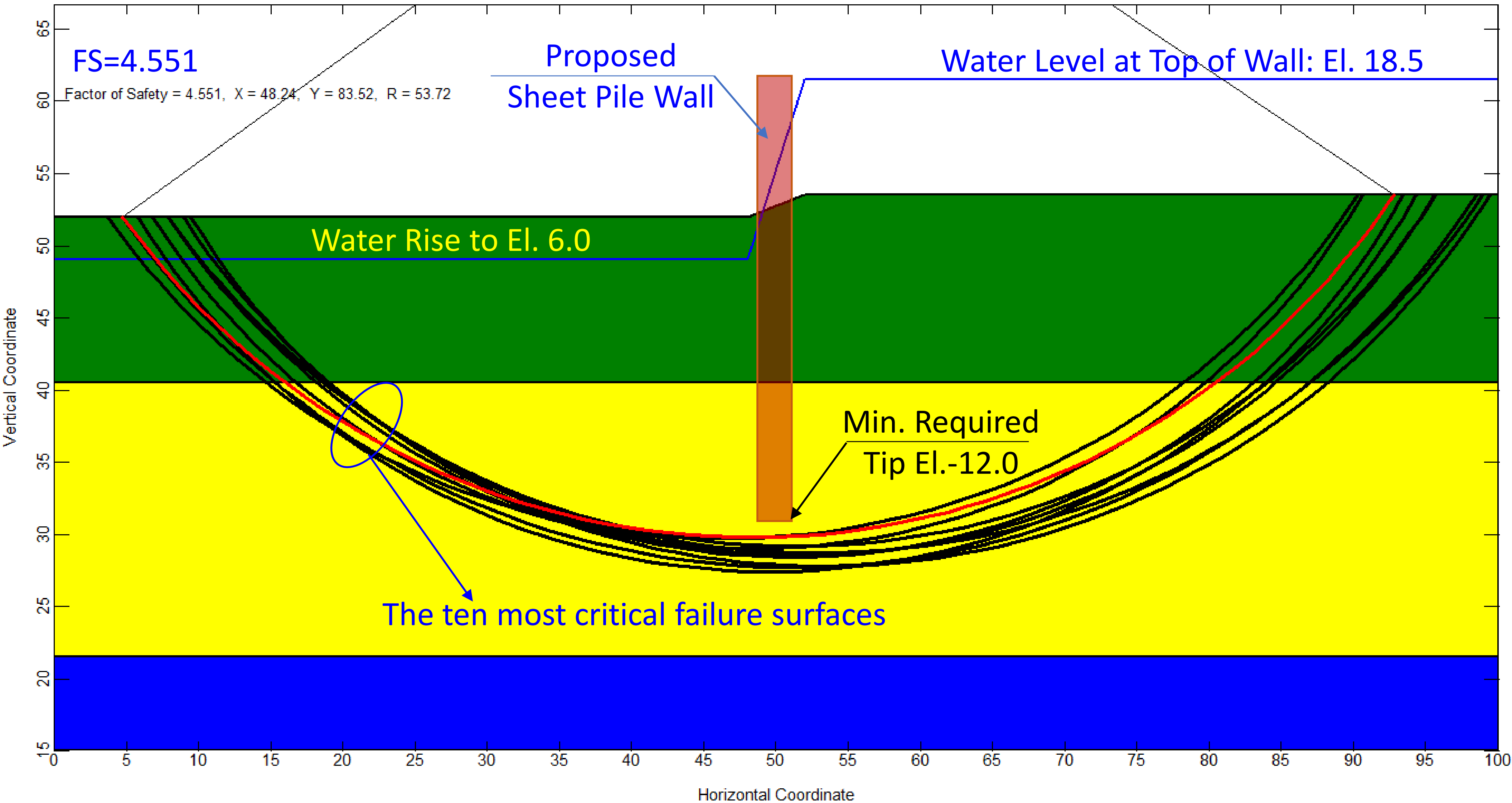

Figure 1: Global Stability for Sheet Pile Wall (I-Type Wall) Near MJH Based on Soil Properties Summarized in Table 10.

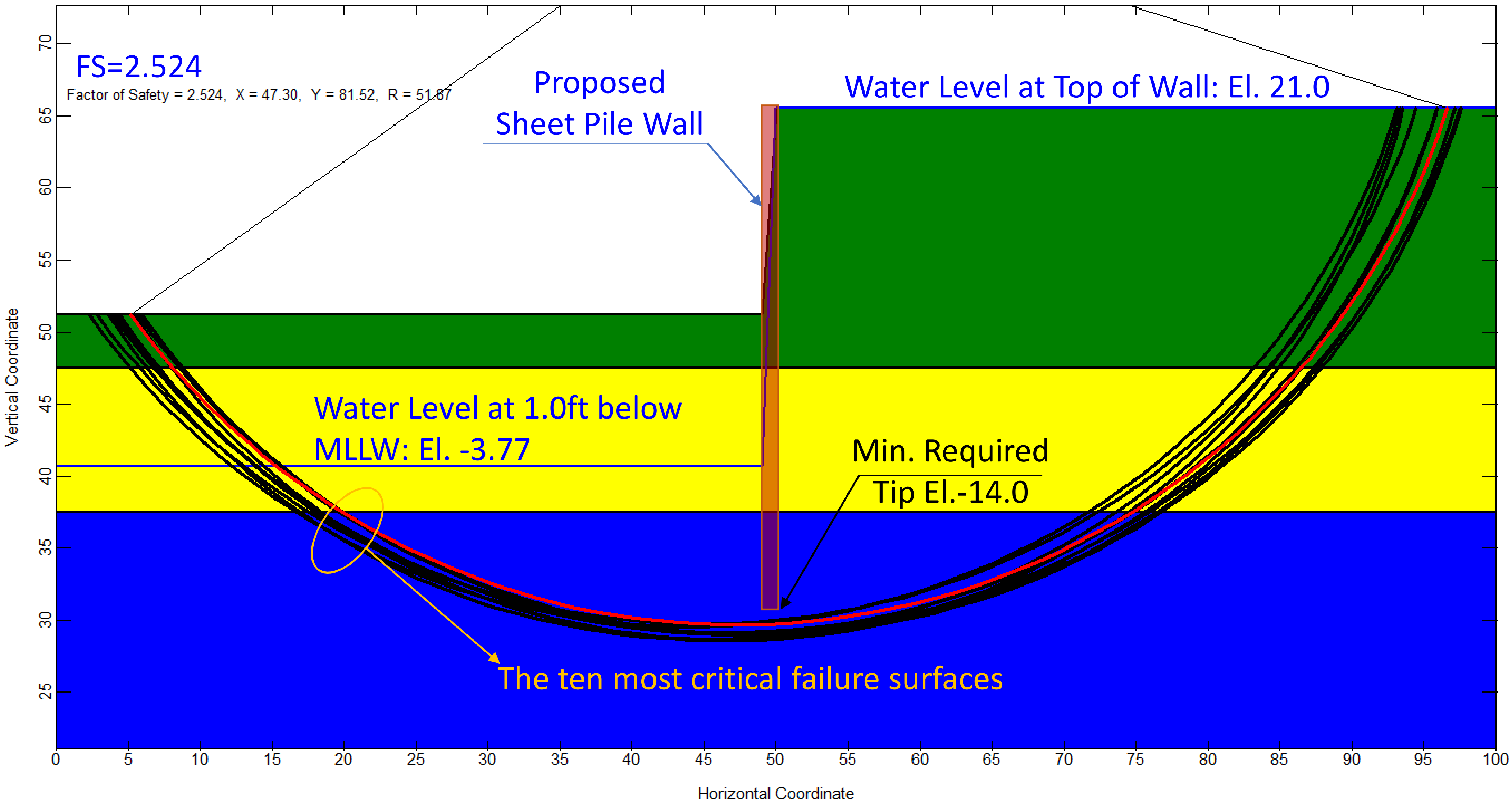

Figure 2: Global Stability for Sheet Pile Wall (I-Type Wall) in Wagner Park Based on Soil Properties Summarized in Table 11.

GLOBAL STABILITY FOR FLOODWALL NEAR MJH BASED ON SOIL PROPERTIES SUMMARIZED IN TABLE 10

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                STABLPro for Windows, Version 2015.4.5

                        Upgraded from:
                        FHWA-PCSTABLE

                 Serial Number :  225625906

                   --Slope Stability Analysis--
                 Simplified Janbu, Simplified Bishop
                   or Spencer Method of Slices

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


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     Path to file locations      : R:\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00
South Battery Park Resiliancy\REPORT\Report calcs\Global Stability\
     Name of input data file     : I-Wall Stability -1 Soil Properties Table 9.sl4d
     Name of output file         : I-Wall Stability -1 Soil Properties Table 9.sl4o
     Name of plot output file    : I-Wall Stability -1 Soil Properties Table 9.sl4p

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

          Date:  December 29, 2020     Time:  10:42:03



1
        PROBLEM DESCRIPTION   New Slope




        BOUNDARY COORDINATES

            3 Top   Boundaries
            8 Total Boundaries


        Boundary     X-Left     Y-Left    X-Right    Y-Right    Soil Type
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No.	ft.	ft.	ft.	ft.	Below Bnd
1	0.00	52.00	48.00	52.00	1
2	48.00	52.00	52.00	53.50	1
3	52.00	53.50	100.00	53.50	1
4	0.00	40.50	100.00	40.50	2
5	0.00	21.50	100.00	21.50	3
6	0.00	8.50	100.00	8.50	4
7	0.00	4.50	100.00	4.50	5
8	0.00	0.00	100.00	0.00	6

1

ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

Soil Type No.	Total Unit Wt. pcf	Saturated Unit Wt. pcf	Cohesion Intercept psf	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant psf	Piez. Surface No.
1	120.0	125.0	0.0	33.2	0.00	0.0	1
2	112.0	115.0	0.0	30.0	0.00	0.0	1
3	115.0	120.0	0.0	31.8	0.00	0.0	1
4	104.0	107.0	600.0	0.0	0.00	0.0	1
5	114.0	120.0	0.0	30.9	0.00	0.0	1
6	142.0	150.0	10000.0	40.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 63.90 pcf

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water ft.	Y-Water ft.
1	0.00	49.00
2	48.00	49.00
3	52.00	61.50
4	100.00	61.50

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

200 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 20 Points Equally Spaced
Along The Ground Surface Between X = 0.00 ft.
and X = 10.00 ft.

Each Surface Terminates Between X = 90.00 ft.
and X = 100.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.

1.50 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation.
The Angle Has Been Restricted Between The Angles Of -82.0
And -53.0 deg.

1

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 70 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	4.74	52.00
2	5.63	50.80
3	6.56	49.62
4	7.53	48.47

5	8.52	47.35
6	9.55	46.25
7	10.60	45.19
8	11.69	44.15
9	12.80	43.15
10	13.94	42.17
11	15.11	41.23
12	16.30	40.32
13	17.52	39.45
14	18.76	38.61
15	20.03	37.80
16	21.32	37.03
17	22.63	36.30
18	23.95	35.60
19	25.30	34.94
20	26.67	34.32
21	28.05	33.74
22	29.45	33.19
23	30.86	32.69
24	32.29	32.22
25	33.72	31.80
26	35.17	31.41
27	36.63	31.07
28	38.10	30.77
29	39.58	30.50
30	41.06	30.28
31	42.55	30.10
32	44.05	29.96
33	45.54	29.87
34	47.04	29.81
35	48.54	29.80
36	50.04	29.83
37	51.54	29.90
38	53.04	30.02
39	54.53	30.17
40	56.01	30.37
41	57.50	30.60
42	58.97	30.88
43	60.43	31.20
44	61.89	31.56
45	63.34	31.97
46	64.77	32.41
47	66.19	32.89
48	67.60	33.41
49	68.99	33.97
50	70.36	34.57
51	71.72	35.21
52	73.06	35.88
53	74.38	36.59
54	75.68	37.34

55	76.96	38.12
56	78.22	38.94
57	79.45	39.80
58	80.66	40.69
59	81.84	41.61
60	83.00	42.56
61	84.13	43.55
62	85.23	44.57
63	86.30	45.61
64	87.35	46.69
65	88.36	47.80
66	89.34	48.93
67	90.29	50.09
68	91.21	51.28
69	92.09	52.49
70	92.78	53.50

Circle Center At X = 48.2 ; Y = 83.5 and Radius, 53.7

*** 4.551 ***

Individual data on the 74 slices

Slice No.	Width Ft	Weight Lbs	Water Force Top Lbs	Water Force Bot Lbs	Tie Force Norm Lbs	Tie Force Tan Lbs	Earthquake Force Hor Lbs	Earthquake Force Ver Lbs	Surcharge Load Lbs
1	0.9	0.65E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	0.9	0.20E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	0.5	0.17E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	0.4	0.17E+03	0.00E+00	0.12E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	1.0	0.49E+03	0.00E+00	0.10E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	1.0	0.65E+03	0.00E+00	0.21E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7	1.1	0.81E+03	0.00E+00	0.31E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8	1.1	0.98E+03	0.00E+00	0.42E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
9	1.1	0.11E+04	0.00E+00	0.51E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	1.1	0.13E+04	0.00E+00	0.61E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	1.2	0.15E+04	0.00E+00	0.70E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	1.0	0.13E+04	0.00E+00	0.63E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13	0.2	0.33E+03	0.00E+00	0.16E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
14	1.2	0.18E+04	0.00E+00	0.87E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	1.2	0.20E+04	0.00E+00	0.96E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
16	1.3	0.21E+04	0.00E+00	0.10E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	1.3	0.23E+04	0.00E+00	0.11E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

18	1.3	0.24E+04	0.00E+00	0.12E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
19	1.3	0.26E+04	0.00E+00	0.13E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	1.3	0.27E+04	0.00E+00	0.13E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
21	1.4	0.29E+04	0.00E+00	0.14E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22	1.4	0.30E+04	0.00E+00	0.14E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23	1.4	0.31E+04	0.00E+00	0.15E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	1.4	0.32E+04	0.00E+00	0.15E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	1.4	0.33E+04	0.00E+00	0.16E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
26	1.4	0.35E+04	0.00E+00	0.16E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
27	1.4	0.35E+04	0.00E+00	0.17E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
28	1.5	0.36E+04	0.00E+00	0.17E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
29	1.5	0.37E+04	0.00E+00	0.17E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	1.5	0.38E+04	0.00E+00	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
31	1.5	0.38E+04	0.00E+00	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
32	1.5	0.39E+04	0.00E+00	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
33	1.5	0.39E+04	0.00E+00	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
34	1.5	0.40E+04	0.00E+00	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	1.5	0.40E+04	0.00E+00	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
36	1.0	0.25E+04	0.00E+00	0.12E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
37	0.5	0.14E+04	0.00E+00	0.69E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
38	1.5	0.41E+04	0.56E+02	0.22E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
39	1.5	0.42E+04	0.48E+03	0.27E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40	0.5	0.13E+04	0.23E+03	0.91E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
41	1.0	0.29E+04	0.53E+03	0.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
42	1.5	0.42E+04	0.76E+03	0.30E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
43	1.5	0.42E+04	0.76E+03	0.30E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
44	1.5	0.41E+04	0.76E+03	0.30E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45	1.5	0.40E+04	0.75E+03	0.29E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
46	1.5	0.40E+04	0.75E+03	0.29E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
47	1.5	0.39E+04	0.74E+03	0.29E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
48	1.4	0.38E+04	0.74E+03	0.29E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
49	1.4	0.37E+04	0.73E+03	0.28E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	1.4	0.36E+04	0.73E+03	0.28E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51	1.4	0.35E+04	0.72E+03	0.27E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
52	1.4	0.34E+04	0.71E+03	0.27E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53	1.4	0.32E+04	0.70E+03	0.26E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
54	1.4	0.31E+04	0.69E+03	0.26E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
55	1.3	0.29E+04	0.68E+03	0.25E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
56	1.3	0.28E+04	0.68E+03	0.24E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
57	1.3	0.26E+04	0.66E+03	0.24E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
58	1.3	0.25E+04	0.65E+03	0.23E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
59	1.3	0.23E+04	0.64E+03	0.22E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60	1.2	0.22E+04	0.63E+03	0.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
61	1.0	0.16E+04	0.49E+03	0.16E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
62	0.3	0.41E+03	0.13E+03	0.42E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
63	1.2	0.18E+04	0.60E+03	0.20E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
64	1.2	0.17E+04	0.59E+03	0.19E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
65	1.1	0.15E+04	0.58E+03	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
66	1.1	0.13E+04	0.56E+03	0.17E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
67	1.1	0.11E+04	0.55E+03	0.16E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

68	1.0	0.96E+03	0.53E+03	0.15E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
69	1.0	0.79E+03	0.52E+03	0.14E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
70	1.0	0.63E+03	0.50E+03	0.13E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
71	0.9	0.47E+03	0.49E+03	0.11E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
72	0.9	0.32E+03	0.47E+03	0.10E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
73	0.9	0.18E+03	0.45E+03	0.92E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
74	0.7	0.44E+02	0.35E+03	0.66E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Failure Surface Specified By 70 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	3.68	52.00
2	4.56	50.78
3	5.47	49.59
4	6.42	48.43
5	7.40	47.29
6	8.41	46.18
7	9.45	45.11
8	10.53	44.06
9	11.63	43.04
10	12.76	42.06
11	13.92	41.10
12	15.11	40.19
13	16.32	39.30
14	17.56	38.45
15	18.82	37.64
16	20.10	36.87
17	21.41	36.13
18	22.73	35.43
19	24.08	34.76
20	25.44	34.14
21	26.82	33.56
22	28.22	33.01
23	29.63	32.51
24	31.06	32.04
25	32.50	31.62
26	33.95	31.24
27	35.41	30.90
28	36.88	30.61
29	38.36	30.35
30	39.85	30.14
31	41.34	29.97
32	42.83	29.85
33	44.33	29.76
34	45.83	29.72
35	47.33	29.73

36	48.83	29.77
37	50.33	29.86
38	51.82	30.00
39	53.31	30.17
40	54.79	30.39
41	56.27	30.65
42	57.74	30.95
43	59.20	31.30
44	60.65	31.68
45	62.09	32.11
46	63.51	32.58
47	64.92	33.09
48	66.32	33.64
49	67.70	34.23
50	69.06	34.86
51	70.40	35.53
52	71.72	36.23
53	73.03	36.98
54	74.31	37.76
55	75.56	38.58
56	76.80	39.43
57	78.01	40.32
58	79.19	41.24
59	80.34	42.20
60	81.47	43.19
61	82.57	44.21
62	83.64	45.26
63	84.68	46.35
64	85.68	47.46
65	86.66	48.60
66	87.60	49.77
67	88.50	50.96
68	89.38	52.18
69	90.21	53.43
70	90.26	53.50

Circle Center At X = 46.5 ; Y = 81.9 and Radius, 52.2

*** 4.572 ***

1

Failure Surface Specified By 69 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.

1	6.84	52.00
2	7.66	50.74
3	8.51	49.51
4	9.40	48.30
5	10.33	47.12
6	11.29	45.97
7	12.28	44.85
8	13.32	43.76
9	14.38	42.70
10	15.48	41.68
11	16.60	40.69
12	17.76	39.73
13	18.94	38.81
14	20.16	37.93
15	21.40	37.09
16	22.66	36.28
17	23.95	35.51
18	25.26	34.79
19	26.60	34.10
20	27.95	33.45
21	29.33	32.85
22	30.72	32.29
23	32.12	31.77
24	33.55	31.30
25	34.98	30.87
26	36.43	30.48
27	37.89	30.14
28	39.36	29.85
29	40.84	29.59
30	42.33	29.39
31	43.82	29.23
32	45.32	29.11
33	46.82	29.05
34	48.32	29.03
35	49.81	29.05
36	51.31	29.12
37	52.81	29.24
38	54.30	29.40
39	55.79	29.61
40	57.26	29.86
41	58.73	30.16
42	60.19	30.50
43	61.64	30.89
44	63.08	31.32
45	64.50	31.80
46	65.91	32.32
47	67.30	32.88
48	68.67	33.49
49	70.02	34.13
50	71.36	34.82

51	72.67	35.55
52	73.96	36.32
53	75.22	37.13
54	76.46	37.97
55	77.67	38.86
56	78.85	39.78
57	80.01	40.73
58	81.14	41.73
59	82.23	42.75
60	83.29	43.81
61	84.32	44.90
62	85.32	46.02
63	86.28	47.18
64	87.20	48.36
65	88.09	49.57
66	88.94	50.80
67	89.75	52.06
68	90.53	53.35
69	90.61	53.50

Circle Center At X = 48.3 ; Y = 77.9 and Radius, 48.9

*** 4.574 ***

Failure Surface Specified By 71 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	7.90	52.00
2	8.76	50.78
3	9.67	49.58
4	10.60	48.41
5	11.57	47.26
6	12.57	46.15
7	13.61	45.06
8	14.67	44.00
9	15.76	42.97
10	16.88	41.98
11	18.03	41.01
12	19.21	40.08
13	20.41	39.19
14	21.64	38.33
15	22.89	37.50
16	24.17	36.71
17	25.46	35.95

18	26.78	35.24
19	28.12	34.56
20	29.48	33.92
21	30.85	33.32
22	32.24	32.75
23	33.65	32.23
24	35.07	31.75
25	36.50	31.31
26	37.95	30.91
27	39.40	30.55
28	40.87	30.23
29	42.34	29.95
30	43.82	29.72
31	45.31	29.53
32	46.80	29.38
33	48.30	29.27
34	49.80	29.21
35	51.30	29.19
36	52.80	29.21
37	54.30	29.27
38	55.79	29.38
39	57.29	29.53
40	58.77	29.72
41	60.26	29.95
42	61.73	30.23
43	63.20	30.55
44	64.65	30.91
45	66.10	31.31
46	67.53	31.75
47	68.95	32.23
48	70.36	32.75
49	71.75	33.32
50	73.12	33.92
51	74.48	34.56
52	75.82	35.24
53	77.13	35.95
54	78.43	36.71
55	79.71	37.50
56	80.96	38.33
57	82.19	39.19
58	83.39	40.08
59	84.57	41.01
60	85.71	41.98
61	86.84	42.97
62	87.93	44.00
63	88.99	45.06
64	90.03	46.15
65	91.03	47.26
66	92.00	48.41
67	92.93	49.58

68	93.84	50.78
69	94.70	52.00
70	95.54	53.25
71	95.70	53.50

Circle Center At X = 51.3 ; Y = 81.9 and Radius, 52.7

*** 4.586 ***

1

Failure Surface Specified By 69 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	9.47	52.00
2	10.26	50.72
3	11.09	49.47
4	11.96	48.25
5	12.87	47.05
6	13.81	45.89
7	14.78	44.75
8	15.80	43.64
9	16.84	42.57
10	17.92	41.52
11	19.03	40.52
12	20.17	39.54
13	21.34	38.60
14	22.54	37.70
15	23.77	36.84
16	25.02	36.01
17	26.30	35.23
18	27.60	34.48
19	28.92	33.78
20	30.27	33.11
21	31.63	32.49
22	33.02	31.91
23	34.42	31.37
24	35.83	30.88
25	37.27	30.43
26	38.71	30.03
27	40.17	29.67
28	41.63	29.36
29	43.11	29.09
30	44.59	28.87
31	46.08	28.69

32	47.58	28.56
33	49.07	28.47
34	50.57	28.44
35	52.07	28.45
36	53.57	28.50
37	55.07	28.60
38	56.56	28.75
39	58.05	28.95
40	59.53	29.19
41	61.00	29.47
42	62.46	29.80
43	63.92	30.18
44	65.36	30.60
45	66.78	31.07
46	68.19	31.58
47	69.59	32.13
48	70.96	32.73
49	72.32	33.37
50	73.66	34.05
51	74.97	34.77
52	76.26	35.53
53	77.53	36.33
54	78.78	37.17
55	79.99	38.05
56	81.18	38.97
57	82.34	39.92
58	83.47	40.91
59	84.57	41.93
60	85.63	42.98
61	86.66	44.07
62	87.66	45.19
63	88.63	46.34
64	89.55	47.52
65	90.44	48.73
66	91.30	49.96
67	92.11	51.22
68	92.88	52.51
69	93.44	53.50

Circle Center At X = 51.0 ; Y = 76.9 and Radius, 48.4

*** 4.629 ***

Failure Surface Specified By 71 Coordinate Points

Point	X-Surf	Y-Surf

No.	ft.	ft.
1	8.95	52.00
2	9.78	50.75
3	10.64	49.52
4	11.54	48.32
5	12.48	47.15
6	13.45	46.01
7	14.45	44.89
8	15.49	43.81
9	16.55	42.75
10	17.65	41.73
11	18.78	40.74
12	19.93	39.78
13	21.12	38.86
14	22.33	37.98
15	23.56	37.13
16	24.82	36.31
17	26.11	35.54
18	27.41	34.80
19	28.74	34.10
20	30.08	33.44
21	31.45	32.82
22	32.83	32.24
23	34.23	31.70
24	35.65	31.20
25	37.08	30.75
26	38.52	30.33
27	39.97	29.96
28	41.44	29.64
29	42.91	29.35
30	44.39	29.11
31	45.88	28.91
32	47.37	28.76
33	48.87	28.65
34	50.37	28.59
35	51.87	28.57
36	53.37	28.59
37	54.86	28.66
38	56.36	28.77
39	57.85	28.93
40	59.34	29.12
41	60.82	29.37
42	62.29	29.65
43	63.75	29.98
44	65.21	30.36
45	66.65	30.77
46	68.08	31.23
47	69.49	31.73
48	70.89	32.27

49	72.27	32.85
50	73.64	33.48
51	74.98	34.14
52	76.31	34.84
53	77.61	35.58
54	78.90	36.36
55	80.15	37.17
56	81.39	38.03
57	82.60	38.92
58	83.78	39.84
59	84.93	40.80
60	86.06	41.79
61	87.15	42.81
62	88.22	43.87
63	89.25	44.96
64	90.25	46.07
65	91.22	47.22
66	92.15	48.39
67	93.05	49.60
68	93.92	50.82
69	94.74	52.07
70	95.53	53.35
71	95.62	53.50

Circle Center At X = 51.8 ; Y = 79.5 and Radius, 50.9

*** 4.643 ***

1

Failure Surface Specified By 73 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	7.90	52.00
2	8.78	50.79
3	9.69	49.60
4	10.64	48.44
5	11.62	47.30
6	12.63	46.19
7	13.67	45.11
8	14.74	44.06
9	15.83	43.03
10	16.96	42.04
11	18.11	41.08
12	19.28	40.14

13	20.48	39.25
14	21.71	38.38
15	22.96	37.55
16	24.23	36.75
17	25.52	35.99
18	26.83	35.26
19	28.16	34.57
20	29.51	33.92
21	30.88	33.30
22	32.26	32.72
23	33.66	32.17
24	35.07	31.67
25	36.50	31.20
26	37.94	30.78
27	39.39	30.39
28	40.85	30.04
29	42.31	29.73
30	43.79	29.46
31	45.27	29.24
32	46.76	29.05
33	48.25	28.90
34	49.75	28.80
35	51.25	28.73
36	52.75	28.71
37	54.25	28.72
38	55.75	28.78
39	57.24	28.88
40	58.74	29.01
41	60.23	29.19
42	61.71	29.41
43	63.19	29.67
44	64.66	29.97
45	66.12	30.31
46	67.57	30.69
47	69.01	31.11
48	70.44	31.57
49	71.85	32.06
50	73.26	32.60
51	74.64	33.17
52	76.01	33.78
53	77.37	34.43
54	78.70	35.11
55	80.02	35.83
56	81.31	36.59
57	82.59	37.38
58	83.84	38.20
59	85.07	39.06
60	86.28	39.95
61	87.46	40.87
62	88.62	41.83

63	89.74	42.82
64	90.85	43.83
65	91.92	44.88
66	92.97	45.96
67	93.98	47.06
68	94.97	48.19
69	95.92	49.35
70	96.84	50.53
71	97.73	51.74
72	98.59	52.97
73	98.94	53.50

Circle Center At X = 52.9 ; Y = 83.8 and Radius, 55.1

*** 4.687 ***

Failure Surface Specified By 73 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	5.79	52.00
2	6.59	50.73
3	7.43	49.49
4	8.30	48.27
5	9.21	47.08
6	10.16	45.91
7	11.13	44.77
8	12.14	43.66
9	13.19	42.58
10	14.26	41.54
11	15.36	40.52
12	16.49	39.54
13	17.65	38.58
14	18.84	37.67
15	20.06	36.79
16	21.29	35.94
17	22.56	35.13
18	23.84	34.36
19	25.15	33.63
20	26.48	32.93
21	27.83	32.28
22	29.20	31.66
23	30.58	31.08
24	31.98	30.55
25	33.40	30.05

26	34.83	29.60
27	36.27	29.19
28	37.73	28.82
29	39.19	28.50
30	40.66	28.21
31	42.15	27.97
32	43.63	27.78
33	45.12	27.62
34	46.62	27.51
35	48.12	27.45
36	49.62	27.42
37	51.12	27.45
38	52.62	27.51
39	54.11	27.62
40	55.61	27.77
41	57.09	27.97
42	58.57	28.21
43	60.05	28.49
44	61.51	28.81
45	62.96	29.18
46	64.41	29.59
47	65.84	30.04
48	67.25	30.54
49	68.66	31.07
50	70.04	31.65
51	71.41	32.26
52	72.76	32.92
53	74.09	33.61
54	75.40	34.35
55	76.68	35.12
56	77.95	35.93
57	79.19	36.77
58	80.40	37.65
59	81.59	38.57
60	82.75	39.52
61	83.88	40.50
62	84.99	41.51
63	86.06	42.56
64	87.10	43.64
65	88.11	44.75
66	89.09	45.89
67	90.04	47.05
68	90.95	48.24
69	91.82	49.46
70	92.66	50.71
71	93.46	51.97
72	94.23	53.26
73	94.36	53.50

Circle Center At X = 49.6 ; Y = 78.8 and Radius, 51.4

*** 4.794 ***

1

Failure Surface Specified By 74 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	7.90	52.00
2	8.75	50.76
3	9.63	49.55
4	10.55	48.37
5	11.50	47.20
6	12.48	46.07
7	13.49	44.96
8	14.53	43.88
9	15.60	42.83
10	16.70	41.81
11	17.83	40.83
12	18.99	39.87
13	20.17	38.94
14	21.37	38.05
15	22.60	37.19
16	23.85	36.37
17	25.13	35.58
18	26.43	34.82
19	27.74	34.10
20	29.08	33.42
21	30.43	32.77
22	31.80	32.17
23	33.19	31.60
24	34.59	31.07
25	36.01	30.57
26	37.44	30.12
27	38.88	29.71
28	40.34	29.33
29	41.80	29.00
30	43.27	28.71
31	44.75	28.45
32	46.23	28.24
33	47.72	28.07
34	49.22	27.94
35	50.71	27.85
36	52.21	27.80
37	53.71	27.80

38	55.21	27.83
39	56.71	27.91
40	58.21	28.03
41	59.70	28.19
42	61.18	28.39
43	62.67	28.63
44	64.14	28.91
45	65.60	29.23
46	67.06	29.59
47	68.50	30.00
48	69.94	30.44
49	71.36	30.92
50	72.77	31.44
51	74.16	32.00
52	75.53	32.59
53	76.89	33.23
54	78.23	33.90
55	79.56	34.61
56	80.86	35.35
57	82.14	36.13
58	83.40	36.95
59	84.64	37.80
60	85.85	38.68
61	87.04	39.59
62	88.20	40.54
63	89.33	41.52
64	90.44	42.53
65	91.52	43.58
66	92.57	44.65
67	93.59	45.74
68	94.58	46.87
69	95.54	48.02
70	96.47	49.20
71	97.36	50.41
72	98.22	51.64
73	99.05	52.89
74	99.43	53.50

Circle Center At X = 53.2 ; Y = 82.3 and Radius, 54.5

*** 4.794 ***

Failure Surface Specified By 75 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.

1	4.74	52.00
2	5.61	50.78
3	6.51	49.58
4	7.45	48.41
5	8.41	47.26
6	9.41	46.14
7	10.43	45.04
8	11.49	43.98
9	12.57	42.94
10	13.68	41.93
11	14.81	40.95
12	15.97	40.00
13	17.16	39.08
14	18.37	38.19
15	19.60	37.34
16	20.86	36.52
17	22.14	35.73
18	23.43	34.98
19	24.75	34.26
20	26.09	33.58
21	27.44	32.93
22	28.81	32.32
23	30.19	31.74
24	31.59	31.21
25	33.01	30.71
26	34.44	30.24
27	35.87	29.82
28	37.32	29.43
29	38.78	29.09
30	40.25	28.78
31	41.73	28.51
32	43.21	28.28
33	44.70	28.09
34	46.19	27.94
35	47.69	27.83
36	49.18	27.76
37	50.68	27.72
38	52.18	27.73
39	53.68	27.78
40	55.18	27.87
41	56.67	28.00
42	58.17	28.16
43	59.65	28.37
44	61.13	28.62
45	62.60	28.90
46	64.07	29.23
47	65.52	29.59
48	66.97	29.99
49	68.40	30.43

50	69.82	30.91
51	71.23	31.43
52	72.63	31.98
53	74.01	32.57
54	75.37	33.20
55	76.71	33.86
56	78.04	34.56
57	79.35	35.29
58	80.64	36.06
59	81.91	36.86
60	83.15	37.69
61	84.38	38.56
62	85.58	39.46
63	86.75	40.39
64	87.90	41.36
65	89.03	42.35
66	90.13	43.37
67	91.20	44.42
68	92.24	45.50
69	93.25	46.61
70	94.23	47.74
71	95.19	48.90
72	96.11	50.08
73	97.00	51.29
74	97.86	52.52
75	98.50	53.50

Circle Center At X =   51.1 ; Y =   84.2 and Radius,   56.4

```
      ***     4.822   ***
```

1

```
           Y            A     X     I     S            F     T


           0.00     12.50     25.00     37.50     50.00     62.50

X      0.00 *---*--*--+------*--+---------+-*-----.W..*-------+
            -                               ...........
            -                            ............21
            -                         .............2113
            -                       .............211334
            -                    ..............21133455
      12.50 +                  ...............213445.
            -                 ..............211445
            -                ..............21345
```

```
                 -             ...............2134
                 -            ...............2145
                 -           ..............8114
A       25.00 +             ...............214
                 -          ..............814
                 -        ...............8217
                 -        ..............8314
                 -       ...............814
                 -       ..............831
X       37.50 +        ...............821
                 -      ...............81
                 -      ..............851
                 -     ...............831
                 -     ...............831
                 -     ...............831            W  *
I       50.00 +       ...............831
                 -     ...............831                 *     W
                 -     ...............841
                 -     ...............8512
                 -      ..............9511
                 -      ...............531
S       62.50 +        ...............8411
                 -       ..............9531
                 -       ...............7411
                 -        ..............95412
                 -         .............974312
                 -         ..............964312
        75.00 +           ..............964112
                 -           ..............954132
                 -            .............9744112
                 -              ...........9764.122
                 -              ..............7645112
                 -                ............97744.122
F       87.50 +                  ............9744511222
                 -                  ...........77044511322
                 -                    ...........77.44511.
                 -                      ...........77.4441
                 -                          ........977..4
                 -                             .......9777
T      100.00 *   *  *         *              *      ...9*     W
```

GLOBAL STABILITY FOR FLOODWALL IN THE WAGNER PARK BASED ON SOIL PROPERTIES SUMMARIZED IN TABLE 11

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

                 STABLPro for Windows, Version 2015.4.5

                         Upgraded from:
                         FHWA-PCSTABLE

                  Serial Number :  225625906

                     --Slope Stability Analysis--
                  Simplified Janbu, Simplified Bishop
                    or Spencer Method of Slices

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


This program is licensed to :

Oweis Engineering Inc.
Cedar Knolls, New Jersey

Path to file locations      : R:\14 WORK IN PROGRESS\NEW YORK\AECOM\17-NY165-00
South Battery Park Resiliancy\REPORT\Report calcs\Global Stability\
Name of input data file     : I-Wall Stability -2 Soil Properties Table 11.sl4d
Name of output file         : I-Wall Stability -2 Soil Properties Table 11.sl4o
Name of plot output file    : I-Wall Stability -2 Soil Properties Table 11.sl4p

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

          Date:  March 03, 2021     Time:  12:46:34



1
          PROBLEM DESCRIPTION   New Slope




          BOUNDARY COORDINATES

              3 Top   Boundaries
              7 Total Boundaries


          Boundary     X-Left     Y-Left     X-Right     Y-Right     Soil Type
```

No.	ft.	ft.	ft.	ft.	Below Bnd
1	0.00	51.20	49.00	51.20	1
2	49.00	51.20	50.00	65.50	1
3	50.00	65.50	100.00	65.50	1
4	0.00	47.50	100.00	47.50	2
5	0.00	37.50	100.00	37.50	3
6	0.00	7.50	100.00	7.50	4
7	0.00	0.00	100.00	0.00	5

1

ISOTROPIC SOIL PARAMETERS

5 Type(s) of Soil

Soil Type No.	Total Unit Wt. pcf	Saturated Unit Wt. pcf	Cohesion Intercept psf	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant psf	Piez. Surface No.
1	118.0	122.0	0.0	31.2	0.00	0.0	1
2	120.0	125.0	0.0	32.9	0.00	0.0	1
3	114.0	118.0	0.0	30.3	0.00	0.0	1
4	120.0	125.0	0.0	32.6	0.00	0.0	1
5	142.0	150.0	10000.0	40.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 63.90 pcf

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water ft.	Y-Water ft.
1	0.00	40.70
2	49.00	40.70
3	50.00	65.50
4	100.00	65.50

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

200 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 20 Points Equally Spaced
Along The Ground Surface Between X = 1.00 ft.
and X = 6.00 ft.

Each Surface Terminates Between X = 93.00 ft.
and X = 98.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.

1.50 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation.
The Angle Has Been Restricted Between The Angles Of -75.0
And -53.0 deg.

1

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 78 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	5.21	51.20
2	6.11	50.00
3	7.03	48.82
4	8.00	47.67
5	8.99	46.55
6	10.02	45.45

7	11.08	44.39
8	12.17	43.36
9	13.29	42.36
10	14.43	41.39
11	15.61	40.46
12	16.81	39.56
13	18.03	38.69
14	19.28	37.87
15	20.56	37.07
16	21.85	36.32
17	23.17	35.60
18	24.51	34.92
19	25.87	34.29
20	27.24	33.69
21	28.63	33.13
22	30.04	32.61
23	31.46	32.13
24	32.90	31.69
25	34.34	31.29
26	35.80	30.94
27	37.27	30.63
28	38.74	30.36
29	40.23	30.14
30	41.72	29.95
31	43.21	29.81
32	44.71	29.72
33	46.21	29.66
34	47.71	29.65
35	49.20	29.69
36	50.70	29.76
37	52.20	29.88
38	53.69	30.05
39	55.17	30.25
40	56.65	30.50
41	58.13	30.79
42	59.59	31.13
43	61.04	31.51
44	62.48	31.92
45	63.91	32.38
46	65.32	32.88
47	66.72	33.43
48	68.10	34.01
49	69.47	34.63
50	70.81	35.29
51	72.14	35.99
52	73.45	36.73
53	74.73	37.50
54	75.99	38.31
55	77.23	39.16
56	78.44	40.04

57	79.63	40.96
58	80.79	41.91
59	81.92	42.90
60	83.02	43.92
61	84.10	44.97
62	85.14	46.05
63	86.15	47.15
64	87.12	48.29
65	88.07	49.46
66	88.98	50.65
67	89.85	51.87
68	90.69	53.11
69	91.50	54.38
70	92.26	55.67
71	92.99	56.98
72	93.68	58.31
73	94.33	59.66
74	94.95	61.03
75	95.52	62.42
76	96.05	63.82
77	96.54	65.24
78	96.63	65.50

Circle Center At X = 47.3 ; Y = 81.5 and Radius, 51.9

*** 2.524 ***

Individual data on the 85 slices

Slice No.	Width Ft	Weight Lbs	Water Force Top Lbs	Water Force Bot Lbs	Tie Force Norm Lbs	Tie Force Tan Lbs	Earthquake Force Hor Lbs	Earthquake Force Ver Lbs	Surcharge Load Lbs
1	0.9	0.64E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	0.9	0.20E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1.0	0.34E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	0.1	0.63E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	0.8	0.42E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	1.0	0.63E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7	1.1	0.79E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8	1.1	0.95E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
9	1.1	0.11E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	1.1	0.13E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	0.9	0.11E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

12	0.3	0.39E+03	0.00E+00	0.30E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13	1.2	0.16E+04	0.00E+00	0.66E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
14	1.2	0.18E+04	0.00E+00	0.15E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	1.3	0.19E+04	0.00E+00	0.23E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
16	0.6	0.96E+03	0.00E+00	0.13E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	0.7	0.11E+04	0.00E+00	0.18E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
18	1.3	0.23E+04	0.00E+00	0.38E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
19	1.3	0.24E+04	0.00E+00	0.45E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	1.3	0.26E+04	0.00E+00	0.52E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
21	1.4	0.27E+04	0.00E+00	0.58E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22	1.4	0.28E+04	0.00E+00	0.64E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23	1.4	0.30E+04	0.00E+00	0.70E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	1.4	0.31E+04	0.00E+00	0.75E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	1.4	0.32E+04	0.00E+00	0.80E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
26	1.4	0.33E+04	0.00E+00	0.84E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
27	1.4	0.34E+04	0.00E+00	0.88E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
28	1.5	0.35E+04	0.00E+00	0.92E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
29	1.5	0.36E+04	0.00E+00	0.95E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	1.5	0.37E+04	0.00E+00	0.98E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
31	1.5	0.37E+04	0.00E+00	0.10E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
32	1.5	0.38E+04	0.00E+00	0.10E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
33	1.5	0.38E+04	0.00E+00	0.10E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
34	1.5	0.38E+04	0.00E+00	0.10E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	1.5	0.39E+04	0.00E+00	0.11E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
36	1.5	0.39E+04	0.00E+00	0.11E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
37	1.3	0.33E+04	0.00E+00	0.91E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
38	0.2	0.56E+03	0.00E+00	0.18E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
39	0.1	0.21E+03	0.00E+00	0.75E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40	0.7	0.27E+04	0.00E+00	0.12E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
41	0.7	0.31E+04	0.00E+00	0.16E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
42	1.5	0.65E+04	0.00E+00	0.34E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
43	1.5	0.65E+04	0.00E+00	0.34E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
44	1.5	0.64E+04	0.00E+00	0.34E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45	1.5	0.63E+04	0.00E+00	0.34E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
46	1.5	0.63E+04	0.00E+00	0.33E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
47	1.5	0.62E+04	0.00E+00	0.33E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
48	1.5	0.61E+04	0.00E+00	0.33E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
49	1.4	0.59E+04	0.00E+00	0.32E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	1.4	0.58E+04	0.00E+00	0.32E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
51	1.4	0.57E+04	0.00E+00	0.32E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
52	1.4	0.55E+04	0.00E+00	0.31E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
53	1.4	0.54E+04	0.00E+00	0.30E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
54	1.4	0.52E+04	0.00E+00	0.30E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
55	1.3	0.50E+04	0.00E+00	0.29E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
56	1.3	0.49E+04	0.00E+00	0.29E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
57	1.3	0.47E+04	0.00E+00	0.28E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
58	1.3	0.45E+04	0.00E+00	0.27E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
59	0.0	0.11E+02	0.00E+00	0.65E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60	1.3	0.43E+04	0.00E+00	0.26E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
61	1.2	0.41E+04	0.00E+00	0.26E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

62	1.2	0.39E+04	0.00E+00	0.25E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
63	1.2	0.36E+04	0.00E+00	0.24E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
64	1.2	0.34E+04	0.00E+00	0.23E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
65	1.1	0.32E+04	0.00E+00	0.22E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
66	1.1	0.30E+04	0.00E+00	0.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
67	1.1	0.28E+04	0.00E+00	0.20E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
68	1.0	0.25E+04	0.00E+00	0.19E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
69	1.0	0.23E+04	0.00E+00	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
70	0.3	0.66E+03	0.00E+00	0.53E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
71	0.7	0.15E+04	0.00E+00	0.12E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
72	0.9	0.19E+04	0.00E+00	0.16E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
73	0.9	0.17E+04	0.00E+00	0.15E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
74	0.9	0.15E+04	0.00E+00	0.14E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
75	0.8	0.13E+04	0.00E+00	0.12E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
76	0.8	0.12E+04	0.00E+00	0.11E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
77	0.8	0.98E+03	0.00E+00	0.10E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
78	0.7	0.82E+03	0.00E+00	0.88E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
79	0.7	0.66E+03	0.00E+00	0.75E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80	0.7	0.52E+03	0.00E+00	0.62E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
81	0.6	0.39E+03	0.00E+00	0.49E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
82	0.6	0.26E+03	0.00E+00	0.36E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
83	0.5	0.15E+03	0.00E+00	0.23E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
84	0.5	0.58E+02	0.00E+00	0.93E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
85	0.1	0.13E+01	0.00E+00	0.23E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Failure Surface Specified By 78 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	2.84	51.20
2	3.74	50.00
3	4.67	48.82
4	5.64	47.68
5	6.64	46.56
6	7.67	45.47
7	8.73	44.41
8	9.82	43.38
9	10.94	42.38
10	12.09	41.42
11	13.27	40.49
12	14.47	39.59
13	15.70	38.73
14	16.95	37.90
15	18.23	37.12
16	19.53	36.36
17	20.85	35.65
18	22.18	34.97

19	23.54	34.34
20	24.92	33.74
21	26.31	33.18
22	27.72	32.66
23	29.14	32.18
24	30.58	31.75
25	32.02	31.35
26	33.48	31.00
27	34.95	30.69
28	36.42	30.42
29	37.91	30.20
30	39.40	30.02
31	40.89	29.88
32	42.39	29.78
33	43.89	29.73
34	45.38	29.72
35	46.88	29.75
36	48.38	29.83
37	49.88	29.94
38	51.37	30.11
39	52.86	30.31
40	54.33	30.56
41	55.81	30.85
42	57.27	31.18
43	58.72	31.56
44	60.16	31.97
45	61.59	32.43
46	63.01	32.93
47	64.41	33.47
48	65.79	34.05
49	67.16	34.67
50	68.50	35.33
51	69.83	36.02
52	71.14	36.76
53	72.43	37.53
54	73.69	38.34
55	74.93	39.18
56	76.14	40.06
57	77.33	40.98
58	78.49	41.92
59	79.63	42.91
60	80.73	43.92
61	81.81	44.97
62	82.86	46.04
63	83.87	47.15
64	84.85	48.28
65	85.80	49.44
66	86.71	50.63
67	87.59	51.85
68	88.44	53.09

69	89.25	54.35
70	90.02	55.63
71	90.76	56.94
72	91.45	58.27
73	92.11	59.62
74	92.73	60.99
75	93.31	62.37
76	93.85	63.77
77	94.35	65.18
78	94.45	65.50

Circle Center At X = 45.0 ; Y = 81.8 and Radius, 52.1

*** 2.532 ***

1

Failure Surface Specified By 78 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	2.32	51.20
2	3.20	49.99
3	4.12	48.80
4	5.07	47.64
5	6.06	46.51
6	7.08	45.41
7	8.13	44.34
8	9.21	43.30
9	10.32	42.30
10	11.46	41.32
11	12.63	40.38
12	13.83	39.48
13	15.05	38.61
14	16.29	37.77
15	17.57	36.97
16	18.86	36.21
17	20.17	35.49
18	21.51	34.81
19	22.86	34.17
20	24.24	33.56
21	25.63	33.00
22	27.03	32.48
23	28.45	31.99
24	29.89	31.55
25	31.33	31.16

26	32.79	30.80
27	34.26	30.49
28	35.73	30.22
29	37.22	30.00
30	38.71	29.81
31	40.20	29.68
32	41.70	29.58
33	43.20	29.53
34	44.70	29.52
35	46.20	29.56
36	47.69	29.64
37	49.19	29.76
38	50.68	29.93
39	52.16	30.14
40	53.64	30.40
41	55.11	30.70
42	56.57	31.04
43	58.02	31.42
44	59.46	31.85
45	60.89	32.31
46	62.30	32.82
47	63.69	33.37
48	65.07	33.96
49	66.43	34.59
50	67.77	35.26
51	69.10	35.97
52	70.40	36.72
53	71.68	37.51
54	72.93	38.33
55	74.16	39.19
56	75.36	40.08
57	76.54	41.01
58	77.69	41.97
59	78.81	42.97
60	79.90	44.00
61	80.97	45.06
62	82.00	46.15
63	82.99	47.27
64	83.96	48.42
65	84.89	49.60
66	85.78	50.80
67	86.64	52.03
68	87.46	53.28
69	88.25	54.56
70	89.00	55.86
71	89.71	57.18
72	90.38	58.52
73	91.01	59.88
74	91.61	61.26
75	92.16	62.66

76	92.67	64.07
77	93.14	65.49
78	93.14	65.50

Circle Center At X = 44.2 ; Y = 80.8 and Radius, 51.3

*** 2.548 ***

Failure Surface Specified By 78 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	4.16	51.20
2	5.03	49.98
3	5.95	48.79
4	6.89	47.63
5	7.87	46.49
6	8.88	45.38
7	9.93	44.31
8	11.00	43.26
9	12.10	42.24
10	13.24	41.26
11	14.40	40.31
12	15.59	39.39
13	16.80	38.51
14	18.04	37.67
15	19.30	36.86
16	20.59	36.09
17	21.90	35.35
18	23.23	34.66
19	24.58	34.00
20	25.94	33.38
21	27.33	32.81
22	28.73	32.27
23	30.14	31.77
24	31.57	31.32
25	33.01	30.90
26	34.47	30.53
27	35.93	30.20
28	37.40	29.92
29	38.88	29.67
30	40.37	29.47
31	41.86	29.31
32	43.36	29.20
33	44.85	29.13

34	46.35	29.10
35	47.85	29.12
36	49.35	29.18
37	50.85	29.28
38	52.34	29.43
39	53.83	29.62
40	55.31	29.85
41	56.79	30.13
42	58.25	30.45
43	59.71	30.81
44	61.15	31.21
45	62.59	31.65
46	64.00	32.14
47	65.41	32.67
48	66.80	33.23
49	68.17	33.84
50	69.52	34.49
51	70.86	35.18
52	72.17	35.90
53	73.46	36.66
54	74.73	37.46
55	75.98	38.30
56	77.20	39.17
57	78.39	40.08
58	79.56	41.02
59	80.70	41.99
60	81.81	43.00
61	82.89	44.04
62	83.94	45.11
63	84.96	46.21
64	85.95	47.34
65	86.90	48.50
66	87.83	49.68
67	88.71	50.89
68	89.56	52.13
69	90.37	53.39
70	91.15	54.67
71	91.89	55.98
72	92.59	57.30
73	93.25	58.65
74	93.88	60.01
75	94.46	61.39
76	95.00	62.79
77	95.50	64.21
78	95.92	65.50

Circle Center At X = 46.5 ; Y = 80.8 and Radius, 51.7

*** 2.559 ***

1

Failure Surface Specified By 78 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	6.00	51.20
2	6.87	49.98
3	7.77	48.78
4	8.71	47.61
5	9.68	46.46
6	10.68	45.35
7	11.72	44.26
8	12.79	43.21
9	13.88	42.19
10	15.01	41.20
11	16.17	40.24
12	17.35	39.32
13	18.56	38.44
14	19.80	37.59
15	21.06	36.77
16	22.34	36.00
17	23.65	35.26
18	24.97	34.56
19	26.32	33.90
20	27.69	33.28
21	29.07	32.70
22	30.47	32.16
23	31.88	31.66
24	33.31	31.20
25	34.75	30.79
26	36.21	30.42
27	37.67	30.09
28	39.14	29.80
29	40.62	29.56
30	42.11	29.36
31	43.60	29.20
32	45.10	29.09
33	46.60	29.02
34	48.10	29.00
35	49.60	29.02
36	51.10	29.08
37	52.59	29.19
38	54.08	29.34
39	55.57	29.54
40	57.05	29.78

41	58.52	30.06
42	59.99	30.39
43	61.44	30.75
44	62.89	31.16
45	64.32	31.62
46	65.73	32.11
47	67.13	32.65
48	68.52	33.23
49	69.88	33.84
50	71.23	34.50
51	72.56	35.20
52	73.87	35.93
53	75.15	36.70
54	76.42	37.51
55	77.65	38.36
56	78.87	39.24
57	80.05	40.16
58	81.21	41.11
59	82.34	42.10
60	83.44	43.12
61	84.51	44.17
62	85.55	45.25
63	86.56	46.36
64	87.53	47.50
65	88.47	48.67
66	89.38	49.87
67	90.25	51.09
68	91.08	52.34
69	91.88	53.61
70	92.64	54.90
71	93.36	56.22
72	94.04	57.55
73	94.69	58.91
74	95.29	60.28
75	95.85	61.67
76	96.37	63.08
77	96.85	64.50
78	97.15	65.50

Circle Center At X = 48.2 ; Y = 80.1 and Radius, 51.1

*** 2.561 ***

Failure Surface Specified By 79 Coordinate Points

Point	X-Surf	Y-Surf

No.	ft.	ft.
1	3.90	51.20
2	4.79	49.99
3	5.71	48.81
4	6.67	47.66
5	7.66	46.53
6	8.68	45.43
7	9.73	44.36
8	10.81	43.32
9	11.92	42.31
10	13.06	41.33
11	14.22	40.39
12	15.41	39.48
13	16.63	38.60
14	17.87	37.76
15	19.13	36.95
16	20.42	36.18
17	21.73	35.44
18	23.06	34.75
19	24.40	34.09
20	25.77	33.47
21	27.15	32.88
22	28.55	32.34
23	29.96	31.84
24	31.39	31.37
25	32.83	30.95
26	34.28	30.57
27	35.74	30.23
28	37.21	29.93
29	38.69	29.67
30	40.17	29.45
31	41.66	29.28
32	43.16	29.15
33	44.65	29.06
34	46.15	29.01
35	47.65	29.01
36	49.15	29.05
37	50.65	29.13
38	52.14	29.25
39	53.64	29.41
40	55.12	29.62
41	56.60	29.87
42	58.07	30.16
43	59.54	30.49
44	60.99	30.86
45	62.43	31.28
46	63.86	31.73
47	65.28	32.22
48	66.68	32.76

49	68.06	33.33
50	69.43	33.94
51	70.78	34.60
52	72.12	35.28
53	73.43	36.01
54	74.72	36.77
55	75.99	37.57
56	77.24	38.41
57	78.46	39.28
58	79.66	40.18
59	80.83	41.12
60	81.97	42.09
61	83.09	43.09
62	84.17	44.12
63	85.23	45.19
64	86.26	46.28
65	87.26	47.40
66	88.22	48.55
67	89.15	49.73
68	90.05	50.93
69	90.91	52.15
70	91.74	53.40
71	92.53	54.68
72	93.29	55.97
73	94.01	57.29
74	94.69	58.63
75	95.34	59.98
76	95.94	61.35
77	96.51	62.74
78	97.03	64.15
79	97.50	65.50

Circle Center At X = 47.1 ; Y = 82.1 and Radius, 53.1

*** 2.568 ***

1

Failure Surface Specified By 79 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	5.74	51.20
2	6.61	49.98
3	7.51	48.78
4	8.45	47.61

5	9.42	46.47
6	10.43	45.36
7	11.47	44.27
8	12.53	43.22
9	13.63	42.20
10	14.76	41.21
11	15.92	40.25
12	17.10	39.33
13	18.31	38.45
14	19.54	37.59
15	20.80	36.78
16	22.09	36.00
17	23.39	35.26
18	24.72	34.56
19	26.06	33.89
20	27.43	33.27
21	28.81	32.69
22	30.20	32.14
23	31.62	31.64
24	33.04	31.18
25	34.48	30.76
26	35.94	30.38
27	37.40	30.04
28	38.87	29.75
29	40.35	29.50
30	41.83	29.29
31	43.33	29.13
32	44.82	29.01
33	46.32	28.93
34	47.82	28.90
35	49.32	28.91
36	50.82	28.96
37	52.31	29.06
38	53.81	29.20
39	55.30	29.39
40	56.78	29.61
41	58.25	29.88
42	59.72	30.20
43	61.18	30.55
44	62.62	30.95
45	64.06	31.39
46	65.48	31.87
47	66.89	32.40
48	68.28	32.96
49	69.65	33.56
50	71.00	34.20
51	72.34	34.89
52	73.66	35.61
53	74.95	36.37
54	76.22	37.16

55	77.47	37.99
56	78.69	38.86
57	79.89	39.77
58	81.06	40.70
59	82.20	41.68
60	83.32	42.68
61	84.40	43.72
62	85.45	44.78
63	86.48	45.88
64	87.47	47.01
65	88.42	48.16
66	89.35	49.35
67	90.23	50.56
68	91.09	51.79
69	91.90	53.05
70	92.68	54.33
71	93.42	55.63
72	94.13	56.96
73	94.79	58.30
74	95.42	59.67
75	96.00	61.05
76	96.55	62.45
77	97.05	63.86
78	97.51	65.29
79	97.58	65.50

Circle Center At X = 48.2 ; Y = 80.5 and Radius, 51.6

*** 2.569 ***

Failure Surface Specified By 79 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	4.42	51.20
2	5.28	49.97
3	6.17	48.76
4	7.09	47.58
5	8.05	46.43
6	9.04	45.30
7	10.07	44.21
8	11.13	43.14
9	12.22	42.11
10	13.33	41.11
11	14.48	40.14

12	15.66	39.21
13	16.86	38.31
14	18.08	37.45
15	19.34	36.63
16	20.61	35.84
17	21.91	35.09
18	23.23	34.38
19	24.57	33.70
20	25.93	33.07
21	27.31	32.48
22	28.70	31.92
23	30.11	31.41
24	31.54	30.94
25	32.98	30.51
26	34.43	30.13
27	35.89	29.79
28	37.36	29.49
29	38.83	29.23
30	40.32	29.02
31	41.81	28.85
32	43.30	28.72
33	44.80	28.64
34	46.30	28.60
35	47.80	28.61
36	49.30	28.66
37	50.80	28.76
38	52.29	28.90
39	53.78	29.08
40	55.26	29.30
41	56.74	29.57
42	58.21	29.89
43	59.66	30.24
44	61.11	30.64
45	62.54	31.08
46	63.96	31.56
47	65.37	32.09
48	66.76	32.65
49	68.13	33.26
50	69.48	33.91
51	70.82	34.59
52	72.13	35.31
53	73.42	36.08
54	74.69	36.88
55	75.94	37.71
56	77.16	38.59
57	78.35	39.50
58	79.52	40.44
59	80.65	41.42
60	81.76	42.43
61	82.84	43.47

62	83.89	44.54
63	84.91	45.65
64	85.89	46.78
65	86.84	47.94
66	87.75	49.13
67	88.63	50.34
68	89.47	51.59
69	90.28	52.85
70	91.05	54.14
71	91.78	55.45
72	92.47	56.78
73	93.13	58.13
74	93.74	59.50
75	94.31	60.89
76	94.84	62.29
77	95.33	63.71
78	95.78	65.14
79	95.88	65.50

Circle Center At X = 46.8 ; Y = 79.7 and Radius, 51.1

*** 2.589 ***

1

Failure Surface Specified By 77 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	5.47	51.20
2	6.29	49.94
3	7.15	48.71
4	8.04	47.51
5	8.98	46.33
6	9.94	45.19
7	10.95	44.07
8	11.98	42.99
9	13.05	41.94
10	14.16	40.92
11	15.29	39.93
12	16.45	38.99
13	17.64	38.08
14	18.86	37.20
15	20.11	36.37
16	21.38	35.57
17	22.67	34.81

18	23.99	34.10
19	25.33	33.42
20	26.69	32.79
21	28.07	32.19
22	29.46	31.65
23	30.88	31.14
24	32.30	30.68
25	33.75	30.26
26	35.20	29.89
27	36.66	29.57
28	38.14	29.29
29	39.62	29.05
30	41.11	28.86
31	42.60	28.72
32	44.10	28.62
33	45.59	28.57
34	47.09	28.57
35	48.59	28.61
36	50.09	28.70
37	51.59	28.83
38	53.07	29.01
39	54.56	29.24
40	56.03	29.51
41	57.50	29.83
42	58.95	30.20
43	60.40	30.61
44	61.83	31.06
45	63.24	31.56
46	64.64	32.10
47	66.02	32.68
48	67.38	33.31
49	68.73	33.98
50	70.05	34.69
51	71.35	35.44
52	72.62	36.23
53	73.87	37.06
54	75.10	37.92
55	76.29	38.83
56	77.46	39.77
57	78.60	40.75
58	79.71	41.76
59	80.78	42.80
60	81.82	43.88
61	82.83	44.99
62	83.81	46.13
63	84.74	47.30
64	85.65	48.50
65	86.51	49.73
66	87.33	50.98
67	88.12	52.26

68	88.87	53.56
69	89.57	54.88
70	90.24	56.23
71	90.86	57.59
72	91.44	58.98
73	91.98	60.38
74	92.47	61.79
75	92.92	63.23
76	93.32	64.67
77	93.53	65.50

Circle Center At X = 46.5 ; Y = 77.0 and Radius, 48.4

*** 2.590 ***

Failure Surface Specified By 78 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	3.63	51.20
2	4.47	49.96
3	5.35	48.74
4	6.26	47.55
5	7.20	46.38
6	8.19	45.25
7	9.20	44.15
8	10.25	43.07
9	11.33	42.03
10	12.44	41.03
11	13.58	40.05
12	14.75	39.11
13	15.95	38.21
14	17.18	37.34
15	18.43	36.52
16	19.70	35.72
17	21.00	34.97
18	22.32	34.26
19	23.66	33.59
20	25.02	32.95
21	26.40	32.36
22	27.79	31.82
23	29.21	31.31
24	30.63	30.85
25	32.07	30.43
26	33.52	30.05

27	34.99	29.72
28	36.46	29.43
29	37.94	29.18
30	39.43	28.98
31	40.92	28.83
32	42.41	28.72
33	43.91	28.66
34	45.41	28.64
35	46.91	28.66
36	48.41	28.74
37	49.91	28.85
38	51.40	29.01
39	52.88	29.22
40	54.36	29.47
41	55.83	29.77
42	57.29	30.11
43	58.74	30.49
44	60.18	30.92
45	61.61	31.39
46	63.01	31.90
47	64.41	32.46
48	65.78	33.06
49	67.14	33.70
50	68.48	34.38
51	69.79	35.10
52	71.09	35.85
53	72.36	36.65
54	73.60	37.49
55	74.82	38.36
56	76.02	39.27
57	77.18	40.21
58	78.32	41.19
59	79.43	42.21
60	80.50	43.25
61	81.54	44.33
62	82.55	45.44
63	83.53	46.58
64	84.47	47.75
65	85.38	48.94
66	86.25	50.16
67	87.08	51.41
68	87.87	52.69
69	88.63	53.98
70	89.34	55.30
71	90.02	56.64
72	90.65	58.00
73	91.25	59.37
74	91.80	60.77
75	92.31	62.18
76	92.78	63.61

```
   77         93.20       65.04
   78         93.32       65.50

Circle Center At X =   45.3 ; Y =   78.4  and Radius,   49.7


      ***     2.593   ***



1

                Y            A     X     I     S            F     T


                0.00     14.41     28.82     43.23     57.64     72.05

X      0.00 *----*----+---------+-----*-W-+--*--*---+---------+
            -                              ...32
            -                          .....2221
            -                       ......32111
            -                      .....32215
            -                    ......3211
      14.41 +                  .......211
            -                 .......215
            -               ........211
            -              ........211
            -              .......211
            -             .......011
A     28.82 +            ........21
            -           ........811
            -           ........31
            -          ........01
            -          ........81
            -          ........41
X     43.23 +         .........31
            -         .........31
            -         .........41      W       *
            -         .........41                       *
            -         .........41
            -         .........51
I     57.64 +          .........12
            -          .........41
            -          .........512
            -           .........112
            -            ........711
            -            .........512
S     72.05 +             .........4123
            -              .........1123
            -               .........5123
```

```
           -                 .........51223
           -                   ........71122
           -                    .........11122
      86.46 +                     ........5511223
           -                        ........71112223
           -                           .......551112233
           -                             ........55112222
           -                                 .......71111
           -                                       .....6
F    100.87 *    *                    *      *           *
           -
           -
           -
           -
           -
T    115.28 +
```

APPENDIX L

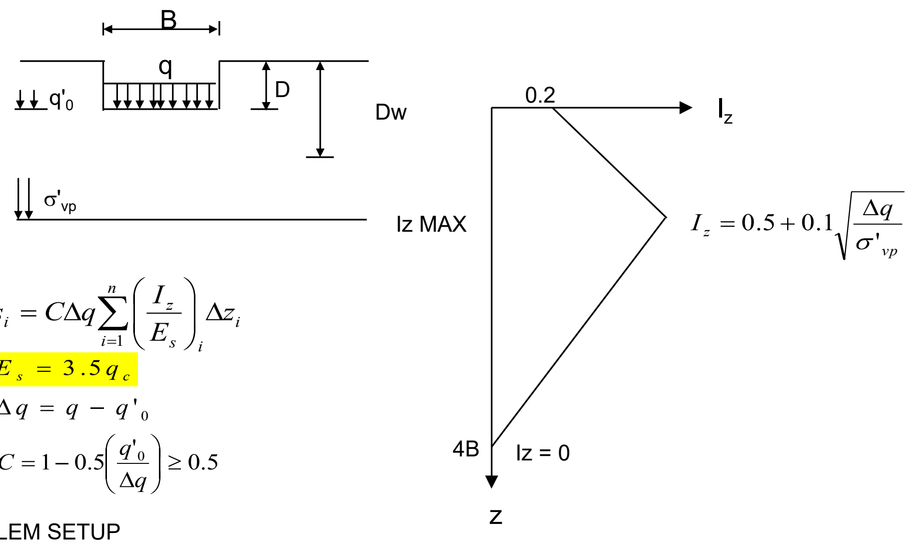
SETTLEMENT ESTIMATION FOR STRIP FOOTING

CALCULATION OF ELASTIC SETTLEMENTS - SCHMERTMAN METHOD-Stip Footing
WP1~WP4

Calculated by Shengyan Gao **Date** 7/16/2021

Checked by Jim Malak **Date** 7/16/2021

MODEL



$$I_z = 0.5 + 0.1\sqrt{\frac{\Delta q}{\sigma'_{vp}}}$$

$$s_i = C\Delta q \sum_{i=1}^{n}\left(\frac{I_z}{E_s}\right)_i \Delta z_i$$

$$E_s = 3.5 q_c$$

$$\Delta q = q - q'_0$$

$$C = 1 - 0.5\left(\frac{q'_0}{\Delta q}\right) \geq 0.5$$

PROBLEM SETUP

Width of foundation B:	2.5 ft	Iz maximum is at	1 x B
Embedment depth D:	4 ft	Iz is zero at	4 x B
Depth to water Dw:	8 ft	q_c/N Relation:	
Unit weight of soil γ:	120 pcf	Uniform load q:	1 tsf
		E_s =	7 N (0~9ft deep)
			5 N (9~36ft deep)

SOLUTION

Effective Overburden q'_0:	0.2400 tsf	Iz maximum depth z=	2.5 ft
Load increase Δq:	0.7600 tsf	Iz zero depth z=	10 ft
Effective Stress at Iz Max σ'_{vp}:	0.3900 tsf	Maximum Iz:	0.64
		Correction factor C:	0.842105

Depth from GL ft bottom	middle	Layer	z_{bottom} ft	z_{middle} ft	Δz ft	N blow/ft	q_c tsf	E_s tsf	I_z	Δz*Iz/Es ft/tsf
8	4	1	0	0	0	27		189	0.200	0.00000
13.5	6.75	2	5.5	2.75	5.5	12		84	0.618	0.04048
23.5	14.5	3	15.5	10.5	10	6		30	0.000	0.00000

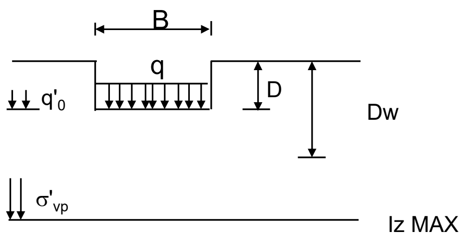
Total Settlement (ft) 0.0259

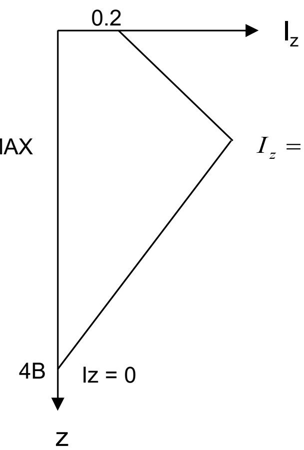
Total Settlement (in) 0.3109

CALCULATION OF ELASTIC SETTLEMENTS - SCHMERTMAN METHOD-Stip Footing
WP43~WP47

Calculated by	Shengyan Gao	**Date**	3/8/2021
Checked by	Jim Malak	**Date**	3/8/2021

MODEL





$$I_z = 0.5 + 0.1\sqrt{\frac{\Delta q}{\sigma'_{vp}}}$$

$$s_i = C\Delta q \sum_{i=1}^{n}\left(\frac{I_z}{E_s}\right)_i \Delta z_i$$

$$E_s = 3.5 q_c$$

$$\Delta q = q - q'_0$$

$$C = 1 - 0.5\left(\frac{q'_0}{\Delta q}\right) \geq 0.5$$

PROBLEM SETUP

Width of foundation B:	12 ft	Iz maximum is at	1 x B
Embedment depth D:	3.5 ft	Iz is zero at	4 x B
Depth to water Dw:	11 ft	q_c/N Relation:	
Unit weight of soil γ:	120 pcf	Uniform load q:	1 tsf
		E_s =	7 N (0~9ft deep)
			5 N (9~36ft deep)

SOLUTION

Effective Overburden q'_0:	0.2100 tsf	Iz maximum depth z=	12 ft
Load increase Δq:	0.7900 tsf	Iz zero depth z=	48 ft
Effective Stress at Iz Max σ'_{vp}:	0.7896 tsf	Maximum Iz:	0.60
		Correction factor C:	0.867089

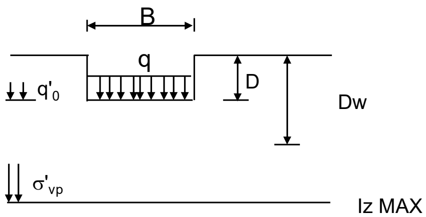
Depth from GL ft bottom	middle	Layer	z_{bottom} ft	z_{middle} ft	Δz ft	N blow/ft	q_c tsf	E_s tsf	I_z	Δz*Iz/Es ft/tsf
3.5	3.5	1	0	0	0	12		81.9	0.200	0.00000
9	6.25	2	5.5	2.75	5.5	12		81.9	0.292	0.01959
16	12.5	3	12.5	9	7	12		58.5	0.500	0.05983
21	18.5	4	17.5	15	5	47		234	0.550	0.01175
26	23.5	5	22.5	20	5	27.3		136.5	0.467	0.01709
31	28.5	5	27.5	25	5	16.9		84.5	0.383	0.02268
36	23.5	6	22.5	20	5	117		585	0.467	0.00399
41	28.5	6	27.5	25	5	130		650	0.383	0.00295

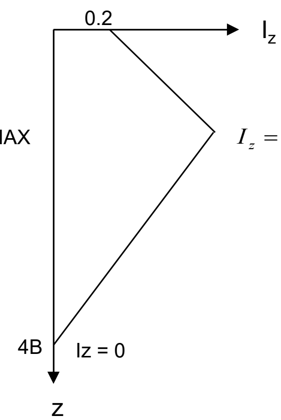
Total Settlement (ft)	0.0945
Total Settlement (in)	1.1334

CALCULATION OF ELASTIC SETTLEMENTS - SCHMERTMAN METHOD-Stip Footing
WP47~WP48

Calculated by	Shengyan Gao	**Date**	3/8/2021
Checked by	Jim Malak	**Date**	3/8/2021

MODEL





$$I_z = 0.5 + 0.1\sqrt{\frac{\Delta q}{\sigma'_{vp}}}$$

$$s_i = C\Delta q \sum_{i=1}^{n}\left(\frac{I_z}{E_s}\right)_i \Delta z_i$$

$$E_s = 3.5 q_c$$

$$\Delta q = q - q'_0$$

$$C = 1 - 0.5\left(\frac{q'_0}{\Delta q}\right) \geq 0.5$$

PROBLEM SETUP

Width of foundation B:	10	ft	Iz maximum is at	1	x B
Embedment depth D:	3.5	ft	Iz is zero at	4	x B
Depth to water Dw:	11	ft	q_c/N Relation:		
Unit weight of soil γ:	120	pcf	Uniform load q:	1	tsf
			E_s =	7	N (0~9ft deep)
				5	N (9~36ft deep)

SOLUTION

Effective Overburden q'_0:	0.2100	tsf	Iz maximum depth z=	10	ft
Load increase Δq:	0.7900	tsf	Iz zero depth z=	40	ft
Effective Stress at Iz Max σ'_{vp}:	0.7320	tsf	Maximum Iz:	0.60	
			Correction factor C:	0.867089	

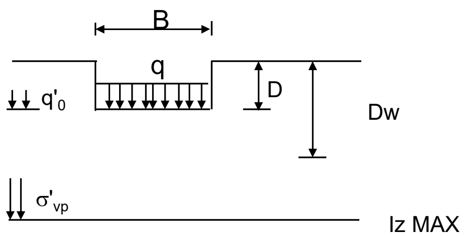
Depth from GL ft bottom	middle	Layer	z_{bottom} ft	z_{middle} ft	Δz ft	N blow/ft	q_c tsf	E_s tsf	I_z	Δz*Iz/Es ft/tsf
3.5	3.5	1	0	0	0	12		81.9	0.200	0.00000
9	6.25	2	5.5	2.75	5.5	12		81.9	0.311	0.02089
16	12.5	3	12.5	9	7	12		58.5	0.563	0.06743
21	18.5	4	17.5	15	5	47		234	0.503	0.01075
26	23.5	5	22.5	20	5	27.3		136.5	0.403	0.01475
31	28.5	5	27.5	25	5	16.9		84.5	0.302	0.01787
36	23.5	6	22.5	20	5	117		585	0.403	0.00344
41	28.5	6	27.5	25	5	130		650	0.302	0.00232

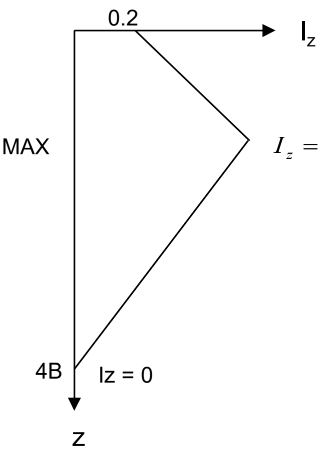
Total Settlement (ft)	0.0942
Total Settlement (in)	1.1298

CALCULATION OF ELASTIC SETTLEMENTS - SCHMERTMAN METHOD-Stip Footing
WP48~WP52

Calculated by	Shengyan Gao	**Date**	3/8/2021
Checked by	Jim Malak	**Date**	3/8/2021

MODEL





$$I_z = 0.5 + 0.1\sqrt{\frac{\Delta q}{\sigma'_{vp}}}$$

$$s_i = C\Delta q \sum_{i=1}^{n} \left(\frac{I_z}{E_s}\right)_i \Delta z_i$$

$$E_s = 3.5 q_c$$

$$\Delta q = q - q'_0$$

$$C = 1 - 0.5\left(\frac{q'_0}{\Delta q}\right) \geq 0.5$$

PROBLEM SETUP

Width of foundation B:	7.5 ft	Iz maximum is at	1 x B
Embedment depth D:	3.5 ft	Iz is zero at	4 x B
Depth to water Dw:	11 ft	q_c/N Relation:	
Unit weight of soil γ:	120 pcf	Uniform load q:	1 tsf
		E_s =	7 N (0~9ft deep)
			5 N (9~36ft deep)

SOLUTION

Effective Overburden q'_0:	0.2100 tsf	Iz maximum depth z=	7.5 ft
Load increase Δq:	0.7900 tsf	Iz zero depth z=	30 ft
Effective Stress at Iz Max σ'_{vp}:	0.6600 tsf	Maximum Iz:	0.61
		Correction factor C:	0.867089

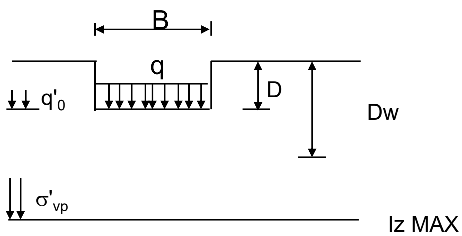
Depth from GL ft bottom	middle	Layer	z_{bottom} ft	z_{middle} ft	Δz ft	N blow/ft	q_c tsf	E_s tsf	I_z	Δz*Iz/Es ft/tsf
3.5	3.5	1	0	0	0	12		81.9	0.200	0.00000
9	6.25	2	5.5	2.75	5.5	12		81.9	0.350	0.02351
16	12.5	3	12.5	9	7	12		58.5	0.569	0.06806
21	18.5	4	17.5	15	5	47		234	0.406	0.00868
26	23.5	5	22.5	20	5	27.3		136.5	0.271	0.00992
31	28.5	5	27.5	25	5	16.9		84.5	0.135	0.00801

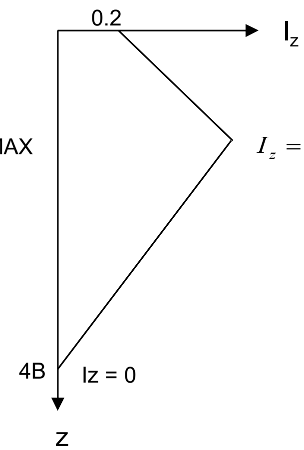
Total Settlement (ft)	0.0810
Total Settlement (in)	0.9715

CALCULATION OF ELASTIC SETTLEMENTS - SCHMERTMAN METHOD-Stip Footing
WP52~WP55

Calculated by	Shengyan Gao	**Date**	3/8/2021
Checked by	Jim Malak	**Date**	3/8/2021

MODEL





$$I_z = 0.5 + 0.1\sqrt{\frac{\Delta q}{\sigma'_{vp}}}$$

$$s_i = C\Delta q \sum_{i=1}^{n}\left(\frac{I_z}{E_s}\right)_i \Delta z_i$$

$$E_s = 3.5 q_c$$

$$\Delta q = q - q'_0$$

$$C = 1 - 0.5\left(\frac{q'_0}{\Delta q}\right) \geq 0.5$$

PROBLEM SETUP

Width of foundation B:	5	ft	Iz maximum is at	1	x B
Embedment depth D:	3.5	ft	Iz is zero at	4	x B
Depth to water Dw:	11	ft	q_c/N Relation:		
Unit weight of soil γ:	120	pcf	Uniform load q:	1	tsf
			E_s =	7	N (0~9ft deep)
				5	N (9~36ft deep)

SOLUTION

Effective Overburden q'_0:	0.2100	tsf	Iz maximum depth z=	5	ft
Load increase Δq:	0.7900	tsf	Iz zero depth z=	20	ft
Effective Stress at Iz Max σ'_{vp}:	0.5100	tsf	Maximum Iz:	0.62	
			Correction factor C:	0.867089	

Depth from GL ft bottom	middle	Layer	z_{bottom} ft	z_{middle} ft	Δz ft	N blow/ft	q_c tsf	E_s tsf	I_z	Δz*Iz/Es ft/tsf
3.5	3.5	1	0	0	0	12		81.9	0.200	0.00000
9	6.25	2	5.5	2.75	5.5	12		81.9	0.433	0.02911
16	12.5	3	12.5	9	7	12		58.5	0.458	0.05480
21	18.5	4	17.5	15	5	47		234	0.208	0.00445

Total Settlement (ft)	0.0605
Total Settlement (in)	0.7263

APPENDIX M

SLOPE STABILITY ANALYSES FOR PIER A INLET

APPENDIX M: SLOPE STABILTY ANALYSES FOR PIER A INLET

Appendix M presents the detailed calculations of slope stability analyses for the existing bulkhead and the proposed bulkhead of Pier A Inlet in accordance with EM 1110-2-1902 Slope Stability.

SOIL PARAMTERS

Table 1: Generalized Soil Profile for Slope Stability Analyses for Pier A Inlet

Elevation (ft.)	Soil Type	Typical Field SPT Range*		Recommended Key Soil/Rock Parameters
		Field N	N_{60}	
6 ~ 3	Fill (medium dense sand, little gravel, with brick fragments)	13	17	γ=123pcf, φ=33.0°
3 ~ -28	Fill (loose silty sand, little gravel with brick fragments)	2~4	3~5	γ'=47.6pcf, φ=31.0
-28 ~ -38	Very soft silty clay	2	3	γ'=44.6pcf, C=400psf
-38 ~ -49	Loose silty sand / clayey sand, trace gravel	5~7	6~9	γ'=52.6pcf, φ=31.0°
<-49	Bedrock-Schist	-	-	γ'=87.6pcf, Strain Factor=0.0001, q_u=5000psi, E_{ini}=1.5E+6psi, RQD=78%

*The typical field SPT range is not the actual range of field SPT values, but it is the typical range based on engineer's judgement.

SOFTWARES

STABLPRO 2015

SELECTED SECTION FOR STABILITY ANALYSES

The most critical section of the existing and the proposed embankment slope was selected for the stability analyses based on the Drawing SM304-Pier A Inlet Pile and Pile Cap Plan and the Drawing SM404 - Pier A Inlet bulkhead Section provided by AECOM. The selected section is the Section B on Drawing SM404 and is presented in Figure1.

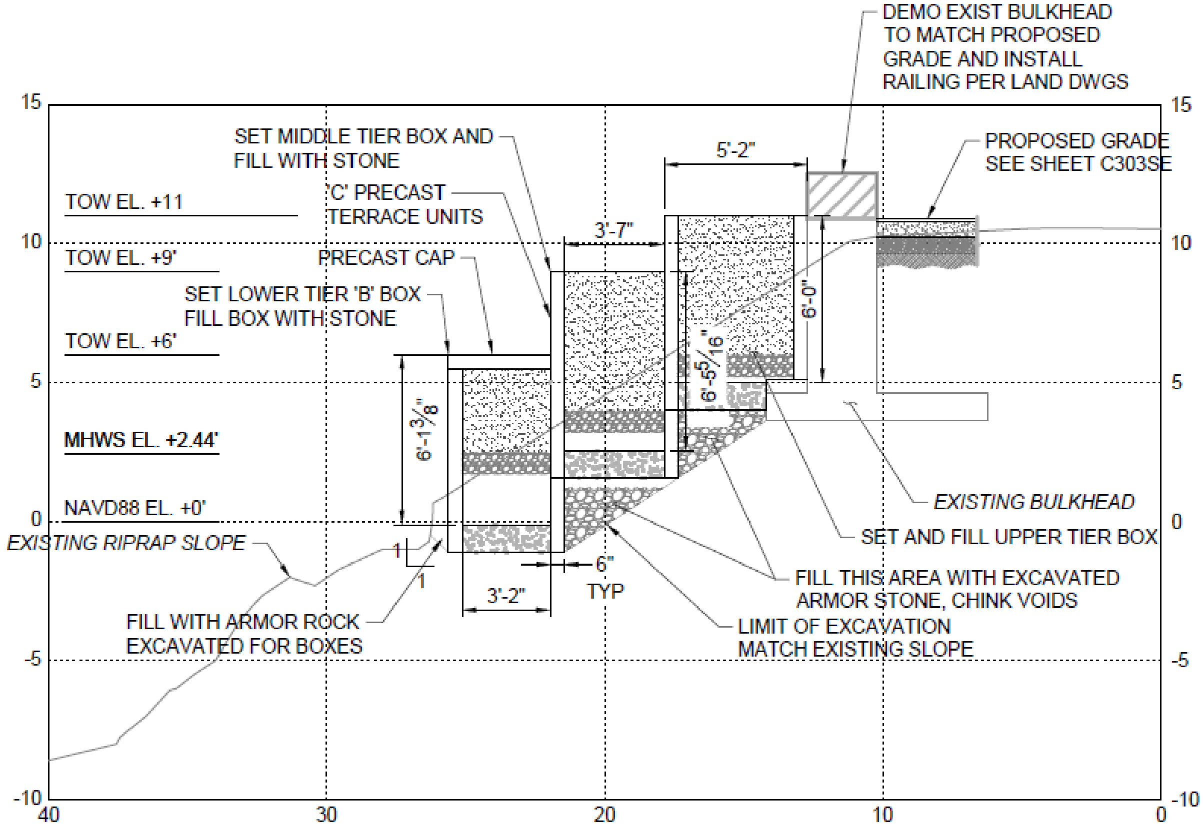


Figure 1: The Most Critical Section Selected for Slope Stability Analyses.

CASES FOR STABILITY ANALYSES

According to EM 1110-2-1902, riverbanks are subject to fluctuations in water level, and the consideration of rapid drawdown is therefore of prime importance. Herein, two cases including one for normal condition with water level at mean sea level of elevation 0.0 and the other one for rapid drawdown condition with water level dropped from mean higher high water at elevation 2.28 to mean lower low water at elevation -2.77 were analyzed for the slope. It was assumed that the existing slope was covered by approximate three feet of riprap stone which is corresponding to a uniform load of 480psf. The added loads due to the proposed construction shown in Figure 1 was estimated using an average unit weight of 130pcf for the precast terrace units, landscape fill and the drainage layer.

RESULTS

Figures 2-5 present the ten most critical of the trial failure surfaces of each case for the existing slope and the new slope:

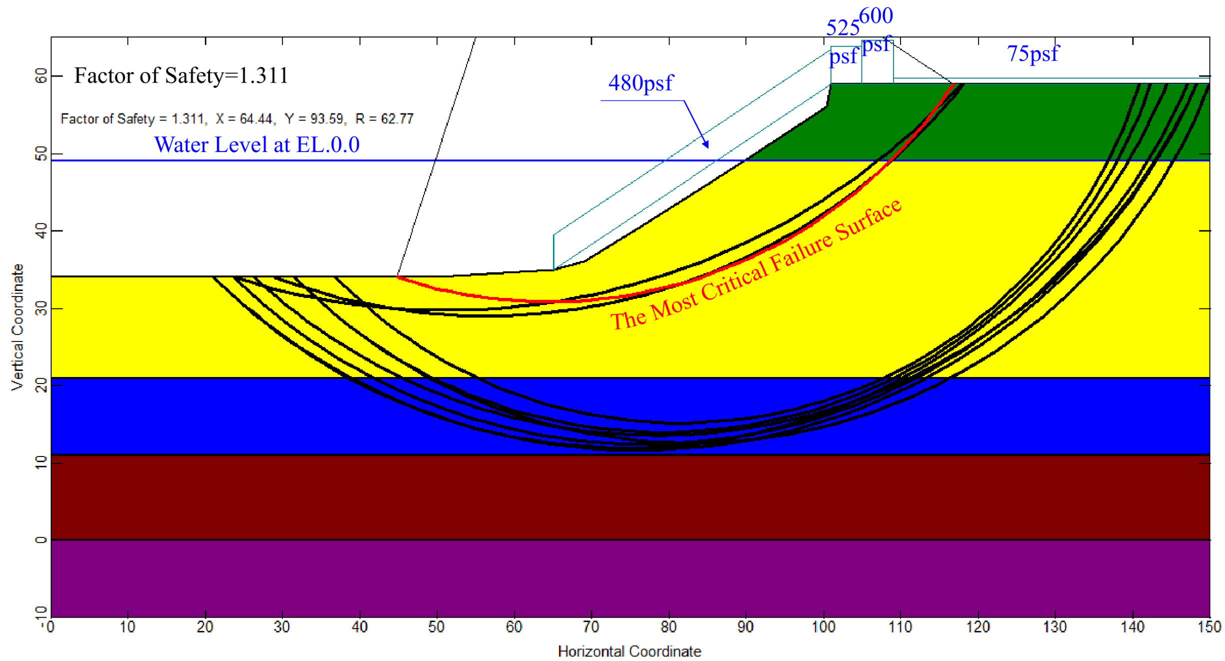


Figure 2: The Ten Most Critical Failure Surfaces for the Existing Slope Under Normal Condition

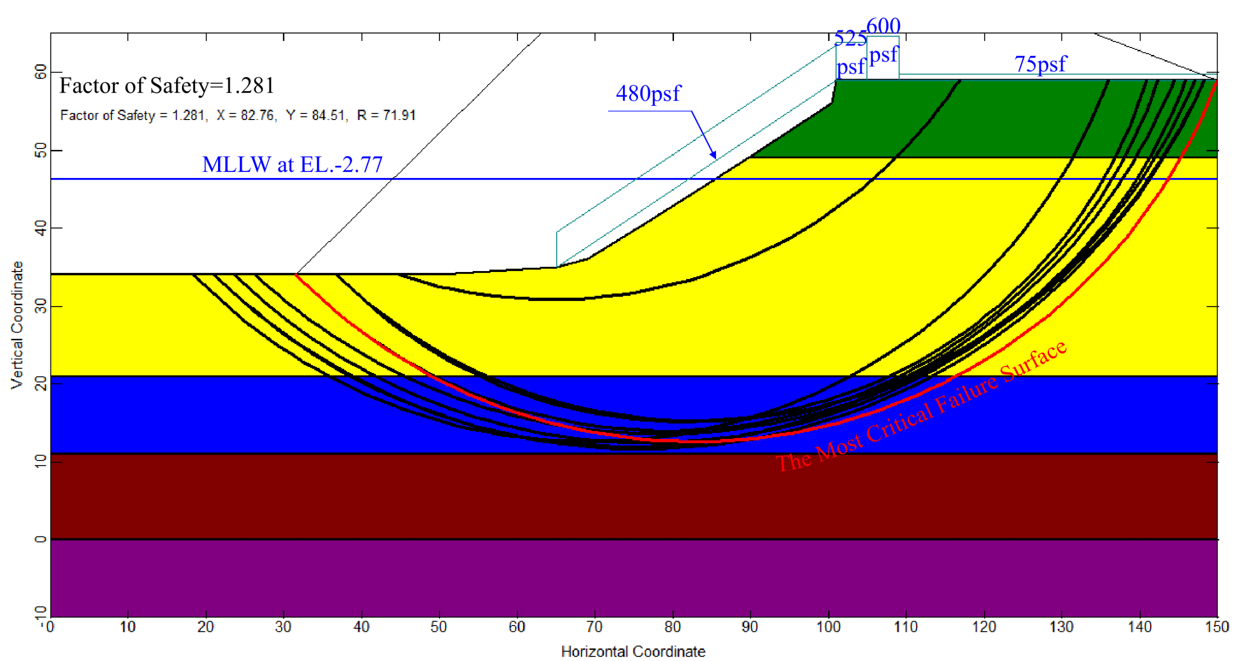


Figure 3: The Ten Most Critical Failure Surfaces for the Existing Slope Under Rapid Drawdown

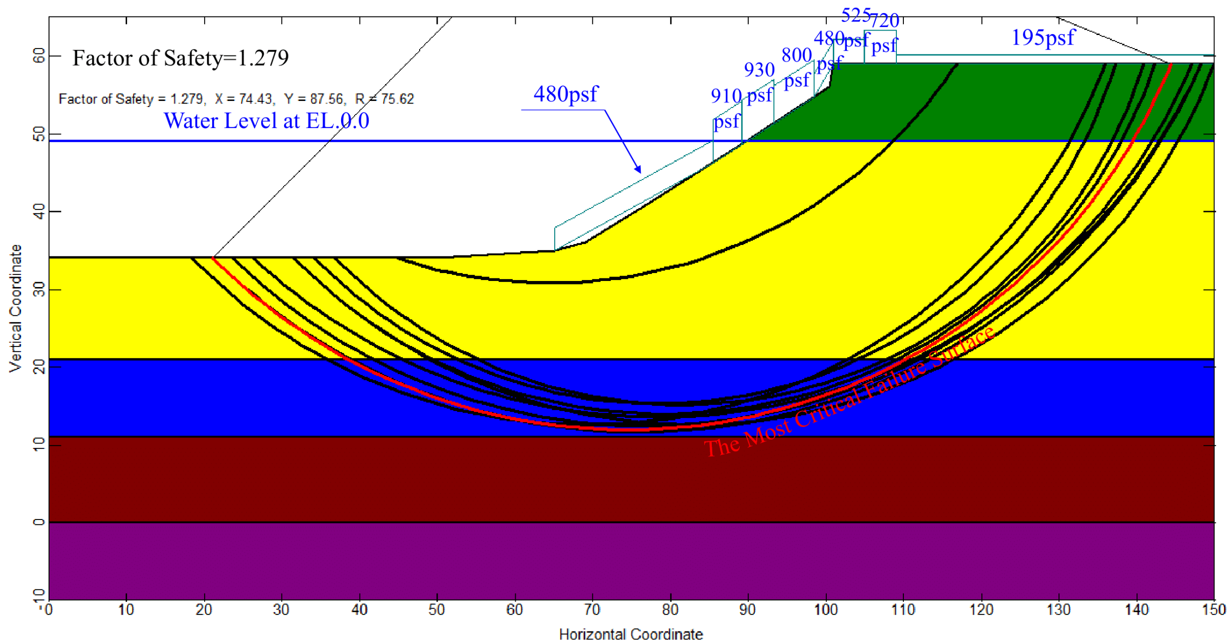


Figure 4: The Ten Most Critical Failure Surfaces for the New Slope Under Normal Condition

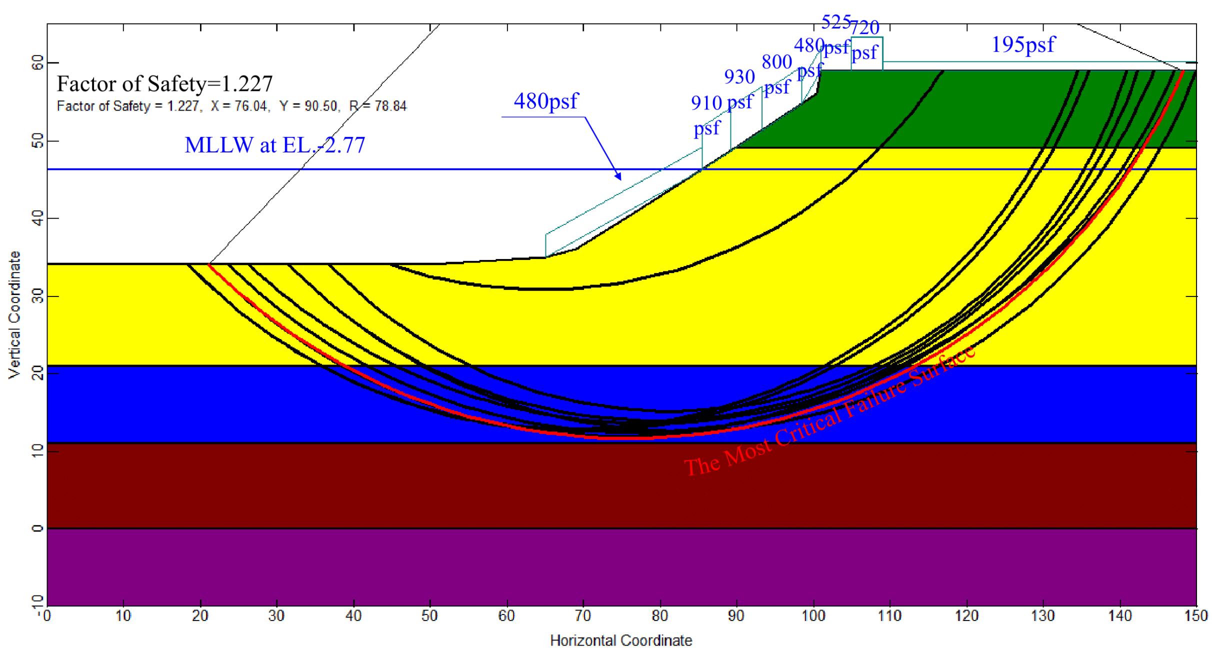


Figure 5: The Ten Most Critical Failure Surfaces for the New Slope Under Rapid Drawdown

The above results are summarized in Table 2.

Table 2: Summary of Slope Stability for Pier A Inlet Bulkhead

CASE / SLOPE	Normal Condition with Water at Mean Sea Level	Rapid Drawdown with Water Dropped from Mean Higher High Water to Mean Lower Low Water Level
The Existing Slope	FS=1.31	FS=1.28
The Proposed Slope	FS=1.28	FS=1.23

DETTAILED OUTPUT

Please see attachments for the detailed outputs.

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

                STABLPro for Windows, Version 2015.4.5

                        Upgraded from:
                        FHWA-PCSTABLE

                 Serial Number :  225625906

                   --Slope Stability Analysis--
                 Simplified Janbu, Simplified Bishop
                   or Spencer Method of Slices

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


This program is licensed to :

Oweis Engineering Inc.
Cedar Knolls, New Jersey

Path to file locations      : R:\07 COMMON\TREVOR CONLIN\17-NY165-01 South
Battery Park Resiliency\Pier A Slope Stability\
Name of input data file     : Existing Slope-Normal Condition-Static-3ft
Riprap.sl4d
Name of output file         : Existing Slope-Normal Condition-Static-3ft
Riprap.sl4o
Name of plot output file    : Existing Slope-Normal Condition-Static-3ft
Riprap.sl4p

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

          Date:  June 04, 2021     Time:  15:18:38




1
     PROBLEM DESCRIPTION   Pier A Inlet Slope Stability




     BOUNDARY COORDINATES

         9 Top   Boundaries
        13 Total Boundaries
```

Boundary No.	X-Left ft.	Y-Left ft.	X-Right ft.	Y-Right ft.	Soil Type Below Bnd
1	0.00	34.00	50.00	34.00	2
2	50.00	34.00	65.00	35.00	2
3	65.00	35.00	69.00	36.00	2
4	69.00	36.00	77.00	41.00	2
5	77.00	41.00	83.50	45.00	2
6	83.50	45.00	89.70	49.00	2
7	89.70	49.00	100.50	56.00	1
8	100.50	56.00	101.00	59.00	1
9	101.00	59.00	150.00	59.00	1
10	89.70	49.00	150.00	49.00	2
11	0.00	21.00	150.00	21.00	3
12	0.00	11.00	150.00	11.00	4
13	0.00	0.00	150.00	0.00	5

1

ISOTROPIC SOIL PARAMETERS

5 Type(s) of Soil

Soil Type No.	Total Unit Wt. pcf	Saturated Unit Wt. pcf	Cohesion Intercept psf	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant psf	Piez. Surface No.
1	123.0	130.0	0.0	33.0	0.00	0.0	1
2	110.0	112.0	0.0	31.0	0.00	0.0	1
3	103.0	110.0	400.0	0.0	0.00	0.0	1
4	110.0	115.0	0.0	31.0	0.00	0.0	1
5	142.0	150.0	10000.0	40.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 63.90 pcf

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point	X-Water	Y-Water

No.	ft.	ft.
1	0.00	49.00
2	150.00	49.00

1

BOUNDARY LOAD(S)

4 Load(s) Specified

Load No.	X-Left ft.	X-Right ft.	Intensity psf	Deflection (deg)
1	65.00	101.00	480.0	0.0
2	101.00	105.00	525.0	0.0
3	105.00	109.00	600.0	0.0
4	109.00	150.00	75.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed
Force Acting On A Horizontally Projected Surface.

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

200 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 20 Points Equally Spaced
Along The Ground Surface Between X = 0.00 ft.
and X = 50.00 ft.

Each Surface Terminates Between X = 114.00 ft.
and X = 150.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.

1.80 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 47 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	44.74	34.00
2	46.45	33.46
3	48.19	32.97
4	49.93	32.53
5	51.69	32.14
6	53.46	31.80
7	55.23	31.51
8	57.02	31.27
9	58.81	31.08
10	60.60	30.94
11	62.40	30.86
12	64.20	30.83
13	66.00	30.85
14	67.80	30.92
15	69.59	31.04
16	71.39	31.21
17	73.17	31.44
18	74.95	31.71
19	76.72	32.04
20	78.48	32.42
21	80.23	32.84
22	81.96	33.32
23	83.68	33.85
24	85.39	34.42
25	87.08	35.05
26	88.75	35.72
27	90.40	36.44
28	92.03	37.21
29	93.63	38.03
30	95.21	38.89
31	96.77	39.79
32	98.30	40.74
33	99.80	41.73
34	101.27	42.77

35	102.71	43.84
36	104.12	44.96
37	105.50	46.12
38	106.85	47.32
39	108.16	48.55
40	109.43	49.82
41	110.67	51.13
42	111.87	52.47
43	113.03	53.85
44	114.15	55.26
45	115.22	56.70
46	116.26	58.17
47	116.81	59.00

Circle Center At X = 64.4 ; Y = 93.6 and Radius, 62.8

*** 1.311 ***

Individual data on the 57 slices

Slice No.	Width Ft	Weight Lbs	Water Force Top Lbs	Water Force Bot Lbs	Tie Force Norm Lbs	Tie Force Tan Lbs	Earthquake Force Hor Lbs	Earthquake Force Ver Lbs	Surcharge Load Lbs
1	1.7	0.52E+02	0.16E+04	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.7	0.15E+03	0.17E+04	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1.7	0.24E+03	0.17E+04	0.19E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	0.1	0.11E+02	0.66E+02	0.74E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	1.7	0.33E+03	0.16E+04	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	1.8	0.44E+03	0.17E+04	0.20E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7	1.8	0.53E+03	0.17E+04	0.20E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8	1.8	0.60E+03	0.17E+04	0.20E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
9	1.8	0.67E+03	0.17E+04	0.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	1.8	0.73E+03	0.16E+04	0.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	1.8	0.78E+03	0.16E+04	0.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	1.8	0.81E+03	0.16E+04	0.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13	0.8	0.37E+03	0.72E+03	0.93E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
14	1.0	0.48E+03	0.91E+03	0.12E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.48E+03
15	1.8	0.93E+03	0.16E+04	0.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
16	1.2	0.66E+03	0.10E+04	0.14E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.58E+03
17	0.6	0.34E+03	0.57E+03	0.68E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.28E+03
18	1.8	0.12E+04	0.16E+04	0.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
19	1.8	0.13E+04	0.15E+04	0.20E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
20	1.8	0.15E+04	0.13E+04	0.20E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.85E+03

21	1.8	0.17E+04	0.12E+04	0.20E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.85E+03
22	0.3	0.28E+03	0.17E+03	0.31E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.13E+03
23	1.5	0.15E+04	0.84E+03	0.16E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.71E+03
24	1.7	0.19E+04	0.86E+03	0.19E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.84E+03
25	1.7	0.20E+04	0.71E+03	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.83E+03
26	1.5	0.19E+04	0.52E+03	0.16E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.74E+03
27	0.2	0.23E+03	0.55E+02	0.19E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.89E+02
28	1.7	0.22E+04	0.43E+03	0.17E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.82E+03
29	1.7	0.23E+04	0.29E+03	0.16E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.81E+03
30	1.7	0.23E+04	0.15E+03	0.16E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.80E+03
31	1.0	0.14E+04	0.22E+02	0.87E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.46E+03
32	0.7	0.10E+04	0.00E+00	0.62E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.33E+03
33	1.6	0.24E+04	0.00E+00	0.14E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.78E+03
34	1.6	0.24E+04	0.00E+00	0.13E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.77E+03
35	1.6	0.25E+04	0.00E+00	0.12E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.76E+03
36	1.6	0.25E+04	0.00E+00	0.11E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.75E+03
37	1.5	0.25E+04	0.00E+00	0.10E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.73E+03
38	1.5	0.24E+04	0.00E+00	0.89E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.72E+03
39	0.7	0.11E+04	0.00E+00	0.38E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.34E+03
40	0.5	0.89E+03	0.00E+00	0.26E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.24E+03
41	0.3	0.53E+03	0.00E+00	0.13E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.14E+03
42	1.4	0.27E+04	0.00E+00	0.66E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.76E+03
43	1.4	0.25E+04	0.00E+00	0.53E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.74E+03
44	0.9	0.14E+04	0.00E+00	0.27E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.46E+03
45	0.5	0.79E+03	0.00E+00	0.13E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.30E+03
46	1.3	0.20E+04	0.00E+00	0.26E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.81E+03
47	1.3	0.18E+04	0.00E+00	0.12E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.79E+03
48	0.4	0.56E+03	0.00E+00	0.91E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.27E+03
49	0.4	0.47E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.24E+03
50	0.4	0.50E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.32E+02
51	1.2	0.13E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.93E+02
52	1.2	0.11E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.90E+02
53	1.2	0.83E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.87E+02
54	1.1	0.61E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.84E+02
55	1.1	0.40E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.81E+02
56	1.0	0.20E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.78E+02
57	0.5	0.28E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.41E+02

Failure Surface Specified By 81 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	31.58	34.00
2	32.86	32.73
3	34.17	31.50
4	35.51	30.30
5	36.89	29.14

6	38.29	28.01
7	39.71	26.91
8	41.17	25.85
9	42.65	24.83
10	44.16	23.84
11	45.69	22.90
12	47.24	21.99
13	48.82	21.12
14	50.41	20.29
15	52.03	19.50
16	53.67	18.75
17	55.32	18.04
18	57.00	17.38
19	58.68	16.75
20	60.39	16.17
21	62.11	15.63
22	63.84	15.14
23	65.58	14.69
24	67.33	14.28
25	69.09	13.91
26	70.87	13.59
27	72.64	13.32
28	74.43	13.09
29	76.22	12.90
30	78.01	12.76
31	79.81	12.66
32	81.61	12.61
33	83.41	12.60
34	85.21	12.64
35	87.01	12.73
36	88.80	12.86
37	90.60	13.03
38	92.38	13.25
39	94.16	13.51
40	95.94	13.82
41	97.70	14.17
42	99.46	14.57
43	101.20	15.01
44	102.94	15.49
45	104.66	16.02
46	106.37	16.59
47	108.06	17.20
48	109.74	17.85
49	111.40	18.55
50	113.04	19.29
51	114.66	20.06
52	116.26	20.88
53	117.85	21.74
54	119.41	22.64
55	120.94	23.58

56	122.46	24.55
57	123.94	25.56
58	125.41	26.61
59	126.84	27.70
60	128.25	28.82
61	129.63	29.97
62	130.98	31.16
63	132.30	32.39
64	133.59	33.64
65	134.85	34.93
66	136.07	36.25
67	137.26	37.60
68	138.42	38.98
69	139.54	40.39
70	140.63	41.82
71	141.68	43.28
72	142.69	44.77
73	143.67	46.28
74	144.61	47.82
75	145.51	49.38
76	146.37	50.96
77	147.19	52.56
78	147.97	54.19
79	148.70	55.83
80	149.40	57.49
81	149.99	59.00

Circle Center At X = 82.8 ; Y = 84.5 and Radius, 71.9

*** 1.341 ***

1

Failure Surface Specified By 84 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	21.05	34.00
2	22.34	32.74
3	23.66	31.52
4	25.01	30.33
5	26.39	29.17
6	27.79	28.04
7	29.22	26.95
8	30.68	25.89
9	32.16	24.86

10	33.66	23.88
11	35.19	22.92
12	36.74	22.01
13	38.31	21.13
14	39.90	20.29
15	41.51	19.49
16	43.14	18.72
17	44.79	18.00
18	46.45	17.31
19	48.13	16.67
20	49.83	16.06
21	51.54	15.49
22	53.26	14.97
23	54.99	14.49
24	56.74	14.04
25	58.49	13.64
26	60.26	13.29
27	62.03	12.97
28	63.81	12.70
29	65.59	12.46
30	67.38	12.28
31	69.18	12.13
32	70.97	12.03
33	72.77	11.96
34	74.57	11.95
35	76.37	11.97
36	78.17	12.04
37	79.97	12.15
38	81.76	12.30
39	83.55	12.50
40	85.34	12.74
41	87.11	13.02
42	88.88	13.34
43	90.65	13.71
44	92.40	14.11
45	94.14	14.56
46	95.88	15.05
47	97.60	15.58
48	99.30	16.16
49	100.99	16.77
50	102.67	17.42
51	104.33	18.11
52	105.98	18.84
53	107.60	19.61
54	109.21	20.42
55	110.80	21.27
56	112.37	22.16
57	113.91	23.08
58	115.44	24.03
59	116.94	25.03

60	118.42	26.06
61	119.87	27.12
62	121.29	28.22
63	122.69	29.35
64	124.06	30.52
65	125.41	31.72
66	126.72	32.95
67	128.01	34.21
68	129.26	35.50
69	130.49	36.82
70	131.68	38.17
71	132.84	39.54
72	133.96	40.95
73	135.06	42.38
74	136.11	43.83
75	137.14	45.31
76	138.13	46.82
77	139.08	48.35
78	139.99	49.90
79	140.87	51.47
80	141.71	53.06
81	142.51	54.67
82	143.28	56.30
83	144.00	57.95
84	144.43	59.00

Circle Center At X = 74.4 ; Y = 87.6 and Radius, 75.6

*** 1.344 ***

Failure Surface Specified By 86 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	21.05	34.00
2	22.36	32.76
3	23.69	31.55
4	25.05	30.37
5	26.43	29.22
6	27.85	28.10
7	29.28	27.02
8	30.75	25.97
9	32.23	24.95
10	33.74	23.97
11	35.27	23.02

12	36.82	22.11
13	38.39	21.23
14	39.98	20.39
15	41.59	19.58
16	43.22	18.82
17	44.86	18.08
18	46.53	17.39
19	48.20	16.74
20	49.89	16.12
21	51.60	15.54
22	53.32	15.00
23	55.05	14.51
24	56.79	14.05
25	58.54	13.63
26	60.30	13.25
27	62.06	12.91
28	63.84	12.61
29	65.62	12.35
30	67.41	12.13
31	69.20	11.96
32	70.99	11.82
33	72.79	11.73
34	74.59	11.67
35	76.39	11.66
36	78.19	11.69
37	79.99	11.76
38	81.78	11.87
39	83.58	12.02
40	85.37	12.21
41	87.15	12.45
42	88.93	12.72
43	90.70	13.03
44	92.47	13.39
45	94.23	13.78
46	95.97	14.22
47	97.71	14.69
48	99.43	15.21
49	101.15	15.76
50	102.85	16.35
51	104.53	16.99
52	106.20	17.66
53	107.86	18.36
54	109.50	19.11
55	111.12	19.89
56	112.72	20.71
57	114.30	21.56
58	115.87	22.46
59	117.41	23.38
60	118.93	24.34
61	120.43	25.34

62	121.91	26.37
63	123.36	27.44
64	124.79	28.53
65	126.19	29.66
66	127.56	30.82
67	128.91	32.01
68	130.23	33.24
69	131.53	34.49
70	132.79	35.77
71	134.03	37.08
72	135.23	38.42
73	136.40	39.78
74	137.55	41.17
75	138.66	42.59
76	139.73	44.03
77	140.78	45.50
78	141.79	46.99
79	142.76	48.50
80	143.71	50.03
81	144.61	51.59
82	145.48	53.16
83	146.32	54.76
84	147.11	56.37
85	147.88	58.00
86	148.31	59.00

Circle Center At X = 76.0 ; Y = 90.5 and Radius, 78.8

*** 1.344 ***

1

Failure Surface Specified By 84 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	23.68	34.00
2	24.99	32.76
3	26.33	31.55
4	27.69	30.38
5	29.08	29.24
6	30.50	28.13
7	31.94	27.05
8	33.41	26.01
9	34.90	25.00
10	36.42	24.03

11	37.95	23.10
12	39.51	22.20
13	41.09	21.34
14	42.70	20.51
15	44.31	19.73
16	45.95	18.98
17	47.61	18.27
18	49.28	17.60
19	50.96	16.97
20	52.66	16.38
21	54.38	15.83
22	56.10	15.32
23	57.84	14.85
24	59.59	14.42
25	61.35	14.04
26	63.12	13.69
27	64.89	13.39
28	66.67	13.13
29	68.46	12.91
30	70.25	12.74
31	72.04	12.60
32	73.84	12.51
33	75.64	12.46
34	77.44	12.45
35	79.24	12.49
36	81.04	12.57
37	82.83	12.69
38	84.63	12.85
39	86.42	13.06
40	88.20	13.30
41	89.98	13.59
42	91.74	13.92
43	93.51	14.30
44	95.26	14.71
45	97.00	15.16
46	98.73	15.66
47	100.45	16.20
48	102.15	16.77
49	103.84	17.39
50	105.52	18.05
51	107.18	18.74
52	108.82	19.48
53	110.45	20.25
54	112.05	21.07
55	113.64	21.91
56	115.21	22.80
57	116.75	23.72
58	118.28	24.68
59	119.77	25.68
60	121.25	26.71

61	122.70	27.77
62	124.13	28.87
63	125.53	30.01
64	126.90	31.17
65	128.24	32.37
66	129.56	33.60
67	130.85	34.85
68	132.10	36.14
69	133.33	37.46
70	134.52	38.81
71	135.69	40.18
72	136.81	41.58
73	137.91	43.01
74	138.97	44.46
75	140.00	45.94
76	140.99	47.44
77	141.95	48.97
78	142.87	50.52
79	143.75	52.08
80	144.60	53.67
81	145.41	55.28
82	146.18	56.91
83	146.91	58.55
84	147.10	59.00

Circle Center At X = 76.8 ; Y = 88.8 and Radius, 76.3

*** 1.352 ***

Failure Surface Specified By 77 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	31.58	34.00
2	32.86	32.73
3	34.17	31.50
4	35.51	30.30
5	36.89	29.14
6	38.29	28.02
7	39.73	26.93
8	41.19	25.88
9	42.69	24.88
10	44.21	23.91
11	45.75	22.99
12	47.32	22.11

13	48.91	21.27
14	50.53	20.47
15	52.16	19.72
16	53.81	19.01
17	55.49	18.35
18	57.18	17.73
19	58.89	17.15
20	60.61	16.63
21	62.34	16.15
22	64.09	15.72
23	65.85	15.33
24	67.62	14.99
25	69.39	14.70
26	71.18	14.46
27	72.96	14.27
28	74.76	14.12
29	76.56	14.03
30	78.36	13.98
31	80.16	13.98
32	81.96	14.02
33	83.75	14.12
34	85.55	14.27
35	87.34	14.46
36	89.12	14.70
37	90.90	14.99
38	92.66	15.33
39	94.42	15.72
40	96.17	16.15
41	97.90	16.63
42	99.63	17.15
43	101.33	17.73
44	103.02	18.34
45	104.70	19.01
46	106.35	19.72
47	107.99	20.47
48	109.60	21.26
49	111.19	22.10
50	112.76	22.99
51	114.31	23.91
52	115.83	24.88
53	117.32	25.88
54	118.78	26.93
55	120.22	28.01
56	121.63	29.14
57	123.00	30.30
58	124.34	31.50
59	125.66	32.73
60	126.93	34.00
61	128.18	35.30
62	129.38	36.64

63	130.55	38.00
64	131.69	39.40
65	132.78	40.83
66	133.84	42.29
67	134.85	43.77
68	135.83	45.29
69	136.77	46.82
70	137.66	48.39
71	138.51	49.97
72	139.32	51.58
73	140.08	53.21
74	140.80	54.86
75	141.48	56.53
76	142.11	58.22
77	142.37	59.00

Circle Center At X = 79.3 ; Y = 80.7 and Radius, 66.8

*** 1.354 ***

1

Failure Surface Specified By 57 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	28.95	34.00
2	30.64	33.39
3	32.35	32.82
4	34.07	32.28
5	35.80	31.79
6	37.54	31.34
7	39.29	30.92
8	41.05	30.55
9	42.82	30.22
10	44.60	29.93
11	46.38	29.67
12	48.17	29.46
13	49.96	29.29
14	51.76	29.17
15	53.55	29.08
16	55.35	29.03
17	57.15	29.03
18	58.95	29.07
19	60.75	29.15
20	62.55	29.27

21	64.34	29.43
22	66.13	29.63
23	67.91	29.87
24	69.69	30.15
25	71.46	30.48
26	73.22	30.84
27	74.98	31.25
28	76.72	31.69
29	78.45	32.18
30	80.18	32.70
31	81.88	33.27
32	83.58	33.87
33	85.26	34.51
34	86.93	35.19
35	88.58	35.91
36	90.21	36.67
37	91.83	37.46
38	93.42	38.29
39	95.00	39.16
40	96.56	40.06
41	98.10	41.00
42	99.61	41.97
43	101.10	42.98
44	102.57	44.02
45	104.01	45.10
46	105.43	46.21
47	106.83	47.35
48	108.19	48.52
49	109.53	49.72
50	110.84	50.95
51	112.12	52.22
52	113.38	53.51
53	114.60	54.83
54	115.79	56.18
55	116.96	57.55
56	118.08	58.95
57	118.12	59.00

Circle Center At X = 56.4 ; Y = 107.5 and Radius, 78.5

*** 1.381 ***

Failure Surface Specified By 82 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.

1	26.32	34.00
2	27.65	32.79
3	29.01	31.61
4	30.40	30.47
5	31.82	29.36
6	33.26	28.28
7	34.73	27.24
8	36.22	26.23
9	37.73	25.25
10	39.27	24.32
11	40.82	23.42
12	42.40	22.55
13	44.00	21.72
14	45.62	20.93
15	47.26	20.18
16	48.91	19.47
17	50.58	18.80
18	52.26	18.16
19	53.96	17.57
20	55.67	17.02
21	57.40	16.50
22	59.14	16.03
23	60.88	15.60
24	62.64	15.21
25	64.41	14.86
26	66.18	14.55
27	67.96	14.29
28	69.75	14.06
29	71.54	13.88
30	73.33	13.74
31	75.13	13.65
32	76.93	13.59
33	78.73	13.58
34	80.53	13.61
35	82.33	13.68
36	84.12	13.80
37	85.92	13.95
38	87.71	14.15
39	89.49	14.39
40	91.27	14.68
41	93.04	15.00
42	94.80	15.37
43	96.55	15.77
44	98.30	16.22
45	100.03	16.71
46	101.75	17.24
47	103.46	17.81
48	105.15	18.42
49	106.83	19.07

50	108.49	19.76
51	110.14	20.49
52	111.77	21.26
53	113.38	22.06
54	114.97	22.91
55	116.54	23.79
56	118.09	24.70
57	119.61	25.65
58	121.12	26.64
59	122.60	27.67
60	124.05	28.72
61	125.49	29.82
62	126.89	30.94
63	128.27	32.10
64	129.62	33.29
65	130.94	34.51
66	132.23	35.76
67	133.50	37.05
68	134.73	38.36
69	135.93	39.70
70	137.10	41.07
71	138.24	42.46
72	139.34	43.88
73	140.41	45.33
74	141.45	46.80
75	142.45	48.30
76	143.41	49.82
77	144.34	51.36
78	145.23	52.92
79	146.09	54.51
80	146.91	56.11
81	147.69	57.73
82	148.26	59.00

Circle Center At X =   78.4 ; Y =   90.1 and Radius,   76.5

*** 1.383 ***

1

Failure Surface Specified By 73 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	36.84	34.00
2	38.12	32.73

3	39.43	31.49
4	40.77	30.30
5	42.15	29.14
6	43.56	28.02
7	45.00	26.95
8	46.48	25.91
9	47.98	24.92
10	49.51	23.98
11	51.07	23.08
12	52.65	22.22
13	54.26	21.41
14	55.89	20.65
15	57.54	19.93
16	59.22	19.26
17	60.91	18.65
18	62.61	18.08
19	64.34	17.56
20	66.07	17.09
21	67.82	16.67
22	69.59	16.30
23	71.36	15.98
24	73.14	15.71
25	74.93	15.50
26	76.72	15.34
27	78.51	15.23
28	80.31	15.17
29	82.11	15.16
30	83.91	15.21
31	85.71	15.30
32	87.50	15.45
33	89.29	15.66
34	91.08	15.91
35	92.85	16.21
36	94.61	16.57
37	96.37	16.98
38	98.11	17.43
39	99.84	17.94
40	101.55	18.50
41	103.24	19.10
42	104.92	19.76
43	106.57	20.46
44	108.21	21.21
45	109.82	22.01
46	111.41	22.86
47	112.98	23.75
48	114.52	24.68
49	116.03	25.66
50	117.51	26.68
51	118.96	27.75
52	120.38	28.85

53	121.77	30.00
54	123.12	31.19
55	124.44	32.41
56	125.72	33.68
57	126.97	34.97
58	128.17	36.31
59	129.34	37.68
60	130.47	39.08
61	131.56	40.52
62	132.60	41.98
63	133.60	43.48
64	134.56	45.00
65	135.48	46.55
66	136.35	48.13
67	137.17	49.73
68	137.95	51.35
69	138.67	53.00
70	139.36	54.66
71	139.99	56.35
72	140.57	58.05
73	140.87	59.00

Circle Center At X = 81.4 ; Y = 77.4 and Radius, 62.2

*** 1.386 ***

Failure Surface Specified By 59 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	23.68	34.00
2	25.41	33.47
3	27.14	32.98
4	28.88	32.52
5	30.63	32.10
6	32.38	31.71
7	34.15	31.35
8	35.92	31.03
9	37.70	30.75
10	39.48	30.50
11	41.27	30.29
12	43.06	30.11
13	44.85	29.97
14	46.65	29.86
15	48.45	29.79

16	50.25	29.76
17	52.05	29.76
18	53.85	29.79
19	55.65	29.87
20	57.44	29.97
21	59.24	30.12
22	61.03	30.30
23	62.82	30.51
24	64.60	30.76
25	66.38	31.05
26	68.15	31.37
27	69.91	31.72
28	71.67	32.11
29	73.42	32.54
30	75.16	33.00
31	76.89	33.49
32	78.61	34.02
33	80.32	34.59
34	82.02	35.18
35	83.70	35.81
36	85.38	36.48
37	87.04	37.17
38	88.68	37.90
39	90.31	38.66
40	91.93	39.46
41	93.53	40.29
42	95.11	41.14
43	96.67	42.03
44	98.22	42.95
45	99.75	43.90
46	101.26	44.88
47	102.75	45.89
48	104.22	46.93
49	105.67	48.00
50	107.09	49.10
51	108.50	50.22
52	109.88	51.38
53	111.24	52.56
54	112.58	53.76
55	113.89	55.00
56	115.17	56.26
57	116.44	57.54
58	117.67	58.85
59	117.81	59.00

Circle Center At X = 51.1 ; Y = 120.4 and Radius, 90.7

*** 1.390 ***

```
1

                Y            A      X      I      S            F      T

                0.00     18.75     37.50     56.25     75.00     93.75

X       0.00 *-----*---+*-----.*-+-----W---+---------+---------+
             -               ...
             -              ....
             -            ......
             -           .......
             -          ........
       18.75 +         .........
             -        ........33
             -        .......335
             -       ......33587
             -      ......335802
             -      .....335822.
A      37.50 +     .....33582279
             -     ....33582.79.
             -    .....3582997.1
             -    ....358299.7.1
             -    ...338299..71*
             -   ....35269...71.
X      56.25 +   ...33229...701.
             -   ...3529.....71.
             -   ...3269.....1..
             -   ...329......10.*/1
             -   ..3229......11.*
             -   ..3269......71...
I      75.00 +   ..326........10..
             -   ..329........10...*
             -    .329........710..
             -    .426.........10... *
             -    ..26..........10..
             -     .26..........110..  *
S      93.75 +     .239..........110..
             -      226...........110..
             -      .239...........110.    **1/2
             -       223............110.
             -       .236.............10.    2/3
             -        2239............11.   3/4
      112.50 +         2439..............11.
             -          2439..............111
             -           2436................7
             -           .24339.............
             -            .24339............
```

```
            -             .224336...........
F    131.25 +               .244366.........
            -                .22433369......
            -                  2224333669...
            -                    .2244333666
            -                      .22244333
            -                         222244
T    150.00 *     *    *              *  .2*4/
```

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

                STABLPro for Windows, Version 2015.4.5

                        Upgraded from:
                        FHWA-PCSTABLE

                 Serial Number :  225625906

                    --Slope Stability Analysis--
                 Simplified Janbu, Simplified Bishop
                   or Spencer Method of Slices

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


     This program is licensed to :

     Oweis Engineering Inc.
     Cedar Knolls, New Jersey

     Path to file locations      : R:\07 COMMON\TREVOR CONLIN\17-NY165-01 South
Battery Park Resiliency\Pier A Slope Stability\
     Name of input data file     : Existing Slope-Rapid Drawdown-Static-3ft
Riprap.sl4d
     Name of output file         : Existing Slope-Rapid Drawdown-Static-3ft
Riprap.sl4o
     Name of plot output file    : Existing Slope-Rapid Drawdown-Static-3ft
Riprap.sl4p

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

               Date:  June 04, 2021     Time:  15:19:51




1
          PROBLEM DESCRIPTION   Pier A Inlet Slope Stability




          BOUNDARY COORDINATES

              9 Top   Boundaries
             13 Total Boundaries
```

Boundary No.	X-Left ft.	Y-Left ft.	X-Right ft.	Y-Right ft.	Soil Type Below Bnd
1	0.00	34.00	50.00	34.00	2
2	50.00	34.00	65.00	35.00	2
3	65.00	35.00	69.00	36.00	2
4	69.00	36.00	77.00	41.00	2
5	77.00	41.00	83.50	45.00	2
6	83.50	45.00	89.70	49.00	2
7	89.70	49.00	100.50	56.00	1
8	100.50	56.00	101.00	59.00	1
9	101.00	59.00	150.00	59.00	1
10	89.70	49.00	150.00	49.00	2
11	0.00	21.00	150.00	21.00	3
12	0.00	11.00	150.00	11.00	4
13	0.00	0.00	150.00	0.00	5

1

ISOTROPIC SOIL PARAMETERS

5 Type(s) of Soil

Soil Type No.	Total Unit Wt. pcf	Saturated Unit Wt. pcf	Cohesion Intercept psf	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant psf	Piez. Surface No.
1	123.0	135.0	0.0	33.0	0.00	0.0	1
2	112.0	123.0	0.0	31.0	0.00	0.0	1
3	105.0	112.0	400.0	0.0	0.00	0.0	1
4	116.0	128.0	0.0	31.0	0.00	0.0	1
5	142.0	150.0	10000.0	40.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 63.90   pcf

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point   X-Water   Y-Water

No.	ft.	ft.
1	0.00	46.20
2	150.00	46.20

1

BOUNDARY LOAD(S)

4 Load(s) Specified

Load No.	X-Left ft.	X-Right ft.	Intensity psf	Deflection (deg)
1	65.00	101.00	480.0	0.0
2	101.00	105.00	525.0	0.0
3	105.00	109.00	600.0	0.0
4	109.00	150.00	75.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed
Force Acting On A Horizontally Projected Surface.

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

200 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 20 Points Equally Spaced
Along The Ground Surface Between X = 0.00 ft.
and X = 50.00 ft.

Each Surface Terminates Between X = 114.00 ft.
and X = 150.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.

1.80 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 81 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	31.58	34.00
2	32.86	32.73
3	34.17	31.50
4	35.51	30.30
5	36.89	29.14
6	38.29	28.01
7	39.71	26.91
8	41.17	25.85
9	42.65	24.83
10	44.16	23.84
11	45.69	22.90
12	47.24	21.99
13	48.82	21.12
14	50.41	20.29
15	52.03	19.50
16	53.67	18.75
17	55.32	18.04
18	57.00	17.38
19	58.68	16.75
20	60.39	16.17
21	62.11	15.63
22	63.84	15.14
23	65.58	14.69
24	67.33	14.28
25	69.09	13.91
26	70.87	13.59
27	72.64	13.32
28	74.43	13.09
29	76.22	12.90
30	78.01	12.76
31	79.81	12.66
32	81.61	12.61
33	83.41	12.60
34	85.21	12.64

35	87.01	12.73
36	88.80	12.86
37	90.60	13.03
38	92.38	13.25
39	94.16	13.51
40	95.94	13.82
41	97.70	14.17
42	99.46	14.57
43	101.20	15.01
44	102.94	15.49
45	104.66	16.02
46	106.37	16.59
47	108.06	17.20
48	109.74	17.85
49	111.40	18.55
50	113.04	19.29
51	114.66	20.06
52	116.26	20.88
53	117.85	21.74
54	119.41	22.64
55	120.94	23.58
56	122.46	24.55
57	123.94	25.56
58	125.41	26.61
59	126.84	27.70
60	128.25	28.82
61	129.63	29.97
62	130.98	31.16
63	132.30	32.39
64	133.59	33.64
65	134.85	34.93
66	136.07	36.25
67	137.26	37.60
68	138.42	38.98
69	139.54	40.39
70	140.63	41.82
71	141.68	43.28
72	142.69	44.77
73	143.67	46.28
74	144.61	47.82
75	145.51	49.38
76	146.37	50.96
77	147.19	52.56
78	147.97	54.19
79	148.70	55.83
80	149.40	57.49
81	149.99	59.00

Circle Center At X = 82.8 ; Y = 84.5 and Radius, 71.9

*** 1.281 ***

Individual data on the 94 slices

Slice No.	Width Ft	Weight Lbs	Water Force Top Lbs	Water Force Bot Lbs	Tie Force Norm Lbs	Tie Force Tan Lbs	Earthquake Force Hor Lbs	Earthquake Force Ver Lbs	Surcharge Load Lbs
1	1.3	0.10E+03	0.10E+04	0.15E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.3	0.30E+03	0.10E+04	0.16E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1.3	0.51E+03	0.10E+04	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	1.4	0.72E+03	0.11E+04	0.19E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	1.4	0.94E+03	0.11E+04	0.20E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	1.4	0.11E+04	0.11E+04	0.22E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7	1.5	0.14E+04	0.11E+04	0.23E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8	1.5	0.16E+04	0.12E+04	0.24E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
9	1.5	0.18E+04	0.12E+04	0.25E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	1.5	0.20E+04	0.12E+04	0.26E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	1.6	0.22E+04	0.12E+04	0.27E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	1.6	0.24E+04	0.12E+04	0.28E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13	0.2	0.36E+03	0.18E+03	0.41E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
14	1.0	0.16E+04	0.75E+03	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	0.4	0.69E+03	0.32E+03	0.77E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
16	1.6	0.28E+04	0.13E+04	0.30E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	1.6	0.30E+04	0.13E+04	0.31E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
18	1.7	0.32E+04	0.13E+04	0.32E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
19	1.7	0.34E+04	0.13E+04	0.33E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	1.7	0.36E+04	0.13E+04	0.34E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
21	1.7	0.37E+04	0.13E+04	0.34E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22	1.7	0.39E+04	0.13E+04	0.35E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23	1.7	0.40E+04	0.13E+04	0.35E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	1.2	0.28E+04	0.84E+03	0.24E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	0.6	0.14E+04	0.42E+03	0.12E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.28E+03
26	1.8	0.44E+04	0.13E+04	0.36E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.84E+03
27	1.7	0.43E+04	0.11E+04	0.35E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.80E+03
28	0.1	0.25E+03	0.72E+02	0.20E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.45E+02
29	1.8	0.48E+04	0.13E+04	0.37E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.85E+03
30	1.8	0.52E+04	0.11E+04	0.38E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.85E+03
31	1.8	0.55E+04	0.99E+03	0.38E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
32	1.8	0.58E+04	0.84E+03	0.38E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
33	0.8	0.26E+04	0.32E+03	0.17E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.37E+03
34	1.0	0.35E+04	0.37E+03	0.22E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.49E+03
35	1.8	0.64E+04	0.54E+03	0.39E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
36	1.8	0.66E+04	0.39E+03	0.39E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03

37	1.8	0.69E+04	0.24E+03	0.39E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
38	0.1	0.35E+03	0.82E+01	0.19E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.43E+02
39	1.7	0.68E+04	0.84E+02	0.37E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.82E+03
40	1.8	0.73E+04	0.00E+00	0.39E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
41	1.8	0.75E+04	0.00E+00	0.38E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
42	0.9	0.38E+04	0.00E+00	0.19E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.43E+03
43	0.9	0.39E+04	0.00E+00	0.19E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.43E+03
44	1.8	0.79E+04	0.00E+00	0.38E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
45	1.8	0.81E+04	0.00E+00	0.38E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.85E+03
46	1.8	0.83E+04	0.00E+00	0.37E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.85E+03
47	1.8	0.84E+04	0.00E+00	0.37E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.85E+03
48	1.8	0.85E+04	0.00E+00	0.37E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.84E+03
49	1.0	0.51E+04	0.00E+00	0.22E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.50E+03
50	0.5	0.26E+04	0.00E+00	0.10E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.24E+03
51	0.2	0.11E+04	0.00E+00	0.42E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.11E+03
52	1.7	0.92E+04	0.00E+00	0.36E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.91E+03
53	1.7	0.90E+04	0.00E+00	0.35E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.90E+03
54	0.3	0.18E+04	0.00E+00	0.69E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.18E+03
55	1.4	0.71E+04	0.00E+00	0.27E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.82E+03
56	1.7	0.86E+04	0.00E+00	0.34E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.10E+04
57	0.9	0.48E+04	0.00E+00	0.19E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.56E+03
58	0.7	0.37E+04	0.00E+00	0.14E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.55E+02
59	1.7	0.82E+04	0.00E+00	0.32E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.12E+03
60	1.6	0.80E+04	0.00E+00	0.31E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.12E+03
61	1.6	0.78E+04	0.00E+00	0.31E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.12E+03
62	1.6	0.75E+04	0.00E+00	0.30E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.12E+03
63	0.2	0.10E+04	0.00E+00	0.40E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.16E+02
64	1.4	0.63E+04	0.00E+00	0.25E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.10E+03
65	1.6	0.70E+04	0.00E+00	0.28E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.12E+03
66	1.5	0.67E+04	0.00E+00	0.27E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.12E+03
67	1.5	0.65E+04	0.00E+00	0.25E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.11E+03
68	1.5	0.62E+04	0.00E+00	0.24E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.11E+03
69	1.5	0.59E+04	0.00E+00	0.23E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.11E+03
70	1.4	0.56E+04	0.00E+00	0.22E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.11E+03
71	1.4	0.53E+04	0.00E+00	0.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.11E+03
72	1.4	0.50E+04	0.00E+00	0.19E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.10E+03
73	1.4	0.47E+04	0.00E+00	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.10E+03
74	1.3	0.44E+04	0.00E+00	0.17E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.99E+02
75	1.3	0.41E+04	0.00E+00	0.15E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.97E+02
76	1.3	0.38E+04	0.00E+00	0.14E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.94E+02
77	1.2	0.35E+04	0.00E+00	0.12E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.92E+02
78	1.2	0.32E+04	0.00E+00	0.11E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.89E+02
79	1.2	0.29E+04	0.00E+00	0.91E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.87E+02
80	1.1	0.26E+04	0.00E+00	0.75E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.84E+02
81	1.1	0.24E+04	0.00E+00	0.59E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.81E+02
82	1.1	0.21E+04	0.00E+00	0.42E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.79E+02
83	1.0	0.18E+04	0.00E+00	0.25E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.76E+02
84	0.9	0.15E+04	0.00E+00	0.78E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.69E+02
85	0.1	0.83E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.41E+01
86	0.9	0.14E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.70E+02

87	0.7	0.88E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.51E+02
88	0.2	0.26E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.16E+02
89	0.9	0.93E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.64E+02
90	0.8	0.73E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.61E+02
91	0.8	0.54E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.58E+02
92	0.7	0.36E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.55E+02
93	0.7	0.20E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.52E+02
94	0.6	0.55E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.44E+02

Failure Surface Specified By 86 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	21.05	34.00
2	22.36	32.76
3	23.69	31.55
4	25.05	30.37
5	26.43	29.22
6	27.85	28.10
7	29.28	27.02
8	30.75	25.97
9	32.23	24.95
10	33.74	23.97
11	35.27	23.02
12	36.82	22.11
13	38.39	21.23
14	39.98	20.39
15	41.59	19.58
16	43.22	18.82
17	44.86	18.08
18	46.53	17.39
19	48.20	16.74
20	49.89	16.12
21	51.60	15.54
22	53.32	15.00
23	55.05	14.51
24	56.79	14.05
25	58.54	13.63
26	60.30	13.25
27	62.06	12.91
28	63.84	12.61
29	65.62	12.35
30	67.41	12.13
31	69.20	11.96
32	70.99	11.82
33	72.79	11.73
34	74.59	11.67

35	76.39	11.66
36	78.19	11.69
37	79.99	11.76
38	81.78	11.87
39	83.58	12.02
40	85.37	12.21
41	87.15	12.45
42	88.93	12.72
43	90.70	13.03
44	92.47	13.39
45	94.23	13.78
46	95.97	14.22
47	97.71	14.69
48	99.43	15.21
49	101.15	15.76
50	102.85	16.35
51	104.53	16.99
52	106.20	17.66
53	107.86	18.36
54	109.50	19.11
55	111.12	19.89
56	112.72	20.71
57	114.30	21.56
58	115.87	22.46
59	117.41	23.38
60	118.93	24.34
61	120.43	25.34
62	121.91	26.37
63	123.36	27.44
64	124.79	28.53
65	126.19	29.66
66	127.56	30.82
67	128.91	32.01
68	130.23	33.24
69	131.53	34.49
70	132.79	35.77
71	134.03	37.08
72	135.23	38.42
73	136.40	39.78
74	137.55	41.17
75	138.66	42.59
76	139.73	44.03
77	140.78	45.50
78	141.79	46.99
79	142.76	48.50
80	143.71	50.03
81	144.61	51.59
82	145.48	53.16
83	146.32	54.76
84	147.11	56.37

85	147.88	58.00
86	148.31	59.00

Circle Center At X = 76.0 ; Y = 90.5 and Radius, 78.8

*** 1.282 ***

1

Failure Surface Specified By 84 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	21.05	34.00
2	22.34	32.74
3	23.66	31.52
4	25.01	30.33
5	26.39	29.17
6	27.79	28.04
7	29.22	26.95
8	30.68	25.89
9	32.16	24.86
10	33.66	23.88
11	35.19	22.92
12	36.74	22.01
13	38.31	21.13
14	39.90	20.29
15	41.51	19.49
16	43.14	18.72
17	44.79	18.00
18	46.45	17.31
19	48.13	16.67
20	49.83	16.06
21	51.54	15.49
22	53.26	14.97
23	54.99	14.49
24	56.74	14.04
25	58.49	13.64
26	60.26	13.29
27	62.03	12.97
28	63.81	12.70
29	65.59	12.46
30	67.38	12.28
31	69.18	12.13
32	70.97	12.03
33	72.77	11.96

34	74.57	11.95
35	76.37	11.97
36	78.17	12.04
37	79.97	12.15
38	81.76	12.30
39	83.55	12.50
40	85.34	12.74
41	87.11	13.02
42	88.88	13.34
43	90.65	13.71
44	92.40	14.11
45	94.14	14.56
46	95.88	15.05
47	97.60	15.58
48	99.30	16.16
49	100.99	16.77
50	102.67	17.42
51	104.33	18.11
52	105.98	18.84
53	107.60	19.61
54	109.21	20.42
55	110.80	21.27
56	112.37	22.16
57	113.91	23.08
58	115.44	24.03
59	116.94	25.03
60	118.42	26.06
61	119.87	27.12
62	121.29	28.22
63	122.69	29.35
64	124.06	30.52
65	125.41	31.72
66	126.72	32.95
67	128.01	34.21
68	129.26	35.50
69	130.49	36.82
70	131.68	38.17
71	132.84	39.54
72	133.96	40.95
73	135.06	42.38
74	136.11	43.83
75	137.14	45.31
76	138.13	46.82
77	139.08	48.35
78	139.99	49.90
79	140.87	51.47
80	141.71	53.06
81	142.51	54.67
82	143.28	56.30
83	144.00	57.95

84	144.43	59.00

Circle Center At X = 74.4 ; Y = 87.6 and Radius, 75.6

*** 1.283 ***

Failure Surface Specified By 84 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	23.68	34.00
2	24.99	32.76
3	26.33	31.55
4	27.69	30.38
5	29.08	29.24
6	30.50	28.13
7	31.94	27.05
8	33.41	26.01
9	34.90	25.00
10	36.42	24.03
11	37.95	23.10
12	39.51	22.20
13	41.09	21.34
14	42.70	20.51
15	44.31	19.73
16	45.95	18.98
17	47.61	18.27
18	49.28	17.60
19	50.96	16.97
20	52.66	16.38
21	54.38	15.83
22	56.10	15.32
23	57.84	14.85
24	59.59	14.42
25	61.35	14.04
26	63.12	13.69
27	64.89	13.39
28	66.67	13.13
29	68.46	12.91
30	70.25	12.74
31	72.04	12.60
32	73.84	12.51
33	75.64	12.46
34	77.44	12.45
35	79.24	12.49

36	81.04	12.57
37	82.83	12.69
38	84.63	12.85
39	86.42	13.06
40	88.20	13.30
41	89.98	13.59
42	91.74	13.92
43	93.51	14.30
44	95.26	14.71
45	97.00	15.16
46	98.73	15.66
47	100.45	16.20
48	102.15	16.77
49	103.84	17.39
50	105.52	18.05
51	107.18	18.74
52	108.82	19.48
53	110.45	20.25
54	112.05	21.07
55	113.64	21.91
56	115.21	22.80
57	116.75	23.72
58	118.28	24.68
59	119.77	25.68
60	121.25	26.71
61	122.70	27.77
62	124.13	28.87
63	125.53	30.01
64	126.90	31.17
65	128.24	32.37
66	129.56	33.60
67	130.85	34.85
68	132.10	36.14
69	133.33	37.46
70	134.52	38.81
71	135.69	40.18
72	136.81	41.58
73	137.91	43.01
74	138.97	44.46
75	140.00	45.94
76	140.99	47.44
77	141.95	48.97
78	142.87	50.52
79	143.75	52.08
80	144.60	53.67
81	145.41	55.28
82	146.18	56.91
83	146.91	58.55
84	147.10	59.00

Circle Center At X =   76.8 ; Y =   88.8 and Radius,   76.3

*** 1.293 ***

1

Failure Surface Specified By 77 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	31.58	34.00
2	32.86	32.73
3	34.17	31.50
4	35.51	30.30
5	36.89	29.14
6	38.29	28.02
7	39.73	26.93
8	41.19	25.88
9	42.69	24.88
10	44.21	23.91
11	45.75	22.99
12	47.32	22.11
13	48.91	21.27
14	50.53	20.47
15	52.16	19.72
16	53.81	19.01
17	55.49	18.35
18	57.18	17.73
19	58.89	17.15
20	60.61	16.63
21	62.34	16.15
22	64.09	15.72
23	65.85	15.33
24	67.62	14.99
25	69.39	14.70
26	71.18	14.46
27	72.96	14.27
28	74.76	14.12
29	76.56	14.03
30	78.36	13.98
31	80.16	13.98
32	81.96	14.02
33	83.75	14.12
34	85.55	14.27
35	87.34	14.46
36	89.12	14.70

37	90.90	14.99
38	92.66	15.33
39	94.42	15.72
40	96.17	16.15
41	97.90	16.63
42	99.63	17.15
43	101.33	17.73
44	103.02	18.34
45	104.70	19.01
46	106.35	19.72
47	107.99	20.47
48	109.60	21.26
49	111.19	22.10
50	112.76	22.99
51	114.31	23.91
52	115.83	24.88
53	117.32	25.88
54	118.78	26.93
55	120.22	28.01
56	121.63	29.14
57	123.00	30.30
58	124.34	31.50
59	125.66	32.73
60	126.93	34.00
61	128.18	35.30
62	129.38	36.64
63	130.55	38.00
64	131.69	39.40
65	132.78	40.83
66	133.84	42.29
67	134.85	43.77
68	135.83	45.29
69	136.77	46.82
70	137.66	48.39
71	138.51	49.97
72	139.32	51.58
73	140.08	53.21
74	140.80	54.86
75	141.48	56.53
76	142.11	58.22
77	142.37	59.00

Circle Center At X = 79.3 ; Y = 80.7 and Radius, 66.8

*** 1.302 ***

Failure Surface Specified By 82 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	26.32	34.00
2	27.65	32.79
3	29.01	31.61
4	30.40	30.47
5	31.82	29.36
6	33.26	28.28
7	34.73	27.24
8	36.22	26.23
9	37.73	25.25
10	39.27	24.32
11	40.82	23.42
12	42.40	22.55
13	44.00	21.72
14	45.62	20.93
15	47.26	20.18
16	48.91	19.47
17	50.58	18.80
18	52.26	18.16
19	53.96	17.57
20	55.67	17.02
21	57.40	16.50
22	59.14	16.03
23	60.88	15.60
24	62.64	15.21
25	64.41	14.86
26	66.18	14.55
27	67.96	14.29
28	69.75	14.06
29	71.54	13.88
30	73.33	13.74
31	75.13	13.65
32	76.93	13.59
33	78.73	13.58
34	80.53	13.61
35	82.33	13.68
36	84.12	13.80
37	85.92	13.95
38	87.71	14.15
39	89.49	14.39
40	91.27	14.68
41	93.04	15.00
42	94.80	15.37
43	96.55	15.77
44	98.30	16.22
45	100.03	16.71

46	101.75	17.24
47	103.46	17.81
48	105.15	18.42
49	106.83	19.07
50	108.49	19.76
51	110.14	20.49
52	111.77	21.26
53	113.38	22.06
54	114.97	22.91
55	116.54	23.79
56	118.09	24.70
57	119.61	25.65
58	121.12	26.64
59	122.60	27.67
60	124.05	28.72
61	125.49	29.82
62	126.89	30.94
63	128.27	32.10
64	129.62	33.29
65	130.94	34.51
66	132.23	35.76
67	133.50	37.05
68	134.73	38.36
69	135.93	39.70
70	137.10	41.07
71	138.24	42.46
72	139.34	43.88
73	140.41	45.33
74	141.45	46.80
75	142.45	48.30
76	143.41	49.82
77	144.34	51.36
78	145.23	52.92
79	146.09	54.51
80	146.91	56.11
81	147.69	57.73
82	148.26	59.00

Circle Center At X = 78.4 ; Y = 90.1 and Radius, 76.5

*** 1.329 ***

1

Failure Surface Specified By 47 Coordinate Points

Point	X-Surf	Y-Surf

No.	ft.	ft.
1	44.74	34.00
2	46.45	33.46
3	48.19	32.97
4	49.93	32.53
5	51.69	32.14
6	53.46	31.80
7	55.23	31.51
8	57.02	31.27
9	58.81	31.08
10	60.60	30.94
11	62.40	30.86
12	64.20	30.83
13	66.00	30.85
14	67.80	30.92
15	69.59	31.04
16	71.39	31.21
17	73.17	31.44
18	74.95	31.71
19	76.72	32.04
20	78.48	32.42
21	80.23	32.84
22	81.96	33.32
23	83.68	33.85
24	85.39	34.42
25	87.08	35.05
26	88.75	35.72
27	90.40	36.44
28	92.03	37.21
29	93.63	38.03
30	95.21	38.89
31	96.77	39.79
32	98.30	40.74
33	99.80	41.73
34	101.27	42.77
35	102.71	43.84
36	104.12	44.96
37	105.50	46.12
38	106.85	47.32
39	108.16	48.55
40	109.43	49.82
41	110.67	51.13
42	111.87	52.47
43	113.03	53.85
44	114.15	55.26
45	115.22	56.70
46	116.26	58.17
47	116.81	59.00

Circle Center At X = 64.4 ; Y = 93.6 and Radius, 62.8

*** 1.330 ***

Failure Surface Specified By 73 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	36.84	34.00
2	38.12	32.73
3	39.43	31.49
4	40.77	30.30
5	42.15	29.14
6	43.56	28.02
7	45.00	26.95
8	46.48	25.91
9	47.98	24.92
10	49.51	23.98
11	51.07	23.08
12	52.65	22.22
13	54.26	21.41
14	55.89	20.65
15	57.54	19.93
16	59.22	19.26
17	60.91	18.65
18	62.61	18.08
19	64.34	17.56
20	66.07	17.09
21	67.82	16.67
22	69.59	16.30
23	71.36	15.98
24	73.14	15.71
25	74.93	15.50
26	76.72	15.34
27	78.51	15.23
28	80.31	15.17
29	82.11	15.16
30	83.91	15.21
31	85.71	15.30
32	87.50	15.45
33	89.29	15.66
34	91.08	15.91
35	92.85	16.21
36	94.61	16.57
37	96.37	16.98

38	98.11	17.43
39	99.84	17.94
40	101.55	18.50
41	103.24	19.10
42	104.92	19.76
43	106.57	20.46
44	108.21	21.21
45	109.82	22.01
46	111.41	22.86
47	112.98	23.75
48	114.52	24.68
49	116.03	25.66
50	117.51	26.68
51	118.96	27.75
52	120.38	28.85
53	121.77	30.00
54	123.12	31.19
55	124.44	32.41
56	125.72	33.68
57	126.97	34.97
58	128.17	36.31
59	129.34	37.68
60	130.47	39.08
61	131.56	40.52
62	132.60	41.98
63	133.60	43.48
64	134.56	45.00
65	135.48	46.55
66	136.35	48.13
67	137.17	49.73
68	137.95	51.35
69	138.67	53.00
70	139.36	54.66
71	139.99	56.35
72	140.57	58.05
73	140.87	59.00

Circle Center At X = 81.4 ; Y = 77.4 and Radius, 62.2

*** 1.338 ***

1

Failure Surface Specified By 81 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.

1	18.42	34.00
2	19.70	32.73
3	21.00	31.49
4	22.34	30.29
5	23.71	29.12
6	25.10	27.98
7	26.53	26.88
8	27.98	25.82
9	29.46	24.79
10	30.97	23.80
11	32.49	22.85
12	34.05	21.94
13	35.62	21.07
14	37.22	20.24
15	38.83	19.45
16	40.47	18.70
17	42.13	17.99
18	43.80	17.33
19	45.49	16.70
20	47.19	16.12
21	48.91	15.58
22	50.64	15.09
23	52.38	14.64
24	54.14	14.24
25	55.90	13.88
26	57.67	13.56
27	59.45	13.29
28	61.24	13.06
29	63.03	12.88
30	64.82	12.75
31	66.62	12.66
32	68.42	12.61
33	70.22	12.62
34	72.02	12.66
35	73.82	12.76
36	75.61	12.89
37	77.40	13.08
38	79.19	13.31
39	80.97	13.58
40	82.74	13.90
41	84.50	14.26
42	86.26	14.67
43	88.00	15.12
44	89.73	15.62
45	91.45	16.16
46	93.15	16.74
47	94.84	17.37
48	96.51	18.03
49	98.16	18.75

50	99.80	19.50
51	101.41	20.29
52	103.01	21.12
53	104.58	22.00
54	106.13	22.91
55	107.66	23.86
56	109.16	24.86
57	110.64	25.88
58	112.09	26.95
59	113.51	28.05
60	114.91	29.19
61	116.27	30.36
62	117.61	31.57
63	118.91	32.81
64	120.19	34.08
65	121.43	35.39
66	122.63	36.72
67	123.81	38.09
68	124.94	39.48
69	126.05	40.91
70	127.11	42.36
71	128.14	43.83
72	129.13	45.34
73	130.08	46.86
74	131.00	48.42
75	131.87	49.99
76	132.70	51.58
77	133.50	53.20
78	134.25	54.84
79	134.96	56.49
80	135.63	58.16
81	135.94	59.00

Circle Center At X = 69.3 ; Y = 83.7 and Radius, 71.1

*** 1.352 ***

Failure Surface Specified By 75 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	36.84	34.00
2	38.15	32.77
3	39.50	31.57
4	40.87	30.41

5	42.28	29.29
6	43.72	28.20
7	45.18	27.15
8	46.67	26.15
9	48.19	25.18
10	49.74	24.26
11	51.31	23.38
12	52.90	22.54
13	54.51	21.74
14	56.15	20.99
15	57.80	20.28
16	59.48	19.62
17	61.17	19.00
18	62.87	18.43
19	64.60	17.90
20	66.33	17.42
21	68.08	16.99
22	69.84	16.61
23	71.60	16.27
24	73.38	15.98
25	75.17	15.74
26	76.95	15.54
27	78.75	15.40
28	80.55	15.30
29	82.35	15.25
30	84.15	15.25
31	85.94	15.30
32	87.74	15.40
33	89.54	15.55
34	91.33	15.74
35	93.11	15.98
36	94.89	16.27
37	96.65	16.61
38	98.41	17.00
39	100.16	17.43
40	101.89	17.91
41	103.62	18.44
42	105.32	19.01
43	107.01	19.63
44	108.69	20.29
45	110.34	21.00
46	111.98	21.75
47	113.59	22.55
48	115.18	23.39
49	116.75	24.27
50	118.29	25.20
51	119.81	26.16
52	121.31	27.17
53	122.77	28.22
54	124.21	29.30

55	125.61	30.42
56	126.99	31.59
57	128.33	32.78
58	129.64	34.02
59	130.92	35.29
60	132.16	36.59
61	133.37	37.92
62	134.54	39.29
63	135.67	40.69
64	136.77	42.12
65	137.82	43.58
66	138.84	45.06
67	139.81	46.58
68	140.75	48.11
69	141.64	49.68
70	142.49	51.26
71	143.30	52.87
72	144.06	54.50
73	144.78	56.15
74	145.46	57.82
75	145.90	59.00

Circle Center At X =   83.2 ; Y =   82.0 and Radius,   66.8

***   1.356   ***

1

```
           Y            A     X     I     S            F     T


           0.00     18.75     37.50     56.25     75.00     93.75

X      0.00 *-----*---+*-----.*-+----W----+---------+---------+
            -               ...
            -              ....
            -            ......
            -           .......
            -          ........
      18.75 +         .......99
            -        .......922
            -        .....99224
            -       .....92246.
            -      .....92246.1
            -      ....9224611.
A     37.50 +     ....922461188
            -     ....22461.88.
```

```
                   -    ....92461880.7
                   -    ....246188...7
                   -    ...326188...7*
                   -   ....24158....7.
X      56.25 +   ...22118.....7.
                   -   ...2418......7.
                   -   ...2158.....7..
                   -   ...2180.....7..*/1
                   -   ..2118......77.*
                   -   ..2158.......7...
I      75.00 +   ..215........7...
                   -   ..218........7....*
                   -    .218.........7...
                   -    .215.........7.... *
                   -    ..15..........7...
                   -     .159.........77...  *
S      93.75 +     .138..........77...
                   -      1159..........77...
                   -      .1389..........77..    **1/2
                   -       11399..........77..
                   -       .13599...........7..    2/3
                   -        113899...........77.   3/4
      112.50 +         123899............77.
                   -         1238.9............777
                   -          1235.99.............
                   -          .12238.99...........
                   -           .12238.999.........
                   -            .112335..99.......
F    131.25 +              .122355..9999...
                   -               .11233358..9999
                   -                 1112233558..9
                   -                   .1122333555
                   -                     .11122333
                   -                        111122
T    150.00 *     *    *             W*  .1*4/
```

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

                 STABLPro for Windows, Version 2015.4.5

                         Upgraded from:
                         FHWA-PCSTABLE

                  Serial Number :  225625906

                     --Slope Stability Analysis--
                  Simplified Janbu, Simplified Bishop
                    or Spencer Method of Slices

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


This program is licensed to :

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Cedar Knolls, New Jersey

Path to file locations      : R:\07 COMMON\TREVOR CONLIN\17-NY165-01 South
Battery Park Resiliency\Pier A Slope Stability\
Name of input data file     : New Slope-Normal Condition-Static.sl4d
Name of output file         : New Slope-Normal Condition-Static.sl4o
Name of plot output file    : New Slope-Normal Condition-Static.sl4p

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

          Date:  June 04, 2021     Time:  15:21:12



1
     PROBLEM DESCRIPTION   Pier A Inlet Slope Stability



     BOUNDARY COORDINATES

         9 Top   Boundaries
        13 Total Boundaries


     Boundary     X-Left     Y-Left    X-Right    Y-Right    Soil Type
```

No.	ft.	ft.	ft.	ft.	Below Bnd
1	0.00	34.00	50.00	34.00	2
2	50.00	34.00	65.00	35.00	2
3	65.00	35.00	69.00	36.00	2
4	69.00	36.00	77.00	41.00	2
5	77.00	41.00	83.50	45.00	2
6	83.50	45.00	89.70	49.00	2
7	89.70	49.00	100.50	56.00	1
8	100.50	56.00	101.00	59.00	1
9	101.00	59.00	150.00	59.00	1
10	89.70	49.00	150.00	49.00	2
11	0.00	21.00	150.00	21.00	3
12	0.00	11.00	150.00	11.00	4
13	0.00	0.00	150.00	0.00	5

1

ISOTROPIC SOIL PARAMETERS

5 Type(s) of Soil

Soil Type No.	Total Unit Wt. pcf	Saturated Unit Wt. pcf	Cohesion Intercept psf	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant psf	Piez. Surface No.
1	123.0	130.0	0.0	33.0	0.00	0.0	1
2	110.0	115.0	0.0	31.0	0.00	0.0	1
3	103.0	110.0	400.0	0.0	0.00	0.0	1
4	116.0	128.0	0.0	31.0	0.00	0.0	1
5	142.0	150.0	10000.0	40.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 63.90 pcf

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water ft.	Y-Water ft.
1	0.00	49.00

2	150.00	49.00

1

BOUNDARY LOAD(S)

8 Load(s) Specified

Load No.	X-Left ft.	X-Right ft.	Intensity psf	Deflection (deg)
1	65.00	85.50	480.0	0.0
2	85.50	89.20	910.0	0.0
3	89.20	93.30	930.0	0.0
4	93.30	98.50	800.0	0.0
5	98.50	101.00	480.0	0.0
6	101.00	105.00	525.0	0.0
7	105.00	109.00	720.0	0.0
8	109.00	150.00	195.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed
Force Acting On A Horizontally Projected Surface.

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

200 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 20 Points Equally Spaced
Along The Ground Surface Between X = 0.00 ft.
and X = 50.00 ft.

Each Surface Terminates Between X = 114.00 ft.
and X = 150.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 0.00 ft.

1.80 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 84 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	21.05	34.00
2	22.34	32.74
3	23.66	31.52
4	25.01	30.33
5	26.39	29.17
6	27.79	28.04
7	29.22	26.95
8	30.68	25.89
9	32.16	24.86
10	33.66	23.88
11	35.19	22.92
12	36.74	22.01
13	38.31	21.13
14	39.90	20.29
15	41.51	19.49
16	43.14	18.72
17	44.79	18.00
18	46.45	17.31
19	48.13	16.67
20	49.83	16.06
21	51.54	15.49
22	53.26	14.97
23	54.99	14.49
24	56.74	14.04
25	58.49	13.64
26	60.26	13.29
27	62.03	12.97
28	63.81	12.70
29	65.59	12.46
30	67.38	12.28
31	69.18	12.13
32	70.97	12.03
33	72.77	11.96

34	74.57	11.95
35	76.37	11.97
36	78.17	12.04
37	79.97	12.15
38	81.76	12.30
39	83.55	12.50
40	85.34	12.74
41	87.11	13.02
42	88.88	13.34
43	90.65	13.71
44	92.40	14.11
45	94.14	14.56
46	95.88	15.05
47	97.60	15.58
48	99.30	16.16
49	100.99	16.77
50	102.67	17.42
51	104.33	18.11
52	105.98	18.84
53	107.60	19.61
54	109.21	20.42
55	110.80	21.27
56	112.37	22.16
57	113.91	23.08
58	115.44	24.03
59	116.94	25.03
60	118.42	26.06
61	119.87	27.12
62	121.29	28.22
63	122.69	29.35
64	124.06	30.52
65	125.41	31.72
66	126.72	32.95
67	128.01	34.21
68	129.26	35.50
69	130.49	36.82
70	131.68	38.17
71	132.84	39.54
72	133.96	40.95
73	135.06	42.38
74	136.11	43.83
75	137.14	45.31
76	138.13	46.82
77	139.08	48.35
78	139.99	49.90
79	140.87	51.47
80	141.71	53.06
81	142.51	54.67
82	143.28	56.30
83	144.00	57.95

84 144.43 59.00

Circle Center At X = 74.4 ; Y = 87.6 and Radius, 75.6

*** 1.279 ***

Individual data on the 100 slices

Slice No.	Width Ft	Weight Lbs	Water Force Top Lbs	Water Force Bot Lbs	Tie Force Norm Lbs	Tie Force Tan Lbs	Earthquake Force Hor Lbs	Earthquake Force Ver Lbs	Surcharge Load Lbs
1	1.3	0.93E+02	0.12E+04	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.3	0.28E+03	0.13E+04	0.19E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1.3	0.48E+03	0.13E+04	0.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	1.4	0.67E+03	0.13E+04	0.22E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	1.4	0.87E+03	0.13E+04	0.23E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	1.4	0.11E+04	0.14E+04	0.25E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7	1.5	0.13E+04	0.14E+04	0.26E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8	1.5	0.15E+04	0.14E+04	0.27E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
9	1.5	0.17E+04	0.14E+04	0.28E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	1.5	0.19E+04	0.15E+04	0.29E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	1.5	0.21E+04	0.15E+04	0.31E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	1.6	0.22E+04	0.15E+04	0.32E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13	0.2	0.37E+03	0.24E+03	0.50E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
14	1.3	0.21E+04	0.13E+04	0.28E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	1.6	0.26E+04	0.15E+04	0.33E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
16	1.6	0.28E+04	0.16E+04	0.34E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	1.6	0.29E+04	0.16E+04	0.35E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
18	1.7	0.31E+04	0.16E+04	0.36E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
19	1.7	0.33E+04	0.16E+04	0.37E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	1.7	0.34E+04	0.16E+04	0.38E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
21	0.2	0.35E+03	0.16E+03	0.38E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22	1.5	0.32E+04	0.15E+04	0.34E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23	1.7	0.37E+04	0.16E+04	0.39E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	1.7	0.38E+04	0.16E+04	0.39E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	1.7	0.40E+04	0.16E+04	0.40E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
26	1.8	0.41E+04	0.16E+04	0.40E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
27	1.8	0.42E+04	0.16E+04	0.41E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
28	1.8	0.43E+04	0.16E+04	0.41E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
29	1.8	0.44E+04	0.16E+04	0.42E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	1.2	0.30E+04	0.11E+04	0.28E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
31	0.6	0.15E+04	0.54E+03	0.14E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.28E+03
32	1.8	0.47E+04	0.16E+04	0.42E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03

33	1.6	0.43E+04	0.14E+04	0.38E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.78E+03
34	0.2	0.48E+03	0.17E+03	0.42E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.85E+02
35	1.8	0.50E+04	0.17E+04	0.42E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
36	1.8	0.53E+04	0.15E+04	0.43E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
37	1.8	0.55E+04	0.14E+04	0.43E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
38	1.8	0.57E+04	0.12E+04	0.43E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
39	0.6	0.20E+04	0.39E+03	0.15E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.30E+03
40	1.2	0.39E+04	0.67E+03	0.28E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.56E+03
41	1.8	0.62E+04	0.91E+03	0.42E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
42	1.8	0.63E+04	0.76E+03	0.42E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
43	1.7	0.63E+04	0.59E+03	0.41E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.83E+03
44	0.1	0.19E+03	0.15E+02	0.12E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.25E+02
45	1.8	0.67E+04	0.46E+03	0.42E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
46	0.2	0.63E+03	0.35E+02	0.39E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.79E+02
47	1.6	0.62E+04	0.27E+03	0.38E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.15E+04
48	1.8	0.70E+04	0.15E+03	0.41E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.16E+04
49	0.3	0.13E+04	0.10E+02	0.73E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.29E+03
50	0.5	0.20E+04	0.61E+01	0.12E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.46E+03
51	0.9	0.39E+04	0.00E+00	0.22E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.88E+03
52	1.8	0.73E+04	0.00E+00	0.40E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.16E+04
53	0.9	0.38E+04	0.00E+00	0.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.84E+03
54	0.8	0.36E+04	0.00E+00	0.19E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.67E+03
55	1.7	0.75E+04	0.00E+00	0.39E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.14E+04
56	1.7	0.76E+04	0.00E+00	0.39E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.14E+04
57	0.9	0.40E+04	0.00E+00	0.20E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.72E+03
58	0.8	0.36E+04	0.00E+00	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.38E+03
59	1.2	0.54E+04	0.00E+00	0.27E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.58E+03
60	0.5	0.23E+04	0.00E+00	0.11E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.24E+03
61	0.0	0.27E+02	0.00E+00	0.12E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.27E+01
62	1.7	0.82E+04	0.00E+00	0.37E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.88E+03
63	1.7	0.80E+04	0.00E+00	0.36E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.87E+03
64	0.7	0.32E+04	0.00E+00	0.14E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.35E+03
65	1.0	0.46E+04	0.00E+00	0.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.70E+03
66	1.6	0.76E+04	0.00E+00	0.34E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.12E+04
67	1.4	0.64E+04	0.00E+00	0.29E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.10E+04
68	0.2	0.96E+03	0.00E+00	0.44E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.42E+02
69	1.1	0.48E+04	0.00E+00	0.22E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.21E+03
70	0.5	0.22E+04	0.00E+00	0.10E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.99E+02
71	1.6	0.68E+04	0.00E+00	0.31E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.31E+03
72	1.5	0.66E+04	0.00E+00	0.30E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.30E+03
73	1.5	0.63E+04	0.00E+00	0.29E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.30E+03
74	1.5	0.61E+04	0.00E+00	0.28E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.29E+03
75	1.5	0.58E+04	0.00E+00	0.27E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.29E+03
76	1.5	0.55E+04	0.00E+00	0.26E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.28E+03
77	1.4	0.53E+04	0.00E+00	0.25E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.28E+03
78	1.4	0.50E+04	0.00E+00	0.23E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.27E+03
79	1.4	0.47E+04	0.00E+00	0.22E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.27E+03
80	1.3	0.44E+04	0.00E+00	0.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.26E+03
81	1.3	0.41E+04	0.00E+00	0.19E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.26E+03
82	1.3	0.39E+04	0.00E+00	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.25E+03

83	1.3	0.36E+04	0.00E+00	0.16E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.24E+03
84	1.2	0.33E+04	0.00E+00	0.15E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.24E+03
85	1.2	0.30E+04	0.00E+00	0.13E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.23E+03
86	1.2	0.28E+04	0.00E+00	0.12E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.23E+03
87	1.1	0.25E+04	0.00E+00	0.10E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.22E+03
88	1.1	0.23E+04	0.00E+00	0.84E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.21E+03
89	1.1	0.20E+04	0.00E+00	0.68E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.21E+03
90	1.0	0.18E+04	0.00E+00	0.51E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.20E+03
91	1.0	0.15E+04	0.00E+00	0.34E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.19E+03
92	1.0	0.13E+04	0.00E+00	0.16E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.19E+03
93	0.4	0.49E+03	0.00E+00	0.16E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.75E+02
94	0.5	0.62E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.10E+03
95	0.9	0.90E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.17E+03
96	0.8	0.70E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.16E+03
97	0.8	0.51E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.16E+03
98	0.8	0.33E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.15E+03
99	0.7	0.17E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.14E+03
100	0.4	0.28E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.84E+02

Failure Surface Specified By 86 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	21.05	34.00
2	22.36	32.76
3	23.69	31.55
4	25.05	30.37
5	26.43	29.22
6	27.85	28.10
7	29.28	27.02
8	30.75	25.97
9	32.23	24.95
10	33.74	23.97
11	35.27	23.02
12	36.82	22.11
13	38.39	21.23
14	39.98	20.39
15	41.59	19.58
16	43.22	18.82
17	44.86	18.08
18	46.53	17.39
19	48.20	16.74
20	49.89	16.12
21	51.60	15.54
22	53.32	15.00
23	55.05	14.51
24	56.79	14.05

25	58.54	13.63
26	60.30	13.25
27	62.06	12.91
28	63.84	12.61
29	65.62	12.35
30	67.41	12.13
31	69.20	11.96
32	70.99	11.82
33	72.79	11.73
34	74.59	11.67
35	76.39	11.66
36	78.19	11.69
37	79.99	11.76
38	81.78	11.87
39	83.58	12.02
40	85.37	12.21
41	87.15	12.45
42	88.93	12.72
43	90.70	13.03
44	92.47	13.39
45	94.23	13.78
46	95.97	14.22
47	97.71	14.69
48	99.43	15.21
49	101.15	15.76
50	102.85	16.35
51	104.53	16.99
52	106.20	17.66
53	107.86	18.36
54	109.50	19.11
55	111.12	19.89
56	112.72	20.71
57	114.30	21.56
58	115.87	22.46
59	117.41	23.38
60	118.93	24.34
61	120.43	25.34
62	121.91	26.37
63	123.36	27.44
64	124.79	28.53
65	126.19	29.66
66	127.56	30.82
67	128.91	32.01
68	130.23	33.24
69	131.53	34.49
70	132.79	35.77
71	134.03	37.08
72	135.23	38.42
73	136.40	39.78
74	137.55	41.17

75	138.66	42.59
76	139.73	44.03
77	140.78	45.50
78	141.79	46.99
79	142.76	48.50
80	143.71	50.03
81	144.61	51.59
82	145.48	53.16
83	146.32	54.76
84	147.11	56.37
85	147.88	58.00
86	148.31	59.00

Circle Center At X = 76.0 ; Y = 90.5 and Radius, 78.8

*** 1.281 ***

1

Failure Surface Specified By 81 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	31.58	34.00
2	32.86	32.73
3	34.17	31.50
4	35.51	30.30
5	36.89	29.14
6	38.29	28.01
7	39.71	26.91
8	41.17	25.85
9	42.65	24.83
10	44.16	23.84
11	45.69	22.90
12	47.24	21.99
13	48.82	21.12
14	50.41	20.29
15	52.03	19.50
16	53.67	18.75
17	55.32	18.04
18	57.00	17.38
19	58.68	16.75
20	60.39	16.17
21	62.11	15.63
22	63.84	15.14
23	65.58	14.69

24	67.33	14.28
25	69.09	13.91
26	70.87	13.59
27	72.64	13.32
28	74.43	13.09
29	76.22	12.90
30	78.01	12.76
31	79.81	12.66
32	81.61	12.61
33	83.41	12.60
34	85.21	12.64
35	87.01	12.73
36	88.80	12.86
37	90.60	13.03
38	92.38	13.25
39	94.16	13.51
40	95.94	13.82
41	97.70	14.17
42	99.46	14.57
43	101.20	15.01
44	102.94	15.49
45	104.66	16.02
46	106.37	16.59
47	108.06	17.20
48	109.74	17.85
49	111.40	18.55
50	113.04	19.29
51	114.66	20.06
52	116.26	20.88
53	117.85	21.74
54	119.41	22.64
55	120.94	23.58
56	122.46	24.55
57	123.94	25.56
58	125.41	26.61
59	126.84	27.70
60	128.25	28.82
61	129.63	29.97
62	130.98	31.16
63	132.30	32.39
64	133.59	33.64
65	134.85	34.93
66	136.07	36.25
67	137.26	37.60
68	138.42	38.98
69	139.54	40.39
70	140.63	41.82
71	141.68	43.28
72	142.69	44.77
73	143.67	46.28

74	144.61	47.82
75	145.51	49.38
76	146.37	50.96
77	147.19	52.56
78	147.97	54.19
79	148.70	55.83
80	149.40	57.49
81	149.99	59.00

Circle Center At X = 82.8 ; Y = 84.5 and Radius, 71.9

*** 1.283 ***

Failure Surface Specified By 84 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	23.68	34.00
2	24.99	32.76
3	26.33	31.55
4	27.69	30.38
5	29.08	29.24
6	30.50	28.13
7	31.94	27.05
8	33.41	26.01
9	34.90	25.00
10	36.42	24.03
11	37.95	23.10
12	39.51	22.20
13	41.09	21.34
14	42.70	20.51
15	44.31	19.73
16	45.95	18.98
17	47.61	18.27
18	49.28	17.60
19	50.96	16.97
20	52.66	16.38
21	54.38	15.83
22	56.10	15.32
23	57.84	14.85
24	59.59	14.42
25	61.35	14.04
26	63.12	13.69
27	64.89	13.39
28	66.67	13.13

29	68.46	12.91
30	70.25	12.74
31	72.04	12.60
32	73.84	12.51
33	75.64	12.46
34	77.44	12.45
35	79.24	12.49
36	81.04	12.57
37	82.83	12.69
38	84.63	12.85
39	86.42	13.06
40	88.20	13.30
41	89.98	13.59
42	91.74	13.92
43	93.51	14.30
44	95.26	14.71
45	97.00	15.16
46	98.73	15.66
47	100.45	16.20
48	102.15	16.77
49	103.84	17.39
50	105.52	18.05
51	107.18	18.74
52	108.82	19.48
53	110.45	20.25
54	112.05	21.07
55	113.64	21.91
56	115.21	22.80
57	116.75	23.72
58	118.28	24.68
59	119.77	25.68
60	121.25	26.71
61	122.70	27.77
62	124.13	28.87
63	125.53	30.01
64	126.90	31.17
65	128.24	32.37
66	129.56	33.60
67	130.85	34.85
68	132.10	36.14
69	133.33	37.46
70	134.52	38.81
71	135.69	40.18
72	136.81	41.58
73	137.91	43.01
74	138.97	44.46
75	140.00	45.94
76	140.99	47.44
77	141.95	48.97
78	142.87	50.52

79	143.75	52.08
80	144.60	53.67
81	145.41	55.28
82	146.18	56.91
83	146.91	58.55
84	147.10	59.00

Circle Center At X = 76.8 ; Y = 88.8 and Radius, 76.3

*** 1.290 ***

1

Failure Surface Specified By 77 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	31.58	34.00
2	32.86	32.73
3	34.17	31.50
4	35.51	30.30
5	36.89	29.14
6	38.29	28.02
7	39.73	26.93
8	41.19	25.88
9	42.69	24.88
10	44.21	23.91
11	45.75	22.99
12	47.32	22.11
13	48.91	21.27
14	50.53	20.47
15	52.16	19.72
16	53.81	19.01
17	55.49	18.35
18	57.18	17.73
19	58.89	17.15
20	60.61	16.63
21	62.34	16.15
22	64.09	15.72
23	65.85	15.33
24	67.62	14.99
25	69.39	14.70
26	71.18	14.46
27	72.96	14.27
28	74.76	14.12
29	76.56	14.03

30	78.36	13.98
31	80.16	13.98
32	81.96	14.02
33	83.75	14.12
34	85.55	14.27
35	87.34	14.46
36	89.12	14.70
37	90.90	14.99
38	92.66	15.33
39	94.42	15.72
40	96.17	16.15
41	97.90	16.63
42	99.63	17.15
43	101.33	17.73
44	103.02	18.34
45	104.70	19.01
46	106.35	19.72
47	107.99	20.47
48	109.60	21.26
49	111.19	22.10
50	112.76	22.99
51	114.31	23.91
52	115.83	24.88
53	117.32	25.88
54	118.78	26.93
55	120.22	28.01
56	121.63	29.14
57	123.00	30.30
58	124.34	31.50
59	125.66	32.73
60	126.93	34.00
61	128.18	35.30
62	129.38	36.64
63	130.55	38.00
64	131.69	39.40
65	132.78	40.83
66	133.84	42.29
67	134.85	43.77
68	135.83	45.29
69	136.77	46.82
70	137.66	48.39
71	138.51	49.97
72	139.32	51.58
73	140.08	53.21
74	140.80	54.86
75	141.48	56.53
76	142.11	58.22
77	142.37	59.00

Circle Center At X = 79.3 ; Y = 80.7 and Radius, 66.8

*** 1.295 ***

Failure Surface Specified By 47 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	44.74	34.00
2	46.45	33.46
3	48.19	32.97
4	49.93	32.53
5	51.69	32.14
6	53.46	31.80
7	55.23	31.51
8	57.02	31.27
9	58.81	31.08
10	60.60	30.94
11	62.40	30.86
12	64.20	30.83
13	66.00	30.85
14	67.80	30.92
15	69.59	31.04
16	71.39	31.21
17	73.17	31.44
18	74.95	31.71
19	76.72	32.04
20	78.48	32.42
21	80.23	32.84
22	81.96	33.32
23	83.68	33.85
24	85.39	34.42
25	87.08	35.05
26	88.75	35.72
27	90.40	36.44
28	92.03	37.21
29	93.63	38.03
30	95.21	38.89
31	96.77	39.79
32	98.30	40.74
33	99.80	41.73
34	101.27	42.77
35	102.71	43.84
36	104.12	44.96
37	105.50	46.12
38	106.85	47.32

39	108.16	48.55
40	109.43	49.82
41	110.67	51.13
42	111.87	52.47
43	113.03	53.85
44	114.15	55.26
45	115.22	56.70
46	116.26	58.17
47	116.81	59.00

Circle Center At X = 64.4 ; Y = 93.6 and Radius, 62.8

*** 1.296 ***

1

Failure Surface Specified By 82 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	26.32	34.00
2	27.65	32.79
3	29.01	31.61
4	30.40	30.47
5	31.82	29.36
6	33.26	28.28
7	34.73	27.24
8	36.22	26.23
9	37.73	25.25
10	39.27	24.32
11	40.82	23.42
12	42.40	22.55
13	44.00	21.72
14	45.62	20.93
15	47.26	20.18
16	48.91	19.47
17	50.58	18.80
18	52.26	18.16
19	53.96	17.57
20	55.67	17.02
21	57.40	16.50
22	59.14	16.03
23	60.88	15.60
24	62.64	15.21
25	64.41	14.86
26	66.18	14.55

27	67.96	14.29
28	69.75	14.06
29	71.54	13.88
30	73.33	13.74
31	75.13	13.65
32	76.93	13.59
33	78.73	13.58
34	80.53	13.61
35	82.33	13.68
36	84.12	13.80
37	85.92	13.95
38	87.71	14.15
39	89.49	14.39
40	91.27	14.68
41	93.04	15.00
42	94.80	15.37
43	96.55	15.77
44	98.30	16.22
45	100.03	16.71
46	101.75	17.24
47	103.46	17.81
48	105.15	18.42
49	106.83	19.07
50	108.49	19.76
51	110.14	20.49
52	111.77	21.26
53	113.38	22.06
54	114.97	22.91
55	116.54	23.79
56	118.09	24.70
57	119.61	25.65
58	121.12	26.64
59	122.60	27.67
60	124.05	28.72
61	125.49	29.82
62	126.89	30.94
63	128.27	32.10
64	129.62	33.29
65	130.94	34.51
66	132.23	35.76
67	133.50	37.05
68	134.73	38.36
69	135.93	39.70
70	137.10	41.07
71	138.24	42.46
72	139.34	43.88
73	140.41	45.33
74	141.45	46.80
75	142.45	48.30
76	143.41	49.82

77	144.34	51.36
78	145.23	52.92
79	146.09	54.51
80	146.91	56.11
81	147.69	57.73
82	148.26	59.00

Circle Center At X = 78.4 ; Y = 90.1 and Radius, 76.5

*** 1.323 ***

Failure Surface Specified By 73 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	36.84	34.00
2	38.12	32.73
3	39.43	31.49
4	40.77	30.30
5	42.15	29.14
6	43.56	28.02
7	45.00	26.95
8	46.48	25.91
9	47.98	24.92
10	49.51	23.98
11	51.07	23.08
12	52.65	22.22
13	54.26	21.41
14	55.89	20.65
15	57.54	19.93
16	59.22	19.26
17	60.91	18.65
18	62.61	18.08
19	64.34	17.56
20	66.07	17.09
21	67.82	16.67
22	69.59	16.30
23	71.36	15.98
24	73.14	15.71
25	74.93	15.50
26	76.72	15.34
27	78.51	15.23
28	80.31	15.17
29	82.11	15.16
30	83.91	15.21

31	85.71	15.30
32	87.50	15.45
33	89.29	15.66
34	91.08	15.91
35	92.85	16.21
36	94.61	16.57
37	96.37	16.98
38	98.11	17.43
39	99.84	17.94
40	101.55	18.50
41	103.24	19.10
42	104.92	19.76
43	106.57	20.46
44	108.21	21.21
45	109.82	22.01
46	111.41	22.86
47	112.98	23.75
48	114.52	24.68
49	116.03	25.66
50	117.51	26.68
51	118.96	27.75
52	120.38	28.85
53	121.77	30.00
54	123.12	31.19
55	124.44	32.41
56	125.72	33.68
57	126.97	34.97
58	128.17	36.31
59	129.34	37.68
60	130.47	39.08
61	131.56	40.52
62	132.60	41.98
63	133.60	43.48
64	134.56	45.00
65	135.48	46.55
66	136.35	48.13
67	137.17	49.73
68	137.95	51.35
69	138.67	53.00
70	139.36	54.66
71	139.99	56.35
72	140.57	58.05
73	140.87	59.00

Circle Center At X = 81.4 ; Y = 77.4 and Radius, 62.2

*** 1.328 ***

1

Failure Surface Specified By 81 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	18.42	34.00
2	19.70	32.73
3	21.00	31.49
4	22.34	30.29
5	23.71	29.12
6	25.10	27.98
7	26.53	26.88
8	27.98	25.82
9	29.46	24.79
10	30.97	23.80
11	32.49	22.85
12	34.05	21.94
13	35.62	21.07
14	37.22	20.24
15	38.83	19.45
16	40.47	18.70
17	42.13	17.99
18	43.80	17.33
19	45.49	16.70
20	47.19	16.12
21	48.91	15.58
22	50.64	15.09
23	52.38	14.64
24	54.14	14.24
25	55.90	13.88
26	57.67	13.56
27	59.45	13.29
28	61.24	13.06
29	63.03	12.88
30	64.82	12.75
31	66.62	12.66
32	68.42	12.61
33	70.22	12.62
34	72.02	12.66
35	73.82	12.76
36	75.61	12.89
37	77.40	13.08
38	79.19	13.31
39	80.97	13.58
40	82.74	13.90
41	84.50	14.26
42	86.26	14.67

43	88.00	15.12
44	89.73	15.62
45	91.45	16.16
46	93.15	16.74
47	94.84	17.37
48	96.51	18.03
49	98.16	18.75
50	99.80	19.50
51	101.41	20.29
52	103.01	21.12
53	104.58	22.00
54	106.13	22.91
55	107.66	23.86
56	109.16	24.86
57	110.64	25.88
58	112.09	26.95
59	113.51	28.05
60	114.91	29.19
61	116.27	30.36
62	117.61	31.57
63	118.91	32.81
64	120.19	34.08
65	121.43	35.39
66	122.63	36.72
67	123.81	38.09
68	124.94	39.48
69	126.05	40.91
70	127.11	42.36
71	128.14	43.83
72	129.13	45.34
73	130.08	46.86
74	131.00	48.42
75	131.87	49.99
76	132.70	51.58
77	133.50	53.20
78	134.25	54.84
79	134.96	56.49
80	135.63	58.16
81	135.94	59.00

Circle Center At X = 69.3 ; Y = 83.7 and Radius, 71.1

*** 1.338 ***

Failure Surface Specified By 72 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	34.21	34.00
2	35.48	32.73
3	36.79	31.49
4	38.14	30.30
5	39.52	29.14
6	40.93	28.03
7	42.38	26.95
8	43.85	25.92
9	45.36	24.93
10	46.89	23.99
11	48.45	23.09
12	50.04	22.24
13	51.65	21.44
14	53.28	20.68
15	54.93	19.97
16	56.61	19.31
17	58.30	18.70
18	60.01	18.14
19	61.74	17.63
20	63.48	17.16
21	65.23	16.75
22	66.99	16.40
23	68.77	16.09
24	70.55	15.84
25	72.34	15.63
26	74.13	15.48
27	75.93	15.39
28	77.73	15.34
29	79.53	15.35
30	81.33	15.41
31	83.12	15.52
32	84.92	15.69
33	86.70	15.90
34	88.48	16.17
35	90.25	16.50
36	92.01	16.87
37	93.76	17.29
38	95.50	17.77
39	97.22	18.30
40	98.93	18.87
41	100.61	19.50
42	102.28	20.17
43	103.93	20.90
44	105.56	21.67
45	107.16	22.49
46	108.74	23.35
47	110.29	24.26

48	111.82	25.22
49	113.31	26.22
50	114.78	27.26
51	116.22	28.35
52	117.62	29.48
53	118.99	30.64
54	120.32	31.85
55	121.62	33.10
56	122.88	34.38
57	124.11	35.70
58	125.29	37.05
59	126.44	38.44
60	127.54	39.87
61	128.60	41.32
62	129.62	42.80
63	130.60	44.32
64	131.53	45.86
65	132.41	47.42
66	133.25	49.02
67	134.04	50.63
68	134.79	52.27
69	135.48	53.93
70	136.13	55.61
71	136.73	57.31
72	137.27	59.00

Circle Center At X =   78.4 ; Y =   76.9 and Radius,   61.6

*** 1.348 ***

1

```
                 Y            A     X     I     S           F     T


                 0.00     18.75     37.50     56.25     75.00     93.75

X      0.00 *-----*---+*-----.*-+-----W---+---------+---------+
            -               ...
            -              ....
            -            ......
            -           .......
            -          ........
      18.75 +         .......99
            -        .......911
            -        .....99114
            -       .....91147.
```

```
              -      .....91147.3
              -      ....91147330
A      37.50 +     ....911473388
              -     ....11473088.
              -    ....9147388..6
              -    ....147388...6
              -    ...117388...6*
              -   ....14358....6.
X      56.25 +   ...11338.....6.
              -   ...1438......6.
              -   ...1358.....6..
              -   ...138......6..*/1
              -   ..1138......66.*
              -   ..1358.......6...
I      75.00 +   ..135........6...
              -   ..138........6....*
              -    .118.........6...
              -    .215.........6.... * 1/2
              -    ..150.........6...
              -     .159.........66...  *2/3
S      93.75 +     .218..........66...   3/4
              -      3159..........66...
              -      .2189..........66..    **6
              -       31199..........66..
              -       .21599...........6..    6/7
              -        321899...........66.   7/8
      112.50 +         321899............66.
              -          321809............666
              -           2215099.............
              -           .32118099...........
              -            .321180999.........
              -             .3221150099.......
F     131.25 +               .322155.09999...
              -                .33211158009999
              -                  3322111558.09
              -                    .3222111555
              -                      .33222111
              -                         332222
T     150.00 *     *    *              *  .3*8/
```

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

                  STABLPro for Windows, Version 2015.4.5

                          Upgraded from:
                          FHWA-PCSTABLE

                   Serial Number :  225625906

                      --Slope Stability Analysis--
                   Simplified Janbu, Simplified Bishop
                     or Spencer Method of Slices

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


This program is licensed to :

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Cedar Knolls, New Jersey

Path to file locations      : R:\07 COMMON\TREVOR CONLIN\17-NY165-01 South
Battery Park Resiliency\Pier A Slope Stability\
Name of input data file     : New Slope-Rapid Drawdown-Static.sl4d
Name of output file         : New Slope-Rapid Drawdown-Static.sl4o
Name of plot output file    : New Slope-Rapid Drawdown-Static.sl4p

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

          Date:  June 04, 2021     Time:  15:22:48



1
     PROBLEM DESCRIPTION   Pier A Inlet Slope Stability



     BOUNDARY COORDINATES

         9 Top   Boundaries
        13 Total Boundaries


     Boundary     X-Left     Y-Left    X-Right    Y-Right    Soil Type
```

No.	ft.	ft.	ft.	ft.	Below Bnd
1	0.00	34.00	50.00	34.00	2
2	50.00	34.00	65.00	35.00	2
3	65.00	35.00	69.00	36.00	2
4	69.00	36.00	77.00	41.00	2
5	77.00	41.00	83.50	45.00	2
6	83.50	45.00	89.70	49.00	2
7	89.70	49.00	100.50	56.00	1
8	100.50	56.00	101.00	59.00	1
9	101.00	59.00	150.00	59.00	1
10	89.70	49.00	150.00	49.00	2
11	0.00	21.00	150.00	21.00	3
12	0.00	11.00	150.00	11.00	4
13	0.00	0.00	150.00	0.00	5

1

ISOTROPIC SOIL PARAMETERS

5 Type(s) of Soil

Soil Type No.	Total Unit Wt. pcf	Saturated Unit Wt. pcf	Cohesion Intercept psf	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant psf	Piez. Surface No.
1	125.0	135.0	0.0	33.0	0.00	0.0	1
2	112.0	123.0	0.0	31.0	0.00	0.0	1
3	103.0	110.0	400.0	0.0	0.00	0.0	1
4	116.0	128.0	0.0	31.0	0.00	0.0	1
5	142.0	150.0	10000.0	40.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 63.90 pcf

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water ft.	Y-Water ft.
1	0.00	46.20

2	150.00	46.20

1

BOUNDARY LOAD(S)

8 Load(s) Specified

Load No.	X-Left ft.	X-Right ft.	Intensity psf	Deflection (deg)
1	65.00	85.50	480.0	0.0
2	85.50	89.20	910.0	0.0
3	89.20	93.30	930.0	0.0
4	93.30	98.50	800.0	0.0
5	98.50	101.00	480.0	0.0
6	101.00	105.00	525.0	0.0
7	105.00	109.00	720.0	0.0
8	109.00	150.00	195.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed
Force Acting On A Horizontally Projected Surface.

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

200 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 20 Points Equally Spaced
Along The Ground Surface Between X = 0.00 ft.
and X = 50.00 ft.

Each Surface Terminates Between X = 114.00 ft.
and X = 150.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.

1.80 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 86 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	21.05	34.00
2	22.36	32.76
3	23.69	31.55
4	25.05	30.37
5	26.43	29.22
6	27.85	28.10
7	29.28	27.02
8	30.75	25.97
9	32.23	24.95
10	33.74	23.97
11	35.27	23.02
12	36.82	22.11
13	38.39	21.23
14	39.98	20.39
15	41.59	19.58
16	43.22	18.82
17	44.86	18.08
18	46.53	17.39
19	48.20	16.74
20	49.89	16.12
21	51.60	15.54
22	53.32	15.00
23	55.05	14.51
24	56.79	14.05
25	58.54	13.63
26	60.30	13.25
27	62.06	12.91
28	63.84	12.61
29	65.62	12.35
30	67.41	12.13
31	69.20	11.96
32	70.99	11.82
33	72.79	11.73

34	74.59	11.67
35	76.39	11.66
36	78.19	11.69
37	79.99	11.76
38	81.78	11.87
39	83.58	12.02
40	85.37	12.21
41	87.15	12.45
42	88.93	12.72
43	90.70	13.03
44	92.47	13.39
45	94.23	13.78
46	95.97	14.22
47	97.71	14.69
48	99.43	15.21
49	101.15	15.76
50	102.85	16.35
51	104.53	16.99
52	106.20	17.66
53	107.86	18.36
54	109.50	19.11
55	111.12	19.89
56	112.72	20.71
57	114.30	21.56
58	115.87	22.46
59	117.41	23.38
60	118.93	24.34
61	120.43	25.34
62	121.91	26.37
63	123.36	27.44
64	124.79	28.53
65	126.19	29.66
66	127.56	30.82
67	128.91	32.01
68	130.23	33.24
69	131.53	34.49
70	132.79	35.77
71	134.03	37.08
72	135.23	38.42
73	136.40	39.78
74	137.55	41.17
75	138.66	42.59
76	139.73	44.03
77	140.78	45.50
78	141.79	46.99
79	142.76	48.50
80	143.71	50.03
81	144.61	51.59
82	145.48	53.16
83	146.32	54.76

84	147.11	56.37
85	147.88	58.00
86	148.31	59.00

Circle Center At X = 76.0 ; Y = 90.5 and Radius, 78.8

*** 1.227 ***

Individual data on the 103 slices

Slice No.	Width Ft	Weight Lbs	Water Force Top Lbs	Water Force Bot Lbs	Tie Force Norm Lbs	Tie Force Tan Lbs	Earthquake Force Hor Lbs	Earthquake Force Ver Lbs	Surcharge Load Lbs
1	1.3	0.10E+03	0.10E+04	0.15E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1.3	0.30E+03	0.10E+04	0.16E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1.4	0.51E+03	0.11E+04	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	1.4	0.72E+03	0.11E+04	0.19E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	1.4	0.93E+03	0.11E+04	0.20E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	1.4	0.11E+04	0.11E+04	0.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7	1.5	0.13E+04	0.11E+04	0.23E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8	1.5	0.16E+04	0.12E+04	0.24E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
9	1.5	0.18E+04	0.12E+04	0.25E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	1.5	0.20E+04	0.12E+04	0.26E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	1.6	0.22E+04	0.12E+04	0.27E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	1.6	0.24E+04	0.12E+04	0.28E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13	0.4	0.69E+03	0.34E+03	0.79E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
14	1.2	0.19E+04	0.90E+03	0.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	1.6	0.28E+04	0.13E+04	0.30E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
16	1.6	0.29E+04	0.13E+04	0.31E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	1.6	0.31E+04	0.13E+04	0.32E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
18	1.7	0.33E+04	0.13E+04	0.33E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
19	1.7	0.34E+04	0.13E+04	0.34E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	1.7	0.36E+04	0.13E+04	0.34E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
21	0.1	0.23E+03	0.83E+02	0.22E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22	1.6	0.35E+04	0.12E+04	0.33E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23	1.7	0.39E+04	0.13E+04	0.36E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	1.7	0.40E+04	0.13E+04	0.36E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	1.7	0.42E+04	0.13E+04	0.37E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
26	1.8	0.43E+04	0.13E+04	0.37E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
27	1.8	0.44E+04	0.13E+04	0.38E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
28	1.8	0.45E+04	0.13E+04	0.38E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
29	1.8	0.46E+04	0.13E+04	0.38E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	1.2	0.31E+04	0.84E+03	0.25E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

31	0.6	0.17E+04	0.45E+03	0.14E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.30E+03
32	1.8	0.49E+04	0.13E+04	0.39E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
33	1.6	0.45E+04	0.11E+04	0.35E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.76E+03
34	0.2	0.56E+03	0.15E+03	0.44E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.95E+02
35	1.8	0.53E+04	0.13E+04	0.39E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
36	1.8	0.55E+04	0.11E+04	0.40E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
37	1.8	0.58E+04	0.99E+03	0.40E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
38	1.8	0.61E+04	0.83E+03	0.40E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
39	0.6	0.21E+04	0.25E+03	0.13E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.29E+03
40	1.2	0.42E+04	0.43E+03	0.26E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.57E+03
41	1.8	0.65E+04	0.53E+03	0.40E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
42	1.8	0.68E+04	0.38E+03	0.40E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
43	1.7	0.67E+04	0.22E+03	0.38E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.82E+03
44	0.1	0.31E+03	0.70E+01	0.17E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.38E+02
45	1.8	0.72E+04	0.78E+02	0.39E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.86E+03
46	0.1	0.54E+03	0.00E+00	0.29E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.63E+02
47	1.7	0.68E+04	0.00E+00	0.36E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.15E+04
48	1.8	0.75E+04	0.00E+00	0.39E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.16E+04
49	0.3	0.11E+04	0.00E+00	0.58E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.24E+03
50	0.5	0.21E+04	0.00E+00	0.11E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.46E+03
51	1.0	0.44E+04	0.00E+00	0.22E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.93E+03
52	1.8	0.78E+04	0.00E+00	0.38E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.16E+04
53	0.8	0.37E+04	0.00E+00	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.77E+03
54	0.9	0.42E+04	0.00E+00	0.20E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.74E+03
55	1.7	0.81E+04	0.00E+00	0.37E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.14E+04
56	1.7	0.82E+04	0.00E+00	0.37E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.14E+04
57	0.8	0.38E+04	0.00E+00	0.17E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.63E+03
58	0.9	0.45E+04	0.00E+00	0.19E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.45E+03
59	1.1	0.52E+04	0.00E+00	0.22E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.51E+03
60	0.5	0.25E+04	0.00E+00	0.10E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.24E+03
61	0.1	0.76E+03	0.00E+00	0.30E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.76E+02
62	1.7	0.88E+04	0.00E+00	0.35E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.89E+03
63	1.7	0.87E+04	0.00E+00	0.34E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.88E+03
64	0.5	0.24E+04	0.00E+00	0.94E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.25E+03
65	1.2	0.61E+04	0.00E+00	0.24E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.87E+03
66	1.7	0.83E+04	0.00E+00	0.32E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.12E+04
67	1.1	0.56E+04	0.00E+00	0.22E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.82E+03
68	0.5	0.24E+04	0.00E+00	0.95E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.97E+02
69	1.6	0.78E+04	0.00E+00	0.31E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.32E+03
70	1.6	0.76E+04	0.00E+00	0.30E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.31E+03
71	0.5	0.25E+04	0.00E+00	0.99E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.10E+03
72	1.0	0.48E+04	0.00E+00	0.19E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.20E+03
73	1.6	0.71E+04	0.00E+00	0.28E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.30E+03
74	1.5	0.68E+04	0.00E+00	0.27E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.30E+03
75	1.5	0.66E+04	0.00E+00	0.26E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.30E+03
76	1.5	0.63E+04	0.00E+00	0.25E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.29E+03
77	1.5	0.60E+04	0.00E+00	0.23E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.29E+03
78	1.5	0.57E+04	0.00E+00	0.22E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.28E+03
79	1.4	0.54E+04	0.00E+00	0.21E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.28E+03
80	1.4	0.51E+04	0.00E+00	0.20E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.27E+03

81	1.4	0.49E+04	0.00E+00	0.18E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.27E+03
82	1.3	0.46E+04	0.00E+00	0.17E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.26E+03
83	1.3	0.43E+04	0.00E+00	0.16E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.26E+03
84	1.3	0.40E+04	0.00E+00	0.14E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.25E+03
85	1.3	0.37E+04	0.00E+00	0.13E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.25E+03
86	1.2	0.34E+04	0.00E+00	0.11E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.24E+03
87	1.2	0.31E+04	0.00E+00	0.97E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.23E+03
88	1.2	0.29E+04	0.00E+00	0.82E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.23E+03
89	1.1	0.26E+04	0.00E+00	0.66E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.22E+03
90	1.1	0.23E+04	0.00E+00	0.50E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.22E+03
91	1.1	0.21E+04	0.00E+00	0.33E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.21E+03
92	1.0	0.18E+04	0.00E+00	0.17E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.20E+03
93	0.5	0.77E+03	0.00E+00	0.19E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.93E+02
94	0.5	0.81E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.10E+03
95	1.0	0.14E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.19E+03
96	0.3	0.39E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.60E+02
97	0.6	0.75E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.12E+03
98	0.9	0.93E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.18E+03
99	0.9	0.72E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.17E+03
100	0.8	0.53E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.16E+03
101	0.8	0.34E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.16E+03
102	0.8	0.17E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.15E+03
103	0.4	0.27E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.85E+02

Failure Surface Specified By 84 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	21.05	34.00
2	22.34	32.74
3	23.66	31.52
4	25.01	30.33
5	26.39	29.17
6	27.79	28.04
7	29.22	26.95
8	30.68	25.89
9	32.16	24.86
10	33.66	23.88
11	35.19	22.92
12	36.74	22.01
13	38.31	21.13
14	39.90	20.29
15	41.51	19.49
16	43.14	18.72
17	44.79	18.00
18	46.45	17.31
19	48.13	16.67

20	49.83	16.06
21	51.54	15.49
22	53.26	14.97
23	54.99	14.49
24	56.74	14.04
25	58.49	13.64
26	60.26	13.29
27	62.03	12.97
28	63.81	12.70
29	65.59	12.46
30	67.38	12.28
31	69.18	12.13
32	70.97	12.03
33	72.77	11.96
34	74.57	11.95
35	76.37	11.97
36	78.17	12.04
37	79.97	12.15
38	81.76	12.30
39	83.55	12.50
40	85.34	12.74
41	87.11	13.02
42	88.88	13.34
43	90.65	13.71
44	92.40	14.11
45	94.14	14.56
46	95.88	15.05
47	97.60	15.58
48	99.30	16.16
49	100.99	16.77
50	102.67	17.42
51	104.33	18.11
52	105.98	18.84
53	107.60	19.61
54	109.21	20.42
55	110.80	21.27
56	112.37	22.16
57	113.91	23.08
58	115.44	24.03
59	116.94	25.03
60	118.42	26.06
61	119.87	27.12
62	121.29	28.22
63	122.69	29.35
64	124.06	30.52
65	125.41	31.72
66	126.72	32.95
67	128.01	34.21
68	129.26	35.50
69	130.49	36.82

70	131.68	38.17
71	132.84	39.54
72	133.96	40.95
73	135.06	42.38
74	136.11	43.83
75	137.14	45.31
76	138.13	46.82
77	139.08	48.35
78	139.99	49.90
79	140.87	51.47
80	141.71	53.06
81	142.51	54.67
82	143.28	56.30
83	144.00	57.95
84	144.43	59.00

Circle Center At X = 74.4 ; Y = 87.6 and Radius, 75.6

*** 1.227 ***

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Failure Surface Specified By 81 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	31.58	34.00
2	32.86	32.73
3	34.17	31.50
4	35.51	30.30
5	36.89	29.14
6	38.29	28.01
7	39.71	26.91
8	41.17	25.85
9	42.65	24.83
10	44.16	23.84
11	45.69	22.90
12	47.24	21.99
13	48.82	21.12
14	50.41	20.29
15	52.03	19.50
16	53.67	18.75
17	55.32	18.04
18	57.00	17.38
19	58.68	16.75
20	60.39	16.17

21	62.11	15.63
22	63.84	15.14
23	65.58	14.69
24	67.33	14.28
25	69.09	13.91
26	70.87	13.59
27	72.64	13.32
28	74.43	13.09
29	76.22	12.90
30	78.01	12.76
31	79.81	12.66
32	81.61	12.61
33	83.41	12.60
34	85.21	12.64
35	87.01	12.73
36	88.80	12.86
37	90.60	13.03
38	92.38	13.25
39	94.16	13.51
40	95.94	13.82
41	97.70	14.17
42	99.46	14.57
43	101.20	15.01
44	102.94	15.49
45	104.66	16.02
46	106.37	16.59
47	108.06	17.20
48	109.74	17.85
49	111.40	18.55
50	113.04	19.29
51	114.66	20.06
52	116.26	20.88
53	117.85	21.74
54	119.41	22.64
55	120.94	23.58
56	122.46	24.55
57	123.94	25.56
58	125.41	26.61
59	126.84	27.70
60	128.25	28.82
61	129.63	29.97
62	130.98	31.16
63	132.30	32.39
64	133.59	33.64
65	134.85	34.93
66	136.07	36.25
67	137.26	37.60
68	138.42	38.98
69	139.54	40.39
70	140.63	41.82

71	141.68	43.28
72	142.69	44.77
73	143.67	46.28
74	144.61	47.82
75	145.51	49.38
76	146.37	50.96
77	147.19	52.56
78	147.97	54.19
79	148.70	55.83
80	149.40	57.49
81	149.99	59.00

Circle Center At X = 82.8 ; Y = 84.5 and Radius, 71.9

*** 1.229 ***

Failure Surface Specified By 84 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	23.68	34.00
2	24.99	32.76
3	26.33	31.55
4	27.69	30.38
5	29.08	29.24
6	30.50	28.13
7	31.94	27.05
8	33.41	26.01
9	34.90	25.00
10	36.42	24.03
11	37.95	23.10
12	39.51	22.20
13	41.09	21.34
14	42.70	20.51
15	44.31	19.73
16	45.95	18.98
17	47.61	18.27
18	49.28	17.60
19	50.96	16.97
20	52.66	16.38
21	54.38	15.83
22	56.10	15.32
23	57.84	14.85
24	59.59	14.42
25	61.35	14.04

26	63.12	13.69
27	64.89	13.39
28	66.67	13.13
29	68.46	12.91
30	70.25	12.74
31	72.04	12.60
32	73.84	12.51
33	75.64	12.46
34	77.44	12.45
35	79.24	12.49
36	81.04	12.57
37	82.83	12.69
38	84.63	12.85
39	86.42	13.06
40	88.20	13.30
41	89.98	13.59
42	91.74	13.92
43	93.51	14.30
44	95.26	14.71
45	97.00	15.16
46	98.73	15.66
47	100.45	16.20
48	102.15	16.77
49	103.84	17.39
50	105.52	18.05
51	107.18	18.74
52	108.82	19.48
53	110.45	20.25
54	112.05	21.07
55	113.64	21.91
56	115.21	22.80
57	116.75	23.72
58	118.28	24.68
59	119.77	25.68
60	121.25	26.71
61	122.70	27.77
62	124.13	28.87
63	125.53	30.01
64	126.90	31.17
65	128.24	32.37
66	129.56	33.60
67	130.85	34.85
68	132.10	36.14
69	133.33	37.46
70	134.52	38.81
71	135.69	40.18
72	136.81	41.58
73	137.91	43.01
74	138.97	44.46
75	140.00	45.94

76	140.99	47.44
77	141.95	48.97
78	142.87	50.52
79	143.75	52.08
80	144.60	53.67
81	145.41	55.28
82	146.18	56.91
83	146.91	58.55
84	147.10	59.00

Circle Center At X = 76.8 ; Y = 88.8 and Radius, 76.3

*** 1.238 ***

1

Failure Surface Specified By 77 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	31.58	34.00
2	32.86	32.73
3	34.17	31.50
4	35.51	30.30
5	36.89	29.14
6	38.29	28.02
7	39.73	26.93
8	41.19	25.88
9	42.69	24.88
10	44.21	23.91
11	45.75	22.99
12	47.32	22.11
13	48.91	21.27
14	50.53	20.47
15	52.16	19.72
16	53.81	19.01
17	55.49	18.35
18	57.18	17.73
19	58.89	17.15
20	60.61	16.63
21	62.34	16.15
22	64.09	15.72
23	65.85	15.33
24	67.62	14.99
25	69.39	14.70
26	71.18	14.46

27	72.96	14.27
28	74.76	14.12
29	76.56	14.03
30	78.36	13.98
31	80.16	13.98
32	81.96	14.02
33	83.75	14.12
34	85.55	14.27
35	87.34	14.46
36	89.12	14.70
37	90.90	14.99
38	92.66	15.33
39	94.42	15.72
40	96.17	16.15
41	97.90	16.63
42	99.63	17.15
43	101.33	17.73
44	103.02	18.34
45	104.70	19.01
46	106.35	19.72
47	107.99	20.47
48	109.60	21.26
49	111.19	22.10
50	112.76	22.99
51	114.31	23.91
52	115.83	24.88
53	117.32	25.88
54	118.78	26.93
55	120.22	28.01
56	121.63	29.14
57	123.00	30.30
58	124.34	31.50
59	125.66	32.73
60	126.93	34.00
61	128.18	35.30
62	129.38	36.64
63	130.55	38.00
64	131.69	39.40
65	132.78	40.83
66	133.84	42.29
67	134.85	43.77
68	135.83	45.29
69	136.77	46.82
70	137.66	48.39
71	138.51	49.97
72	139.32	51.58
73	140.08	53.21
74	140.80	54.86
75	141.48	56.53
76	142.11	58.22

77	142.37	59.00

Circle Center At X =   79.3 ; Y =   80.7 and Radius,   66.8

*** 1.248 ***

Failure Surface Specified By 82 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	26.32	34.00
2	27.65	32.79
3	29.01	31.61
4	30.40	30.47
5	31.82	29.36
6	33.26	28.28
7	34.73	27.24
8	36.22	26.23
9	37.73	25.25
10	39.27	24.32
11	40.82	23.42
12	42.40	22.55
13	44.00	21.72
14	45.62	20.93
15	47.26	20.18
16	48.91	19.47
17	50.58	18.80
18	52.26	18.16
19	53.96	17.57
20	55.67	17.02
21	57.40	16.50
22	59.14	16.03
23	60.88	15.60
24	62.64	15.21
25	64.41	14.86
26	66.18	14.55
27	67.96	14.29
28	69.75	14.06
29	71.54	13.88
30	73.33	13.74
31	75.13	13.65
32	76.93	13.59
33	78.73	13.58
34	80.53	13.61
35	82.33	13.68

36	84.12	13.80
37	85.92	13.95
38	87.71	14.15
39	89.49	14.39
40	91.27	14.68
41	93.04	15.00
42	94.80	15.37
43	96.55	15.77
44	98.30	16.22
45	100.03	16.71
46	101.75	17.24
47	103.46	17.81
48	105.15	18.42
49	106.83	19.07
50	108.49	19.76
51	110.14	20.49
52	111.77	21.26
53	113.38	22.06
54	114.97	22.91
55	116.54	23.79
56	118.09	24.70
57	119.61	25.65
58	121.12	26.64
59	122.60	27.67
60	124.05	28.72
61	125.49	29.82
62	126.89	30.94
63	128.27	32.10
64	129.62	33.29
65	130.94	34.51
66	132.23	35.76
67	133.50	37.05
68	134.73	38.36
69	135.93	39.70
70	137.10	41.07
71	138.24	42.46
72	139.34	43.88
73	140.41	45.33
74	141.45	46.80
75	142.45	48.30
76	143.41	49.82
77	144.34	51.36
78	145.23	52.92
79	146.09	54.51
80	146.91	56.11
81	147.69	57.73
82	148.26	59.00

Circle Center At X =   78.4 ; Y =   90.1 and Radius,   76.5

*** 1.274 ***

1

Failure Surface Specified By 73 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	36.84	34.00
2	38.12	32.73
3	39.43	31.49
4	40.77	30.30
5	42.15	29.14
6	43.56	28.02
7	45.00	26.95
8	46.48	25.91
9	47.98	24.92
10	49.51	23.98
11	51.07	23.08
12	52.65	22.22
13	54.26	21.41
14	55.89	20.65
15	57.54	19.93
16	59.22	19.26
17	60.91	18.65
18	62.61	18.08
19	64.34	17.56
20	66.07	17.09
21	67.82	16.67
22	69.59	16.30
23	71.36	15.98
24	73.14	15.71
25	74.93	15.50
26	76.72	15.34
27	78.51	15.23
28	80.31	15.17
29	82.11	15.16
30	83.91	15.21
31	85.71	15.30
32	87.50	15.45
33	89.29	15.66
34	91.08	15.91
35	92.85	16.21
36	94.61	16.57
37	96.37	16.98
38	98.11	17.43

39	99.84	17.94
40	101.55	18.50
41	103.24	19.10
42	104.92	19.76
43	106.57	20.46
44	108.21	21.21
45	109.82	22.01
46	111.41	22.86
47	112.98	23.75
48	114.52	24.68
49	116.03	25.66
50	117.51	26.68
51	118.96	27.75
52	120.38	28.85
53	121.77	30.00
54	123.12	31.19
55	124.44	32.41
56	125.72	33.68
57	126.97	34.97
58	128.17	36.31
59	129.34	37.68
60	130.47	39.08
61	131.56	40.52
62	132.60	41.98
63	133.60	43.48
64	134.56	45.00
65	135.48	46.55
66	136.35	48.13
67	137.17	49.73
68	137.95	51.35
69	138.67	53.00
70	139.36	54.66
71	139.99	56.35
72	140.57	58.05
73	140.87	59.00

Circle Center At X = 81.4 ; Y = 77.4 and Radius, 62.2

*** 1.284 ***

Failure Surface Specified By 81 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	18.42	34.00

2	19.70	32.73
3	21.00	31.49
4	22.34	30.29
5	23.71	29.12
6	25.10	27.98
7	26.53	26.88
8	27.98	25.82
9	29.46	24.79
10	30.97	23.80
11	32.49	22.85
12	34.05	21.94
13	35.62	21.07
14	37.22	20.24
15	38.83	19.45
16	40.47	18.70
17	42.13	17.99
18	43.80	17.33
19	45.49	16.70
20	47.19	16.12
21	48.91	15.58
22	50.64	15.09
23	52.38	14.64
24	54.14	14.24
25	55.90	13.88
26	57.67	13.56
27	59.45	13.29
28	61.24	13.06
29	63.03	12.88
30	64.82	12.75
31	66.62	12.66
32	68.42	12.61
33	70.22	12.62
34	72.02	12.66
35	73.82	12.76
36	75.61	12.89
37	77.40	13.08
38	79.19	13.31
39	80.97	13.58
40	82.74	13.90
41	84.50	14.26
42	86.26	14.67
43	88.00	15.12
44	89.73	15.62
45	91.45	16.16
46	93.15	16.74
47	94.84	17.37
48	96.51	18.03
49	98.16	18.75
50	99.80	19.50
51	101.41	20.29

52	103.01	21.12
53	104.58	22.00
54	106.13	22.91
55	107.66	23.86
56	109.16	24.86
57	110.64	25.88
58	112.09	26.95
59	113.51	28.05
60	114.91	29.19
61	116.27	30.36
62	117.61	31.57
63	118.91	32.81
64	120.19	34.08
65	121.43	35.39
66	122.63	36.72
67	123.81	38.09
68	124.94	39.48
69	126.05	40.91
70	127.11	42.36
71	128.14	43.83
72	129.13	45.34
73	130.08	46.86
74	131.00	48.42
75	131.87	49.99
76	132.70	51.58
77	133.50	53.20
78	134.25	54.84
79	134.96	56.49
80	135.63	58.16
81	135.94	59.00

Circle Center At X = 69.3 ; Y = 83.7 and Radius, 71.1

*** 1.286 ***

1

Failure Surface Specified By 80 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	18.42	34.00
2	19.70	32.73
3	21.00	31.49
4	22.34	30.28
5	23.71	29.11

6	25.10	27.98
7	26.53	26.88
8	27.98	25.82
9	29.46	24.80
10	30.97	23.81
11	32.50	22.87
12	34.06	21.96
13	35.63	21.09
14	37.23	20.27
15	38.85	19.48
16	40.49	18.74
17	42.15	18.04
18	43.83	17.38
19	45.52	16.77
20	47.23	16.20
21	48.95	15.67
22	50.68	15.19
23	52.43	14.75
24	54.19	14.36
25	55.95	14.01
26	57.73	13.71
27	59.51	13.45
28	61.29	13.24
29	63.09	13.08
30	64.88	12.96
31	66.68	12.89
32	68.48	12.86
33	70.28	12.88
34	72.08	12.94
35	73.88	13.06
36	75.67	13.22
37	77.46	13.42
38	79.24	13.67
39	81.02	13.97
40	82.78	14.31
41	84.54	14.69
42	86.29	15.12
43	88.03	15.60
44	89.75	16.12
45	91.46	16.69
46	93.15	17.29
47	94.83	17.95
48	96.49	18.64
49	98.13	19.38
50	99.76	20.15
51	101.36	20.97
52	102.94	21.84
53	104.50	22.74
54	106.03	23.68
55	107.54	24.66

56	109.03	25.68
57	110.48	26.73
58	111.91	27.83
59	113.31	28.95
60	114.69	30.12
61	116.03	31.32
62	117.34	32.55
63	118.62	33.82
64	119.86	35.12
65	121.07	36.45
66	122.25	37.81
67	123.39	39.20
68	124.50	40.63
69	125.57	42.07
70	126.60	43.55
71	127.59	45.05
72	128.55	46.58
73	129.46	48.13
74	130.34	49.70
75	131.17	51.29
76	131.96	52.91
77	132.71	54.55
78	133.42	56.20
79	134.09	57.87
80	134.51	59.00

Circle Center At X = 68.6 ; Y = 83.0 and Radius, 70.1

*** 1.301 ***

Failure Surface Specified By 47 Coordinate Points

Point No.	X-Surf ft.	Y-Surf ft.
1	44.74	34.00
2	46.45	33.46
3	48.19	32.97
4	49.93	32.53
5	51.69	32.14
6	53.46	31.80
7	55.23	31.51
8	57.02	31.27
9	58.81	31.08
10	60.60	30.94
11	62.40	30.86

12	64.20	30.83
13	66.00	30.85
14	67.80	30.92
15	69.59	31.04
16	71.39	31.21
17	73.17	31.44
18	74.95	31.71
19	76.72	32.04
20	78.48	32.42
21	80.23	32.84
22	81.96	33.32
23	83.68	33.85
24	85.39	34.42
25	87.08	35.05
26	88.75	35.72
27	90.40	36.44
28	92.03	37.21
29	93.63	38.03
30	95.21	38.89
31	96.77	39.79
32	98.30	40.74
33	99.80	41.73
34	101.27	42.77
35	102.71	43.84
36	104.12	44.96
37	105.50	46.12
38	106.85	47.32
39	108.16	48.55
40	109.43	49.82
41	110.67	51.13
42	111.87	52.47
43	113.03	53.85
44	114.15	55.26
45	115.22	56.70
46	116.26	58.17
47	116.81	59.00

Circle Center At X = 64.4 ; Y = 93.6 and Radius, 62.8

*** 1.302 ***

1

Y A X I S F T

0.00 18.75 37.50 56.25 75.00 93.75

```
X      0.00 *-----*---+*-----.*-+----W----+---------+---------+
            -              ...
            -             ....
            -           ......
            -          .......
            -         ........
      18.75 +        .......88
            -       .......811
            -       .....88114
            -      .....81146.
            -     .....81146.3
            -     ....8114633.
A     37.50 +    ....811463377
            -    ....11463.77.
            -   ....8146377..0
            -   ....146377...0
            -   ...216377...0*
            -  ....14357....0.
X     56.25 +  ...11337.....0.
            -  ...1437......0.
            -  ...1357.....0..
            -  ...137......0..*/1
            -  ..1237......00.*
            -  ..1357.......0...
I     75.00 +  ..135........0...
            -  ..137........0....*
            -   .127.........0...
            -   .115.........0.... * 1/2
            -   ..15..........0...
            -    .158.........00...  *2/3
S     93.75 +    .1279.........00...   3/4
            -     3158..........00...
            -     .1278..........00..    **6
            -      31288..........00..
            -      .12588...........0..    6/7
            -       312788...........00.   7/8
     112.50 +        312788............00.
            -         3127.89...........000
            -          1125.889............
            -          .31127.889..........
            -           .31127.888.........
            -            .311225..8899.....
F    131.25 +              .311255..88889..
            -               .33122257..8888
            -                 3311122557..8
            -                   .3111222555
            -                     .33111222
            -                        331111
T    150.00 *     *    *             W*  .3*8/
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APPENDIX N

RIGID PAVEMENT DESIGN

APPENDIX N-RIGID PAVEMENT DESIGN

SCENARIOS 2~4:

2) Light Duty Vehicular Paving: Support for BPCA maintenance vehicle
   - Load: Taylor Dunn ET-3000, 2475 base vehicle weight; Max. 3000 lbs load capacity, Total weight of 5475lbs.
   - Load Repetitions: more than 20 times per day.
3) Medium Duty Vehicular Paving: Support for BPCA stage vehicle
   - Load: Stage Trailer (Fully Loaded): 7716lbs, F-250: Max. GVRW-10,000lbs, Total Weight of 17,716lbs.
   - Load Repetitions: 2 times per day when deployed, unknown number of times deployed in a year
4) Heavy Duty Vehicular Paving: Support for YC Fire Department Truck
   - Load: 55,000 lbs (pending confirmation from NYC FD).
   - Load Repetitions: 2 times per day as needed.

For **Scenarios 2-4**, the selection of rigid pavement thickness is based on the Portland Cement Association Design Procedures which is presented in Guide for Design and Construction of Concrete Paring Lots-ACI 330R-01. The primary parameters and assumptions used in the design for each scenario is listed as follows:

(a) Design life of the pavement: 30 years

(b) Subgrade soil type: Sand or sand-gravel mixture with trace to little silt and clay; Subbase: 6-inch granular aggregate. The modulus of subgrade reaction: 200psi according to Table 2.1 and Table 2.2 of the Guide for Design and Construction of Concrete Paring Lots-ACI 330R-01.

(c) Plain pavement: plain concrete is to be used without any reinforcing steel or steel dowels at control joints.

(d) Flexural Strength of Concrete: According to the relationship between compressive strength f_c' and flexural strength M_R by Raphael (1984), $M_R = 2.3{f_c'}^{2/3}$. Estimated flexural strength for each type of concrete are as follows: For 3500psi concrete, the flexural strength M_R =530psi.

Compressive Strength of Concrete	3500psi	4000psi	4500psi	5000psi
Estimated Flexural Strength	530psi	579.5psi	626.9ksi	672.5ksi

(e) For the low-volume pavement, flexural fatigue cracking controls the design of the pavement.

The recommended pavement thicknesses for scenarios 2-4 are summarized as follows:

Scenario 2: According to Table 2.4 in the Reference of Guide for Design and Construction of Concrete Paring Lots-ACI 330R-01, the traffic category of this scenario is Category A with Average Daily Truck Traffic (ADTT, excluding two-axle, four-tire trucks) AADT=0; the recommended thickness of rigid pavement is 4.0 inches. It is noted here that the Table 2.4 in the Reference is for twenty-year design life of pavement. To consider 30-year design life, Figure A.1 of the Reference should be used to determine the flexural stress. Considering rear axle load of 4.5kips and the front axle load is also 4.5 kips (the minimum axle load can be considered in Fig. A-1): load repetitions in 30 years=50 (25 times per day both directions)×365×30=547,500. For 4-inch pavement with M_R =530psi (Compressive Strength of Concrete 3500psi), Stress Ratio for rear axle=135/530=0.26, total fatigue consumption:=2×547,500/10,000,000×100%=22% which is less than the acceptable criterion. Hence, the acceptable pavement section for Scenario 2 is **4-inch thickness of plain 3500psi concrete**.

Scenario 3: According to Table 2.4 in the Reference of Guide for Design and Construction of Concrete Paring Lots-ACI 330R-01, the traffic category of this scenario is Category A-1 with Average Daily Truck Traffic (ADTT, excluding two-axle, four-tire trucks) AADT=2; the recommended thickness of rigid pavement for 20-year design is 4.5 for AADT=1 to 5.5 inches for AADT=10. Assuming a 5-inch concrete pavement with compressive strength of 3500psi and considering rear tandem-axle load of 8kips and the front axle load of 10 kips: load repetitions in 30 years=4 (2 times per day both directions) ×365×30=43,800. For 5-inch pavement with M_R =530psi (3500psi concrete), Stress Ratio for rear axle=125/530=0.24, Stress Ratio for front single axle=180/530=0.34, total fatigue consumption: =2×43,800/10,000,000×100%=1% which is much less than the acceptable criterion. Try 4-inch-thick section with compressive strength of concrete of 3500psi,

M_R =530psi, Stress Ratio for rear axle=145/530=0.28, Stress Ratio for front single axle=325/530=0.62. total fatigue consumption: =43,800/17,500+43800/10,000,000>100%, not acceptable. Try 4-inch-thick section with compressive strength of concrete of 4000psi, M_R =579psi, Stress Ratio for rear axle=145/579=0.25, Stress Ratio for front single axle=325/579=0.56. total fatigue consumption: =43,800/95,000+43800/10,000,000=47%<100%, acceptable. Hence, the acceptable pavement section for Scenario 3 is: **5-inch thickness of 3500psi concrete or 4-inch thick of minimum 4000psi concrete**.

Scenario 4: Based on typical fire apparatus configurations published online, for the total load of 55,000lbs, the truck is expected have a single front axle with a load of 24,000lbs and a single rear axle with a load of 31,000lbs. Try pavement section of 6-inch thick 4000psi concrete: load repetitions in 30 years=4 (2 times per day both directions) ×365×30=43,800. For 6-inch pavement with M_R = 579psi, Stress Ratio for rear axle=485/579=0.84, Stress Ratio for front single axle=385/579=0.67. Total fatigue consumption: =43,800/100+43800/5,000>100%, not acceptable. Try pavement section of 6-inch thick 4500psi concrete: M_R = 626psi, Stress Ratio for rear axle=485/626=0.77, Stress Ratio for front single axle=385/626=0.62. total fatigue consumption: =43,800/350+43800/17,500>100%, not acceptable. Try pavement section of 7-inch thick 4500psi concrete: M_R = 626psi, Stress Ratio for rear axle=390/626=0.62, Stress Ratio for front single axle=290/626=0.46. total fatigue consumption: =43,800/17,500+43800/10,000,000>100%, not acceptable. Try pavement section of 7-inch thick 5000psi concrete: M_R =672psi, Stress Ratio for rear axle=390/672=0.58, Stress Ratio for front single axle=290/672=0.43. total fatigue consumption: =43,800/50,000+43800/10,000,000=88%<100%, acceptable. Hence, the acceptable pavement section for Scenario 4 is: **7-inch thickness of 5000psi concrete**.