Passaic River Tidal – General Reevaluation Report

Floodwall Design Criteria

Revised
April 15, 2016

FLOODWALL DESIGN CRITERIA

1. General

This design criteria addresses the design of floodwalls in typical reaches along the Passaic River extending from Kearny to Newark, NJ. The design elements defined herein represent a preliminary design (i.e., 30-percent level) using the best available information. The analysis was limited to Stability. Pile foundations provide stability against overturning, sliding and flotation resistance. Soil conditions along this reach of the Passaic River were divided into two reaches; East Kearny and West Kearny. The elevation of the bedrock was assumed based on current limited information (see the Geotechnical Report); pile lengths must be refined as more soil data becomes available.

Floodwall designs were also provided which may be used to address Hazardous, Toxic, and Radioactive Waste (HTRW) reaches in which ground disturbance may not permitted[1] (i.e., excavation, augering and drilling of piles is not permitted). In this situation, our recommendation was to construct the T-Wall on top of the existing ground surface. Pile types requiring drilling or augering were not allowed. H-Piles, Pipe Piles and concrete piles were considered; prestressed concrete piles were selected for use in these HTRW reaches. The concrete piles are more resistant to corrosion that is typically found in HTRW soils. Vinyl sheet piling may be a consideration for use as cutoff piling. Although not unconditionally accepted by the USACE, there have been several projects constructed by the Corps that have included vinyl sheeting. Interim guidance is provided in USACE document; ***"General Design Guide: PVC Sheet Pile", dated May 2005***. Given the concern for long term durability, coated steel sheet piling has been included in our proposed designs. An L-Wall design was also developed for the HTRW reaches. In building the Floodwall on top of the ground surface, the overall height of the T-Wall was reduced to a level where L-Walls are a consideration. The L-Wall would only be applicable in the HTRW reaches. The sheet pile cutoff wall acts as both seepage cutoff and axial capacity. Where axial capacity is required, steel pilings would be required, vinyl should not be considered for this structural application. The L-Wall would <u>not</u> be recommended where corrosion rates are proven to be severe as the steel sheet pile would need to include significant, long-term corrosion protection and monitoring Soil testing for corrosive properties and stray currents should be performed in advance of final design. The level of corrosion protection, to include coatings and sacrificial thickness, can then be more accurately determined. In summary, Micro piles and H-Piles were considered in Typical T-wall reaches. Prestressed concrete piles were only considered for use in the HTRW reaches. L-Wall designs should be considered but only in wall heights less than 8ft where corrosion is determined to be moderate. Design calculations for this phase can be found in Appendix x.

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[1] This is a potential construction condition, considered in the analysis for completeness.

For cost comparison purposes, three wall heights were considered; Top of Wall (TOW) at El 18.0, El 16.0 and El 14.0 NAVD[2]. The Still Water Elevation (SWL) was assumed to be 2 feet below the TOW elevation. The typical ground elevation was assumed to be El 7 NAVD throughout the project.

2. Codes and Standards

The following is an abbreviated list of general U.S. Army Corps of Engineers (USACE) References and Industry codes and standards which are applicable to structural and foundation design for this preliminary design effort. Additional codes must be referenced for the final construction Plans & Specifications. Considered in this design are:

- AASHTO, American Association of State Highway and Transportation Officials, LRFD Bridge Design 7th Edition, 2014..
- ACI 318-14 American Concrete Institute, Building Code Requirements for Structural Concrete.
- ACI 350-06 American Concrete Institute, Environmental Engineering Concrete Structures
- AISC, American Institute of Steel Construction, Inc., Manual of Steel Construction, 14th Edition.
- ASCE 7-10 American Society of Civil Engineers, Minimum Design Loads for Buildings and Other Structures.
- ASTM, American Society for Testing and Materials.
- AWS D1.1-15 American Welding Society, Structural Welding Code, latest edition.
- USACE EM 1110-2-2104, Strength Design for Reinforced Concrete Hydraulic Structures.
- USACE EM 1110-2-2502, Retaining and Flood Walls.
- USACE EM 1110-2-2906, Design of Pile Foundations.
- USACE ETL 1110-2-584, Design of Hydraulic Steel Structures.
- USACE ETL 1110-2-575, Evaluation of I-Walls.

3. General Design Load Parameters

3.1.A. Load Combinations

The preliminary design includes four Basic Load Cases; these are the loadings that typically control floodwall designs. Other loadings must also be analyzed in the final design, including Seismic Load Cases for both Operating and Maximum Earthquake conditions. Additionally, sufficient hydraulic modeling should be performed as part of

[2] All elevations are referenced to North American Vertical Datum of 1988 (NAVD).

the future design to establish wave properties and forces. Typically, on inland waterways, when the wall is overbuilt to include uncertainty and sea-level rise the static head to top of wall is similar in force to that imparted by a wave; sufficiently close for this conceptual design. The load cases included in the design are:

1a. Construction. Dead load of the concrete wall components, no earthen backfill, no uplift. A 17 % overstress is permitted for this load case.

1b. Construction with Wind. Dead load of the concrete wall components, no earthen backfill, no uplift; a conservative wind load of 50 psf is applied to the wall stem. A 33 % overstress is permitted for this load case.

2a Flood Stage at Still Water, Impervious Cutoff. Dead load of concrete wall, At-Rest lateral earth pressures, and hydrostatic loading for water to the SWL; Uplift forces assume the sheet pile to be impervious. Wave force is not included.

2b. Flood Stage at Still Water, Pervious Cutoff. Dead load of concrete wall, At-Rest lateral earth pressures, and hydrostatic loading for water to the SWL; Uplift forces assume the sheet pile to be pervious varying linearly from flood side SWL to the ground water elevation on the Protected Side. Wave force is not included.

3a. Flood Stage with Water to Top of Wall, Impervious Cutoff. Dead load of concrete wall, At-Rest lateral earth pressures, and hydrostatic loading for water to the TOW; Uplift forces assume the sheet pile to be impervious. Wave force is not included. A 33% overstress is permitted.

3b. Flood Stage with Water to Top of Wall, Pervious Cutoff. Dead load of concrete wall, At-Rest lateral earth pressures, and hydrostatic loading for water to the TOW; Uplift forces assume the sheet pile to be pervious varying linearly from flood side TOW elevation to the ground water elevation on the Protected Side. Wave force is not included. A 33% overstress is permitted.

4a. Flood Stage at Still Water, Debris Impact Load, Impervious Cutoff. Loadings include: Dead load of concrete wall, At-Rest lateral earth pressures, and hydrostatic loading for water to the SWL. Uplift forces assume the sheet pile to be impervious. A debris load of 500lbs/LF is applied at the SWL. Wave force is not included. A 33% overstress is permitted.

The overstress factors listed in each load case above reflect the stress levels permitted in the HSDRRS design guidance that was developed for the New Orleans District post-Katrina and considered applicable for this flood protection project

3.1.A. Hydraulic Stages

Table 1 – Hydraulic Stages and Design Water Surface Elevations

Stage (NAVD)	Flood Side (NAVD)	Protected Side (NAVD)
TOW El 14.0		
SWL Water	EL. 12.0	EL. 6.0
TOW Water	EL. 14.0	EL. 6.0
TOW El 16.0		
SWL Water	EL. 14.0	EL. 6.0
TOW Water	EL. 16.0	EL. 6.0
TOW El 18.0		
SWL Water	EL. 16.0	EL. 6.0
TOW Water	EL. 18.0	EL. 6.0

SWL – Still Water Level
TOW – Top of Wall

3.2. Load Cases

3.2.1. Dead Loads (D)

Dead loads shall be determined in accordance with applicable engineering manuals and ASCE 7-02, and shall include the self-weight of all permanent construction components including foundations, slabs, walls, roofs, actual weights of equipment, overburden pressures, and all permanent non-removable stationary construction.

Table 2 – Unit Weights

Item	Weight [Pcf]
Water (Fresh)	62.4
Semi-compacted Fill	110
Fully Compacted Granular Fill, wet	120
Fully Compacted Granular Fill, Effective	58
Fully Compacted Clay Fill, wet	110
Fully Compacted Clay Fill, Effective	48
Riprap	130
Silt	94
Reinforced Concrete (Normal weight)	150
Steel	490

3.2.2. Live Loads (L)

Live loads for building structures shall be determined in accordance with applicable engineering manuals and ASCE 7-02.

3.2.2.1 Live Load Surcharge (LS)

A minimum live load surcharge of 200 psf will be applied during construction.

3.2.3. Soil Pressures (S)

Structures are designed for lateral and vertical soil pressures. Lateral pressures are determined using the at-rest coefficients, K_O obtained from the Geotechnical Report:

- Lateral Soils at-rest Pressure Coefficients:
  Ko = 0.8 for Clay.
  Ko = 0.48 for Granular Material.

3.2.4. Hydrostatic Loads (H)

Hydrostatic loads for which structures will be designed refer to the vertical and horizontal loads induced by a static water head and buoyant pressures, excluding uplift pressures. Dynamic Wave Forces have NOT been included.

3.2.5. Uplift Loads (U)

Uplift loads for which structures will be designed to two uplift conditions: Uplift Condition A, assumes the sheet pile cutoff wall is fully effective (Impervious), and Uplift Condition B, assumes the sheet pile cutoff wall is ineffective (Pervious) (pressure assumed to be vary linearly across the base).

3.2.6. Wind Loads (W)

Structures are designed for wind loads established by ASCE No. 7, "Minimum Design Loads for Buildings and Other Structures," ***but in no case less than 50 psf***. The basic sustained wind speed is 110 miles per hour, and the exposure category is "C". Architectural roofs shall be designed for a 135 mile-per-hour sustained wind. An importance factor of 1.15 is included in wind calculations.

4. Concrete Design Criteria

Concrete design shall utilize EM 1110-2-2104 and the ACI 350R Concrete Sanitary Engineering Structures and will comply with the ACI 318 latest edition strength design method, unless otherwise required:

- Structural Concrete: 4,000 psi @ 28 days with a maximum water/cement ratio = 0.40

- Steel reinforcement 60,000 psi (ASTM A615)

5. Steel Design Criteria

Steel design shall utilize the ETL 1110-2-584 and the AISC Steel Construction Manual, 14th edition. Load combinations shall be in accordance with ASCE 7-02. Typical design values are as follows unless otherwise noted:

(a)	Structural steel rolled shapes	ASTM 572, Grade 50 ASTM A992, Grade 50
(b)	Plates	ASTM A992, Grade 36
(c)	Bolts and nuts	ASTM A325, min. ¾“ ASTM A490
(d)	Anchor Bolts	ASTM A449, (¾“ dia. & or greater)
(e)	Corrosion stainless steel	ASTM A304 (freshwater) ASTM A316 (saltwater)
(f)	Sheet Piles	ASTM A328, Grade 50 ASTM A572, Grade 50
(g)	Stainless Steel Embedded Anchors	ASTM A276 or UNS S21800

Normally, components that shall be exposed to the elements are either hot-dipped galvanized or primed, painted and sealed with coats of (10 mils min.) epoxy. Vertical lift gates and steel sheet pile structures shall be painted with an epoxy painting system.

6. Pile Foundation Design Criteria

All forces applied to T-Wall structures are resisted by the pile foundation. T-wall monoliths are assumed to act independent of adjacent monoliths, no load transfer is considered between monoliths. Pile designs are based on a soil structure interactive analysis with the pile supports input in accordance with EM 1110-2-2906. Lateral resistance of the soil is based on the soil horizontal subgrade modulus. In future designs, pile capacities shall be determined utilizing springs based on P-Y and T-Z curves generated by geotechnical analysis. Factors for Group effects have been included in this analysis. Pile capacities have been determined using all-friction and a combination of

friction and end bearing. Micro Piles will be considered where bedrock is reasonably shallow (e.g., <50 feet). Micro-pile capacities include a 10ft deep rock socket. H-Pile and Concrete pile capacities mainly consider friction; very little end bearing was included. Piles embedded the standard 6"-9" were analyzed as both fixed and pinned pile heads. Recent research conducted by the New Orleans and St. Paul Districts has indicated that piles with minimal embedment act as partially fixed, more fixed than pinned. As such, recent practice is to bracket the connection design with a pinned and fixed analysis. Monoliths with all vertical piles were rigidly connected to the base and only analyzed as fixed. In order to assure a very rigid connection, these piles were embedded two pile diameters into the base.

Piles may be Micro-piles with continuous casings to bedrock, steel pipe piles, steel H piles or prestressed concrete. Pipe piles satisfy ASTM A252 with minimum yield strength of 45 ksi. H-piles satisfy Grade 50 Steel. Steel piles are designed structurally per AISC ASD, 14th Edition, as modified by EM 1110-2-2906. Concrete square piles have a design strength equal to 6,000 psi at 28 days, prestressing strands are Low-Lax, Grade 270. Prestressed concrete piles are designed to satisfy both strength and serviceability requirements. Strength design follows the basic criteria set forth by ACI, except the strength reduction factor is 0.7 for all failure modes and the load factor is 1.9 for both dead and live loads. The prestressed concrete pile is designed for an axial strength limited to 80 percent of pure axial strength and a minimum eccentricity equal to 10 percent of the pile width. Control of cracking is achieved by limiting the concrete compressive stress to 0.4f'c and the tensile stress to zero. Combined axial and bending are considered when analyzing the stresses in the piles.

Vertical piles were used only where space restraints prevented the installation of the more efficient battered pile. This condition mainly occurred were the floodwall alignment was sandwiched between the Passaic River/Hackensack River/Newark Bay and buildings located near the top of bank. Cross sections of the bank and infrastructure were not available; therefore, it was assumed that a 15ft top of bank crown at El 8 exists with a floodside bank slope down to the thalweg of the river. The vertical pile design used only a fixed pile head. To assure this fixity occurred, the piles were embedded a minimum of two pile diameters into the base. The pile foundation can be used for bearing and also to stabilize the bank slope, similar to soil nailing, if stability factors of safety are low.

Although not commonly used in the Northeast, Precast Prestressed Concrete (PPC) piles were included for use in reaches that are considered HTRW and have an increased rate of corrosion, in the event that construction on HTRW sites is pursued. The concrete pile is far more resistant to corrosion than steel. Stress levels shall be controlled to prevent cracking of the concrete when experiencing both service loads and driving stresses.

CPGA pile design software was used for this preliminary design. Settlement and ground instability were not considered to be a factor. Forces from downdrag and unbalanced loads were not included in the pile design. It was assumed that pile load tests will be conducted in advance of construction, a Factor of Safety = 2.0 was included for normal load cases and 1.5 for unusual load cases.

GEOTECHNICAL

MICROPILE DESIGN - BASED ON FHWA MICROPILE GUIDELINES (2005)

Project Name: Passic-River - Preliminary Floodwall Design — Calculated by: M.S.

Project Number : — Checked by:

SUMMARY OF ESTIMATED MICROPILE CAPACITY

Steel Casing Outside Diameter (in.)	Steel Casing Thickness (Minimum) (in.)	Rebar Size	Rock Socket (Minimum) (ft)	Maximum Allowable Capacity (tons)	
				Compression	Tension
9-5/8	0.545	#24 (1)	10	80	50
			15	120	75
			20	150	100
			25	180	125
			30	180	150
13-3/8	0.480	#24 (1)	10	120	75
			15	180	100
			20	240	150
			25	260	155
			30	260	155

H-Pile Capacity - BASED ON APILE ANALYSIS USING FHWA METHOD

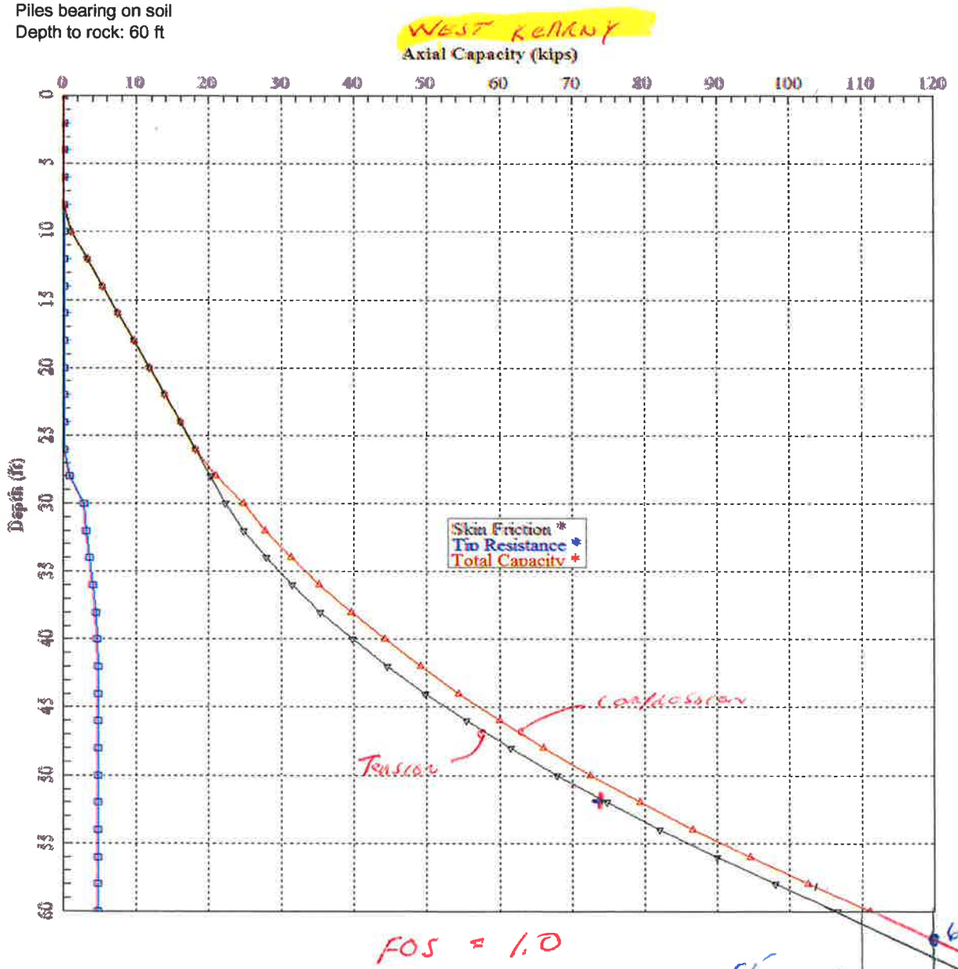
Project Name: Passic-River - Preliminary Floodwall Design — Calculated by: M.S.

Project Number : — Checked by:

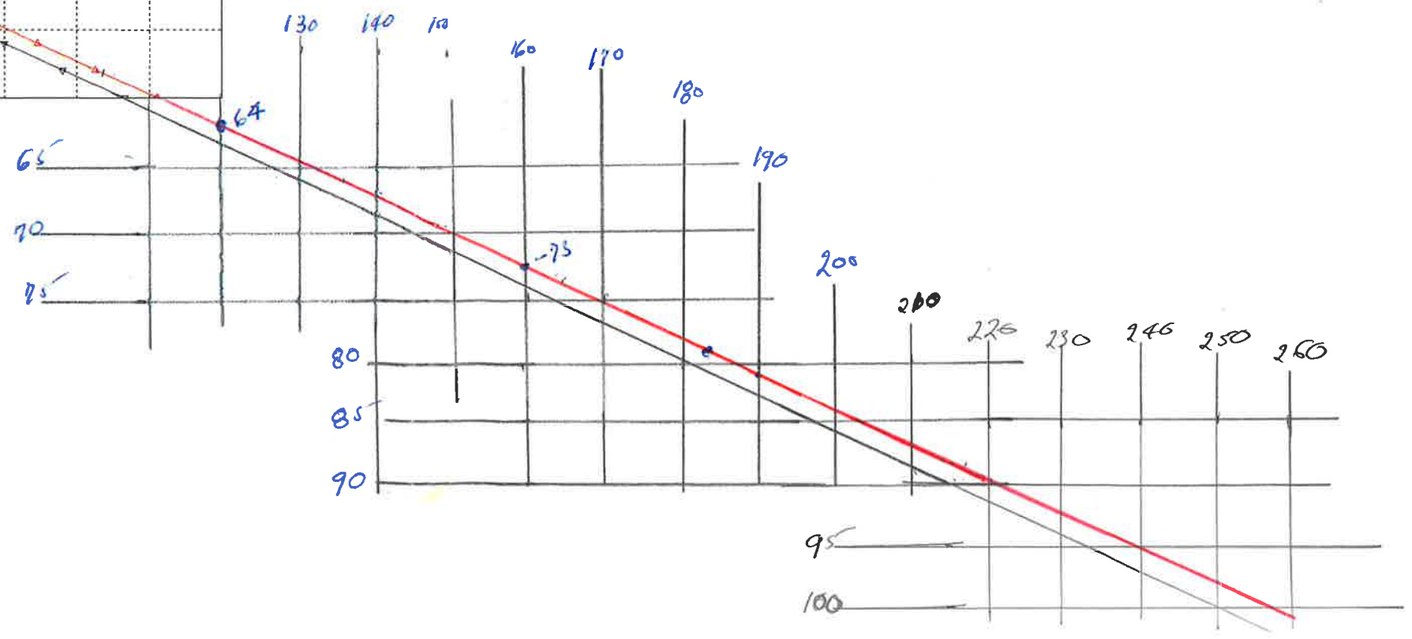
Piles bearing on soil

Depth to rock: 60 ft

WEST KENNY



FOS = 1.0



COM

JOB TITLE _____

JOB NO. _____ CALCULATION NO. _____

ORIGINATOR _____ DATE _____

REVIEWER _____ DATE _____

SCALE _____ SHEET NO. _____ OF _____

H-Pile Capacity - BASED ON APILE ANALYSIS USING FHWA METHOD

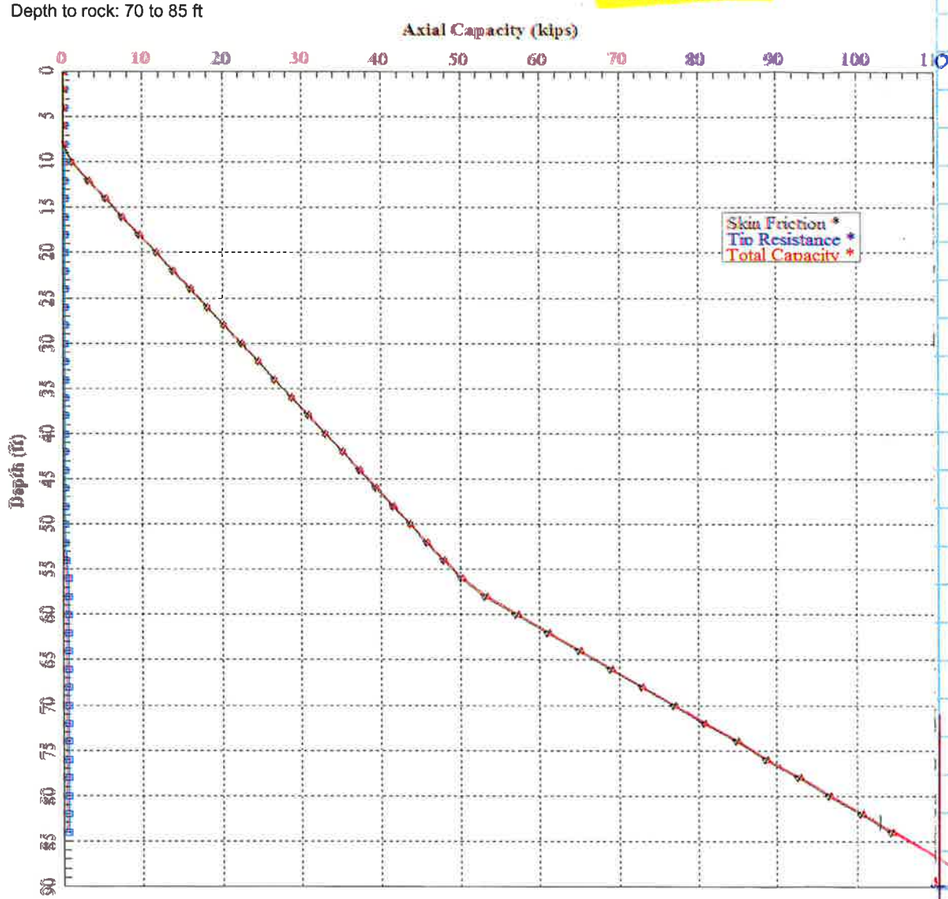
Project Name: Passic-River - Preliminary Floodwall Design — Calculated by: M.S.

Project Number : — Checked by:

Piles bearing on soil

Depth to rock: 70 to 85 ft

EAST KEARNY



FOS = 1.0

120 130 140 150 160 170 180 190 200 210 220

95 100 105 110 115 120 125 130 135 140

Grid: 4x4 = 1"

14" Concrete Prestressed Pile Capacity - BASED ON APILE ANALYSIS USING FHWA METHOD

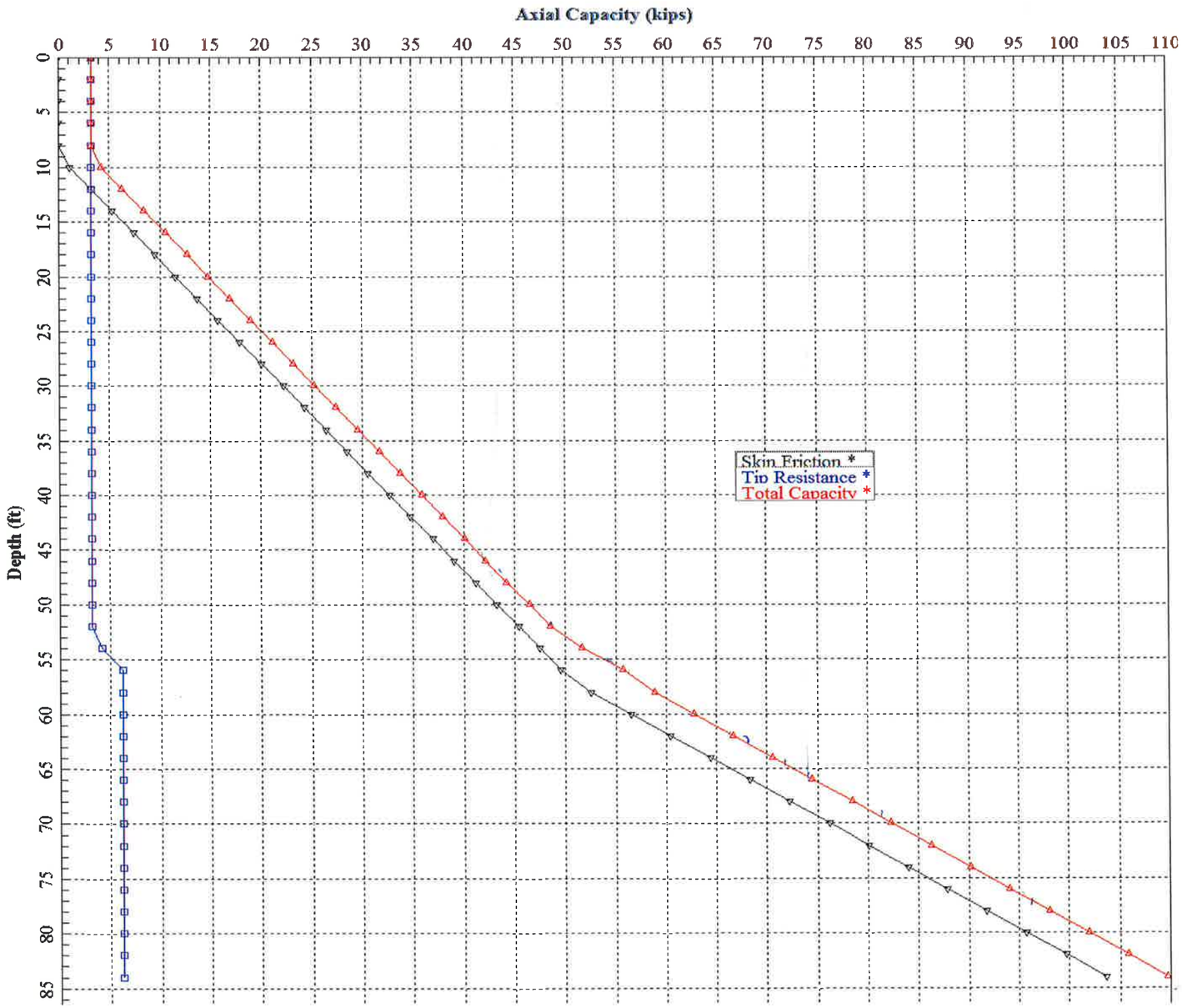
Project Name: Passic-River - Preliminary Floodwall Design — Calculated by: M.S.

Project Number : — Checked by:

Piles bearing on soil

Depth to rock: 70 to 85 ft

EAST OF KEARNY



14" CONC PRESTRESSED

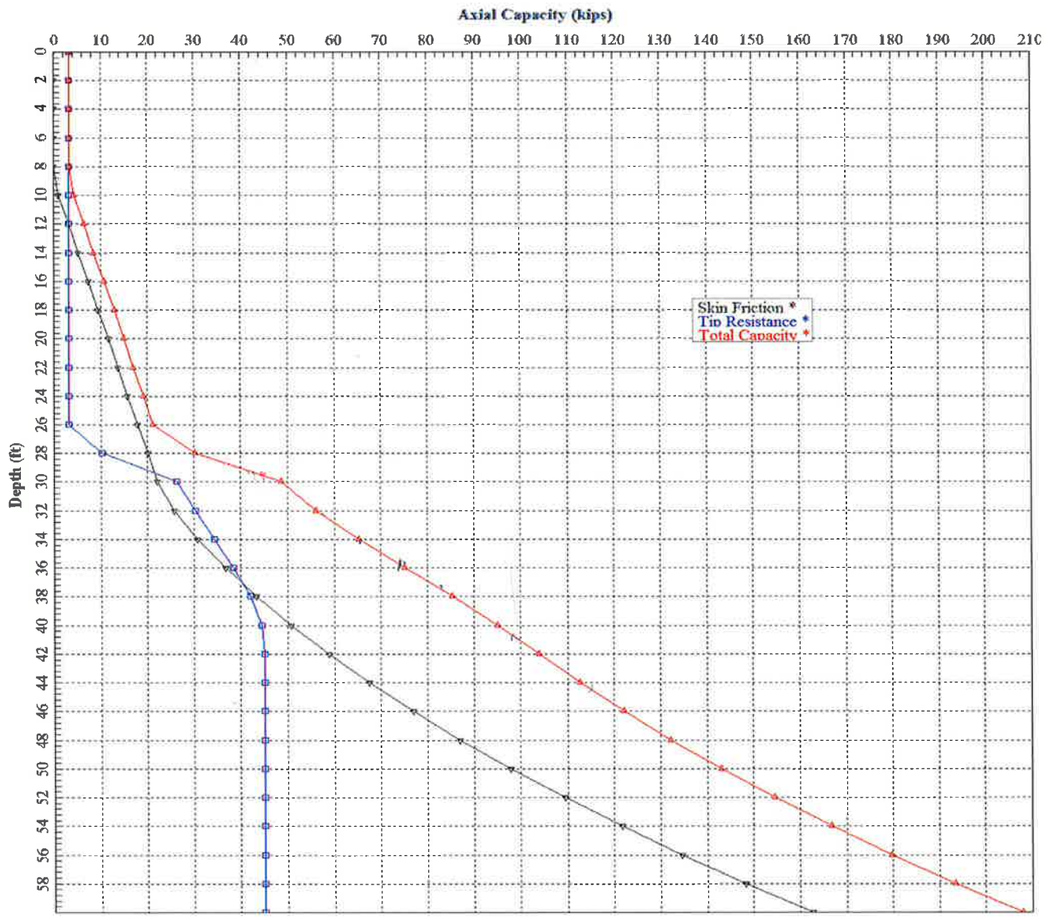
~~H-Pile~~ **Capacity - BASED ON APILE ANALYSIS USING FHWA METHOD**

Project Name: Passic-River - Preliminary Floodwall Design Calculated by: M.S.

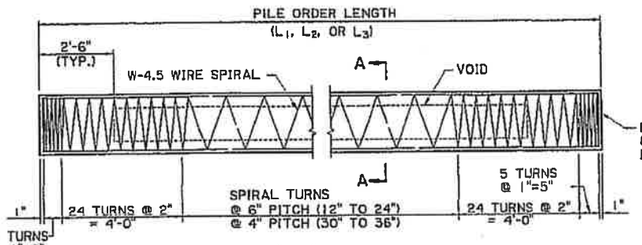
Project Number : Checked by:

Piles bearing on soil WEST OF KEARNY

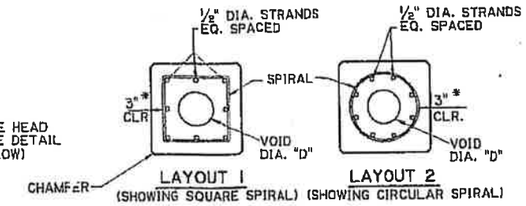
~~Depth to rock: 60 ft~~



FOS = 1.0

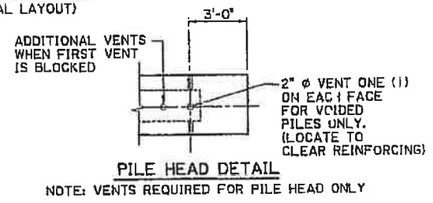


12"-24" ø SOLID
24", 30", 36" ø VOIDED
PRECAST-PRESTRESSED CONCRETE PILES
(FOR CIRCULAR AND SQUARE SPIRAL LAYOUT)



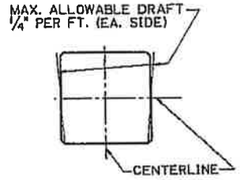
SECTION A-A

* 2" FOR 12" & 14" PILE SIZE

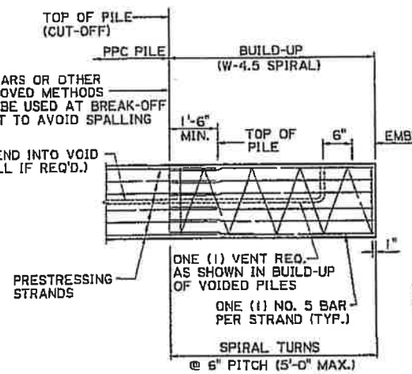


PILE HEAD DETAIL

NOTE: VENTS REQUIRED FOR PILE HEAD ONLY

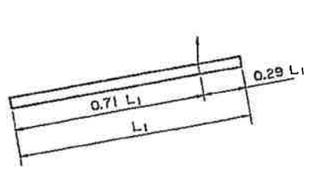


DRAFT DETAIL

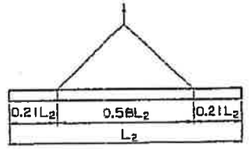


TYP. BUILD-UP WHERE
REDRIVING IS NOT REQUIRED

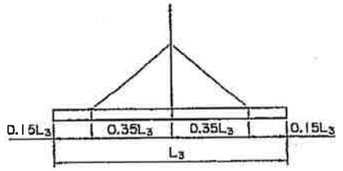
(FOR BUILD-UP IN EXCESS OF 5'-0"
SUBMIT DESIGN AND DETAILS FOR APPROVAL)



1-POINT PICK-UP



2-POINT PICK-UP



3-POINT PICK-UP

PICK-UP DETAILS

GENERAL NOTES

CONCRETE: THE CONTRACTOR SHALL DESIGN AND SUBMIT FOR APPROVAL A CONCRETE MIX WITH MINIMUM COMPRESSIVE CYLINDER STRENGTH OF 6000 psi AT 28 DAYS. CONCRETE STRENGTH AT THE TIME OF TRANSFER OF PRESTRESSED FORCE SHALL BE 4000 psi OR GREATER. BUILD-UP CONCRETE SHALL BE THE SAME DESIGN AS THE PRESTRESS CONCRETE.

PRESTRESSING STEEL: PRETENSIONED REINFORCEMENT SHALL BE ½" DIA. SEVEN-WIRE, UNCOATED LOW-RELAXATION, GRADE 270 AND SHALL CONFORM TO THE REQUIREMENTS OF AASHTO M203. AN INITIAL TENSION OF 30,980 LBS. SHALL BE APPLIED TO EACH STRAND.

DEFORMED REINFORCING STEEL: REINFORCING STEEL SHALL BE DEFORMED BILLET STEEL BARS, GRADE 60 AND SHALL MEET THE REQUIREMENTS OF AASHTO M31.

SPIRAL REINFORCING STEEL: SPIRAL REINFORCEMENT SHALL BE SIZE W-4.5 COLD-DRAWN STEEL WIRE AND SHALL CONFORM TO AASHTO M 32M.

FABRICATION TOLERANCES: MANUFACTURE OF THE PILING AND FABRICATION TOLERANCES SHALL BE IN ACCORDANCE WITH THE "MANUAL FOR QUALITY CONTROL FOR PLANTS AND PRODUCTION OF STRUCTURAL PRECAST CONCRETE PRODUCTS (MNL-116, LATEST EDITION)" PUBLISHED BY PCI.

CHAMFERS AND CORNERS: ON PILES 18" ø OR SMALLER, ALL EXPOSED CONCRETE CORNERS ARE TO HAVE ¾" CHAMFERS. ON PILES 20" ø OR LARGER, ALL EXPOSED CONCRETE CORNERS ARE TO HAVE 1½" CHAMFERS. A 1" RADIUS CURVE WILL BE PERMITTED IN LIEU OF CHAMFERS SHOWN ABOVE. HOWEVER, ALL PILES FURNISHED SHALL BE OF THE SAME CONFIGURATION.

PICK-UP AND HANDLING: LOADING CRITERIA ARE BASED ON CAREFUL HANDLING OF THE PILE. ROTATION OF THE PILE IN THE SLING IS TO BE PREVENTED UNTIL THE PILE IS IN THE VERTICAL POSITION. PICK-UP POINTS FOR ALL PILES ARE TO BE CLEARLY MARKED ON PILES. SUPPORTS FOR STORAGE SHALL BE AT PICK-UP POINTS (FOR 1-POINT PICK-UP USE SUPPORT 0.29L_1 FROM EACH END). PILES WILL BE MADE AT A CENTRAL PLANT AND BE TRANSPORTED TO THE BRIDGE SITE. ALL PRESTRESSED PILING SHALL BE HELD AT THE PLANT FOR 14 DAYS AFTER CASTING, PROVIDING THE COMPRESSIVE STRENGTH OF 6000 psi HAS BEEN ATTAINED. PICK-UP POINTS SHOWN MAY BE MODIFIED FOR TRANSPORTATION PURPOSES, PROVIDED THE PILE STRESSES ARE IN ACCORDANCE WITH DESIGN CRITERIA. THE MODIFIED PICK-UP POINTS SHALL BE SENT TO THE BRIDGE DESIGN ENGINEER FOR REVIEW.

DRIVING: PILES SHALL BE DRIVEN TO AT LEAST THE MINIMUM TIP ELEVATION AS SHOWN ON CONTRACT PLANS UNLESS OTHERWISE DIRECTED BY THE ENGINEER. PILES SHALL BE DRIVEN TO TOLERANCES SPECIFIED IN THE STANDARD SPECIFICATIONS.

PRESTRESS LOSSES: BASED ON "RECOMMENDATION FOR ESTIMATING PRESTRESSED LOSSES" PCI JOURNAL VOL. 20 JULY/AUGUST, 1975. PERCENT OF ULTIMATE SHRINKAGE EQUAL TO 31% AND 62% FOR 14 DAYS AND 90 DAYS RESPECTIVELY. PERCENT ULTIMATE CREEP EQUAL TO 26% AND 51% FOR 14 DAYS AND 90 DAYS RESPECTIVELY.

ALLOWABLE STRESSES: THE MAXIMUM LENGTHS FOR PICK-UP HAVE BEEN DETERMINED USING THE FOLLOWING ALLOWABLE STRESS (1998 AASHTO LRFD BRIDGE SPECS. 5.9.4.2.1, 5.9.4.1.2 & 5.13.4.4.3) AT BOTH 14 DAYS AND 90 DAYS.

ALLOWABLE TENSILE STRESS (psi): $5\sqrt{f'_c}$
ALLOWABLE COMPRESSIVE STRESS (psi): $0.45f'_c$
IMPACT FACTOR: 1.5
MIN. FINAL COMPRESSIVE STRESS: 725 psi

6000 psi

DETAILS THIS SHEET NOT TO SCALE

PILE INFORMATION

PILE SIZE (in.)	SECTION PROPERTIES					SQUARE SPIRAL LAYOUTS						CIRCULAR SPIRAL LAYOUTS					
	VOID "d" (in.)	AREA (in.²)	SECTION MODULUS OF (in.³x10³)	WEIGHT PER FOOT (lb/ft)	CHAMFER (in.)	NO. OF STRANDS	PRESTRESS IN CONCRETE (psi)		MAX. CASTING LENGTH (ft)			NO. OF STRANDS	PRESTRESS IN CONCRETE (psi)		MAX. CASTING LENGTH (ft)		
							AT RELEASE	AT 90 DAYS	L_1	L_2	L_3		AT RELEASE	AT 90 DAYS	L_1	L_2	L_3
12 SOLID	0	144	288	150	¾"	4	830	774	53.7	76.1	108.6	6	1227	1133	61.5	87.0	124.2
14 SOLID	0	196	457	204	¾"	8	1203	1116	66.0	93.4	133.4	8	1203	1116	66.0	93.4	133.4
16 SOLID	0	256	683	267	¾"	12	1373	1273	67.6	95.7	136.7	11	1264	1175	70.1	99.2	141.7
18 SOLID	0	324	972	338	¾"	12	1096	1026	72.6	102.7	146.7	13	1183	1106	74.6	105.6	150.8
20 SOLID	0	400	1333	417	1½"	16	1180	1106	78.7	111.3	159.0	16	1180	1106	78.7	111.3	159.0
24 SOLID	0	576	2304	600	1½"	24	1227	1154	86.7	122.7	175.2	24	1227	1154	86.7	122.7	175.2
24 VOIDED	10.5	489	2254	510	1½"	20	1204	1119	92.9	131.4	187.7	20	1204	1119	92.9	131.4	187.7
30 VOIDED	16.5	686	4257	715	1½"	28	1203	1120	107.8	152.6	217.9	28	1203	1120	107.8	152.6	217.9
36 VOIDED	22.5	898	7077	936	1½"	36	1182	1102	120.8	170.9	244.1	37	1213	1131	121.9	172.5	246.4

JENAH HAKHLEH
REG. No. 19592
REGISTERED
PROFESSIONAL ENGINEER
IN
CIVIL ENGINEERING
7/30/2003

SHEET NUMBER 130a
JEFFERSON | 61301(008) | 742-26-0030
DESIGNED A. ALLEN | CHECKED P. FOSSIER | DETAILED R. SCALLAN | CHECKED J. NAKHLEH | DATE 7-30-2003 | SHEET 19 OF 9
PRECAST-PRESTRESSED CONCRETE PILES
12, 14, 16, 18, 20 AND 24 INCH SOLID
24, 30 AND 36 INCH VOIDED
CLASS PMJ CONCRETE
BRIDGE AND STRUCTURAL DESIGN

$$ ---- SUBMITTAL STAGE ---- $$

FOUNDATION ANALYSIS

FOUNDATION ANALYSIS SUMMARY

The analysis was performed as needed to recommend a stable and economical pile-founded floodwall. Geotechnical data was limited to previous data. As such, for the East and West of Kearny typical floodwall reaches, foundations were developed for both a shallow bedrock and a deeper bedrock. Micro-Piles were selected were rock was shallow. A 10-foot anchor socket was used which developed sufficient tension capacity. Where bedrock was deep, deeper than 50 feet, an H-Pile was used. The deeper piles gained most of their capacity through friction, very little was attributed to end bearing. Multiple pile spacing's were considered. With limited geotechnical data, an acceptable design was considered achieved when at least 75% of the available soil capacity or 75% of the structural combined bending/axial capacity was reached. To assure redundancy, no less than two rows of four piles per row were considered for each 50-foot monolith. Pile capacities included a factor of safety equal to 2.0 for normal operational load cases. Pile foundations were checked considering the pile head to base connection as both fixed and pinned. Pile foundation analysis did not include down-drag, or instability forces. Down-drag would occur if the foundation design included a fill surcharge load. Instability would occur where the piles would experience lateral forces from a wedge failure (similar to soil nailing).

Reaches, short in length and at undetermined locations, may require special HTRW consideration. It was assumed that no excavation and drilling/coring of piles was permitted in these limited reaches. Floodwalls may be constructed on top of the existing ground surface. Driven piles provide bearing, sheet piling provides cutoff. Given the potential for increased corrosion, as is found in contaminated soils, the precast prestressed concrete (PPC) pile was recommended for bearing and vinyl sheet piling for cutoff. Where the soil properties are low to moderate in corrosion severity, H-piles and steel sheet piling are acceptable. L-Walls should also be considered if one of the lower top of wall elevations (El 12 or 14 feet NAVD) is selected in the final design. In that the L-Pile cutoff piling also acts as a bearing pile, the sheet piling must be steel. Vinyl is acceptable for piling acting purely as cutoff, but not when it is also providing support and subject to both axial and flexural stresses. In the final design, it is recommended that the rate of corrosion be established testing both the soil and extent of stray currents.

Limited space for floodwall construction along riverfront reaches required special consideration. There exists a footprint of approximately 15 feet in width between the river top of bank and industrial buildings. A narrow corridor for floodwall construction. Driving battered piles, standard practice for structures resisting lateral loads in soft soils, would be problematic. Piles battered towards the protected side could conflict with the building foundations. Battered Piles driven towards the river would need to be hung over the buildings during driving and would have reduced capacity given the close proximity to the slope. The solution provided is an all vertical pile foundation. The number of piles was increased to maintain the established criteria. Additionally, pile embedment was increased into the base to assure a fixed connection was established.

Passaic River
Tidal Flood Protection System

T-Wall Foundation Analysis

Note: All axial forces below are local forces in acting in the axis of the pile.

East of Kearny - Typical Monolith (Bedrock < 50')

Monolith	50 ft.	Pile	9.5" Micropile
Top of Wall	EL 118	Pile Qty	10
Top of Slab	EL 106	F/S Batter	3 : 1
SWL	EL 116	P/S Batter	3 : 1

LC	Load Case Description	Axial Load, Tension (kip)	Axial Load, Compression (kip)
1	Construction	0.0	46.7
2	Construction + Wind on F.S.	0.0	51.9
3	Water to SWL, Impervious	32.0	105.9
4	Water to SWL, Pervious	29.3	103.1
5	Water to SWL + Debris Load, Impervious	42.6	116.4
6	Water to T.O. Wall, Impervious	57.8	132.9
7	Water to T.O. Wall, Pervious	54.6	129.8

East of Kearny - Typical Monolith (Bedrock > 50')

Monolith	50 ft.	Pile	HP14x73
Top of Wall	EL 118	Pile Qty	10
Top of Slab	EL 106	F/S Batter	3 : 1
SWL	EL 116	P/S Batter	3 : 1

LC	Load Case Description	Axial Load, Tension (kip)	Axial Load, Compression (kip)
1	Construction	0.0	46.5
2	Construction + Wind on F.S.	0.0	50.9
3	Water to SWL, Impervious	32.6	106.5
4	Water to SWL, Pervious	30.4	104.2
5	Water to SWL + Debris Load, Impervious	42.6	116.4
6	Water to T.O. Wall, Impervious	58.3	133.4
7	Water to T.O. Wall, Pervious	55.7	130.9

West of Kearny - Typical Monolith (Bedrock < 50')

Monolith	50 ft.	Pile	9.5" Micropile
Top of Wall	EL 118	Pile Qty	10
Top of Slab	EL 106	F/S Batter	3 : 1
SWL	EL 116	P/S Batter	3 : 1

LC	Load Case Description	Axial Load, Tension (kip)	Axial Load, Compression (kip)
1	Construction	0.0	46.7
2	Construction + Wind on F.S.	0.0	51.9
3	Water to SWL, Impervious	32.0	105.9
4	Water to SWL, Pervious	29.3	103.1
5	Water to SWL + Debris Load, Impervious	42.6	116.4
6	Water to T.O. Wall, Impervious	57.8	132.9
7	Water to T.O. Wall, Pervious	54.6	129.8

West of Kearny - Typical Monolith (Bedrock > 50')

Monolith	50 ft.	Pile	HP14x73
Top of Wall	EL 118	Pile Qty	10
Top of Slab	EL 106	F/S Batter	3 : 1
SWL	EL 116	P/S Batter	3 : 1

LC	Load Case Description	Axial Load, Tension (kip)	Axial Load, Compression (kip)
1	Construction	0.0	46.5
2	Construction + Wind on F.S.	0.0	51.0
3	Water to SWL, Impervious	33.1	107.0
4	Water to SWL, Pervious	30.9	104.7
5	Water to SWL + Debris Load, Impervious	43.1	117.0
6	Water to T.O. Wall, Impervious	59.0	134.1
7	Water to T.O. Wall, Pervious	56.4	131.5

HTRW Sites - Typical Monolith (Bedrock > 50')

Monolith	50 ft.	Pile	12" PPC
Top of Wall	EL 118	Pile Qty	16
Top of Slab	EL 110.5	F/S Batter	3 : 1
SWL	EL 116	P/S Batter	3 : 1

LC	Load Case Description	Axial Load, Tension (kip)	Axial Load, Compression (kip)
1	Construction	0.0	24.4
2	Construction + Wind on F.S.	0.0	25.0
3	Water to SWL, Impervious	1.4	35.9
4	Water to SWL, Pervious	0.3	34.8
5	Water to SWL + Debris Load, Impervious	6.5	41.0
6	Water to T.O. Wall, Impervious	10.6	45.9
7	Water to T.O. Wall, Pervious	5.1	40.4

Water Front (Bedrock > 50')

Monolith	50 ft.	Pile	HP14x89
Top of Wall	EL 118	Pile Qty	20
Top of Slab	EL 106	F/S Batter	Vertical
SWL	EL 116	P/S Batter	Vertical

LC	Load Case Description	Axial Load, Tension (kip)	Axial Load, Compression (kip)
1	Construction	0.0	22.6
2	500yr SWL, Impervious	0.0	28.8
3	500yr SWL, Pervious	31.5	66.5
4	500yr SWL + 500 yr Wave, Impervious	29.4	64.5
5	500yr SWL + 100 yr Wave + Debris, Impervious	39.1	74.2
6	Water to T.O. Wall, Impervious	50.0	85.7
7	Water to T.O. Wall, Pervious	47.6	83.3

T-WALL

EAST OF KEARNY

USACE Passaic River Flood Protection

Feasibility Level Flood Protection

TYPICAL EAST OF KEARNY MONOLITH
TOW EL. 18; TOS EL 6.0

URS Project : 60442748

Monolith Foundations

1515 Poydras Street

Suite 2700

New Orleans, LA 70112

(504) 586-8111

Computed by: RBJ Checked by: _____

Date: Jan-16 Date: _____

AECOM

Job USACE Passaic River Flood Protection
Feasibility Level Flood Protection

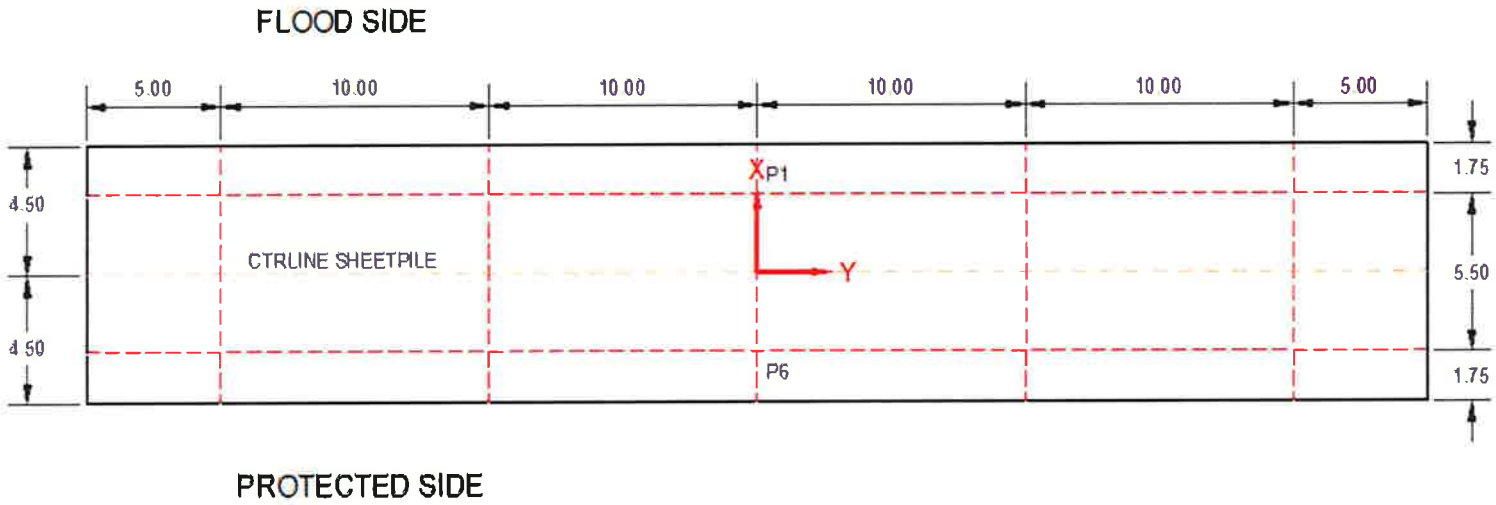
Description TYPICAL WEST OF KEARNY MONOLITH
TOW EL. 18; TOS EL 6.0
Monolith Foundation Layout & Axis

Project No. 60442748

Computed by RBJ Date Jan-16

Checked by 0 Date Jan-00

TOW EL. 18; TOS EL 6.0



AECOM

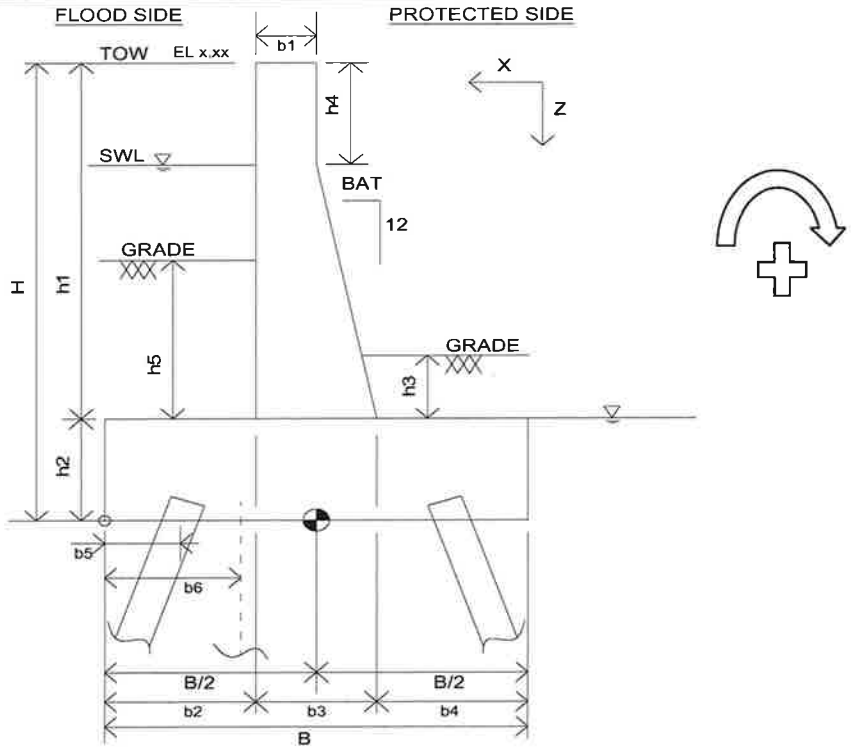
Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL EAST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00

References

LOAD CALCULATIONS

TOW EL. 18; TOS EL 6.0

Top of Wall EL.	18.0	NAVD88
Normal Water El.	6.0	NAVD88
Still Water El.	16.0	NAVD88
Top of Slab EL.	6.0	NAVD88
H=	15.0	ft.
h1=	12.0	ft.
h2=	36.0	in. (Base Slab Height)
h3=	12.0	in. (P.S. Soil Height)
h4=	0.0	ft.
h5=	1.00	ft. (F.S. Soil Height, **T.O. Slab**)
B=	9.0	ft. (Base Slab Width)
b1=	18.0	in. (Wall Stem Width, top)
b2=	66.0	in. (F.S. Slab Width)
b3=	18.0	in. (Wall Stem Width, bottom)
b4=	24.0	in. (P.S. Slab Width)
b5=	21.0	in. (F.S. Pile Row Edge Space)
b6=	54.0	in. (Sheet Pile Edge Space)
BAT=	0.0	(Wall Batter, N/A)
PS Grade =	7.00	NAVD88 (Average of PS soil for all)
Monolith Length	50.0	ft
Bottom Of Slab =	3.0	NAVD88



T-WALL CROSS-SECTION

Notes: 1) positive 'Y' axis is into page
2) pile batters vary from those show in diagram

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL EAST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
				References	

ASSUMED UNIT WEIGHTS:

Unit Weight of Storm Water:
62.4 pcf

Wet Unit Weight of Soil: 110 pcf

Unit Weight of Riprap: 0 pcf

Sat Unit Weight of Soil:
47.6 pcf

Unit Weight of Concrete
150 pcf

Unbalanced Load for Stability Analysis:

F_{cap} (k/ft) = 0.00 (Operation Case; Force acts at bottom of slab)

F_{cap} (k/ft) = 0.00 (Water to TOW Case; Force acts at bottom of slab)

K_0, Clay fill = 0.80 (for lateral soil forces)

EM 1110-2-2502: $P_{hz} = K_0 * (\gamma * z_w + \gamma' * (z - z_w))$

- PS design water elevation <BOS elevation, no PS uplift or PS hydrostatic loads

FS Wind force above SWL= 50.0 psf

Construction Surcharge Pressure = 200 psf

Wave Point Load = 0 kip/ft

Dist from B.O. Slab to Wave Load = 0 ft

	LOAD CASES ANALYZED:	FS Water El.	PS Water El.	Overstress for Design	Notes
1	Construction	6.0	7.0	1.17	Temporary Construction Case
2	Construction + Wind on F.S.	6.0	7.0	1.33	Unusual Construction Case
3	Water to SWL, Impervious	16.0	7.0	1.00	Still Water Level Flood, Impervious uplift
4	Water to SWL, Pervious	16.0	7.0	1.00	Still Water Level Flood, Pervious uplift
5	Water to SWL + Debris Load, Impervious	16.0	7.0	1.00	Still Water Level Flood, Impervious uplift
6	Water to T.O. Wall, Impervious	18.0	7.0	1.33	Flood, Impervious uplift
7	Water to T.O. Wall, Pervious	18.0	7.0	1.33	Flood, Pervious uplift

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL EAST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
				References	

All forces on this page are per foot of monolith length

Soil Forces:

Water EL.	FS Soil EL.	PS Soil EL.	Wt. of FS Soil (k/ft)	Wt. of PS Soil (k/ft)	FS Soil Lateral Force (k/ft)	PS Soil Lateral Force (k/ft)
7.0	7.00	7.00	**0.2618**	**0.220**	**-0.3046**	**0.7040**
16.0	7.00	7.00	**0.2618**	**0.220**	**-0.3046**	**0.7040**
18.0	7.00	7.00	**0.2618**	**0.220**	**-0.3046**	**0.7040**

Water Forces:

Water EL.	Wt. of FS Water (k/ft)	FS Water Lateral Force (k/ft)
7.0	**0.3432**	**-0.499**
16.0	**3.432**	**-5.273**
18.0	**4.1184**	**-7.020**

Wind Force: 50 psf * monolith height / 1000 = **-0.75 k/ft**

MDE Earthquake Force:

	Vertical (k-ft)	Lateral (k-ft)		
Soil		**0.127**	Z-coord = -2.67	
Concrete	**0.270**	**0.844**	Z-coord = -4.50	X-coord = -0.700

Surcharge Forces:

F.S. = 200 psf * F.S. width / 1000 = **1.1 k/ft**

P.S. = 200 psf * P.S. width / 1000 = **0.4 k/ft**

Unbalanced Load:

Operating: 0.000 k/ft in (+) X Direction, acting at bottom of slab (Z-coordinate = 0)

TOW: 0.000 k/ft in (+) X Direction, acting at bottom of slab (Z-coordinate = 0)

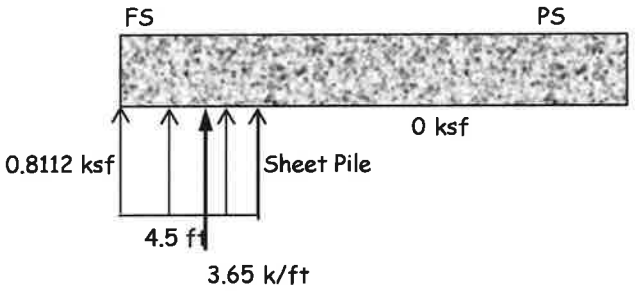
AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL EAST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
					References

Uplift Loads:

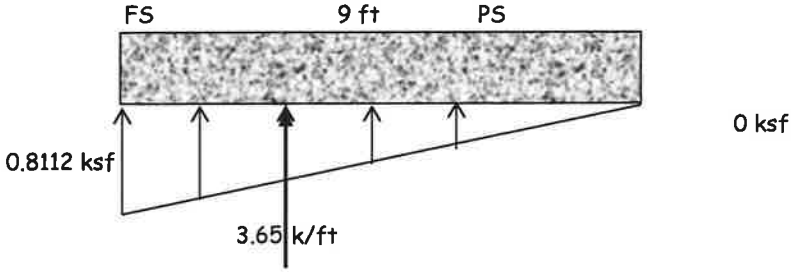
Water to SWL:

Impervious:



X-coordinate = 2.25

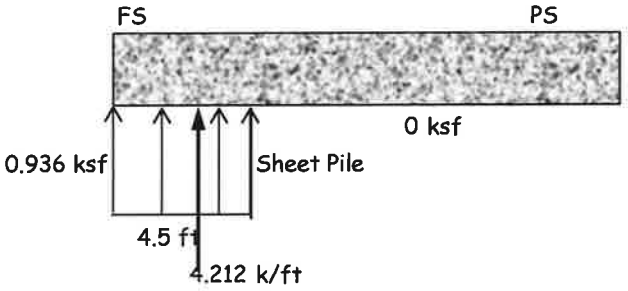
Pervious:



X-coordinate = 1.500

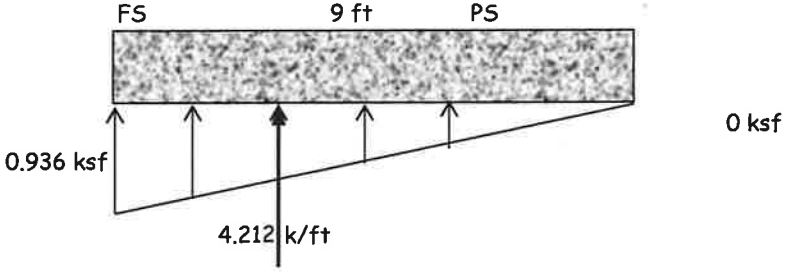
Water to TOW:

Impervious:



X-coordinate = 2.25

Pervious:



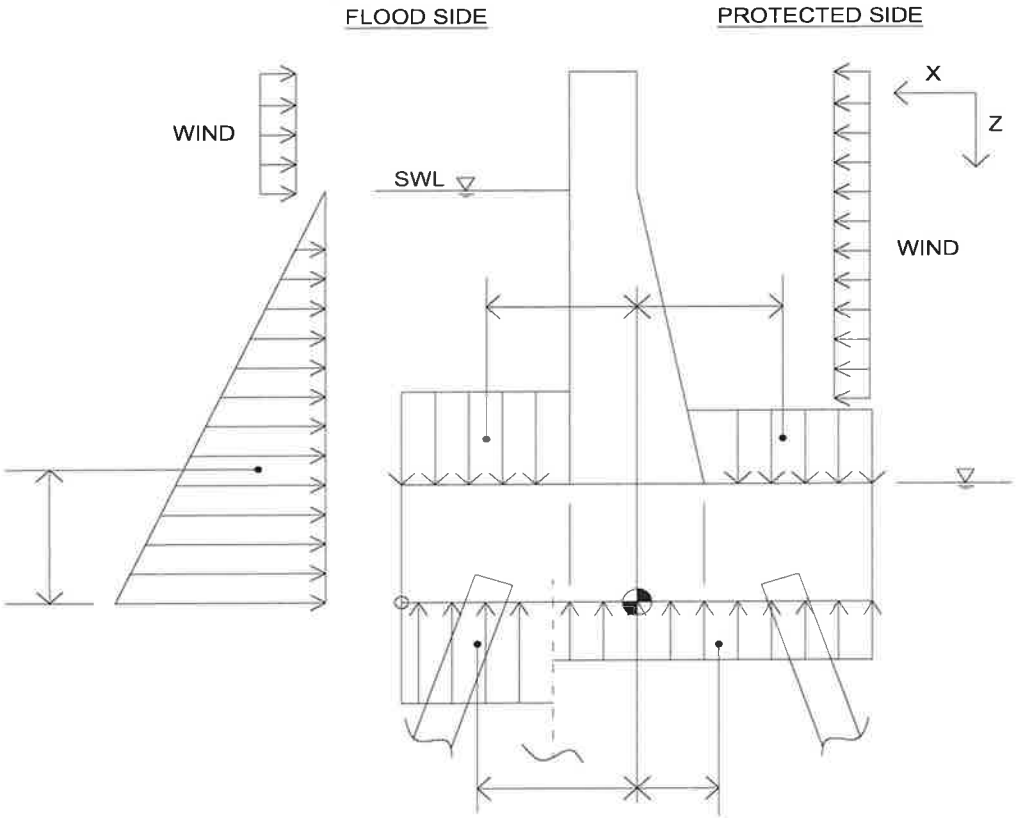
X-coordinate = 1.500

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL EAST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00

References

LOAD DIAGRAMS FOR IMPERVIOUS SHEET PILE CONDITIONS



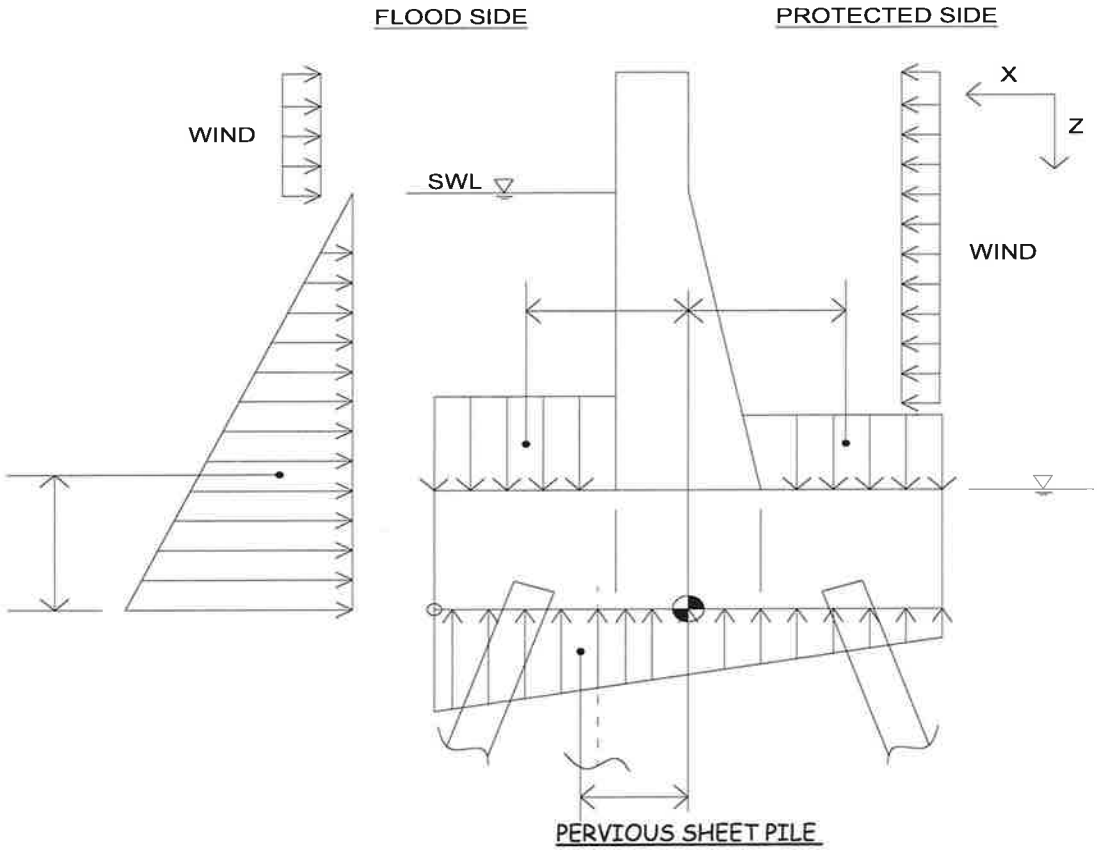
IMPERVIOUS SHEET PILE

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL EAST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00

References

LOAD DIAGRAMS FOR PERVIOUS SHEET PILE CONDITIONS



AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748
	Feasibility Level Flood Protection		
Description	TYPICAL EAST OF KEARNY MONOLITH	Computed by	RBJ
	TOW EL. 18; TOS EL 6.0	Date	Jan-16
	Foundation Load Cases & Combinations	Checked by	0
		Date	Jan-00
			References

LC 1: Construction, 1.17 allowable overstress								
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FOOT OF WALL LENGTH								
	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
		2.70	-1.75				4.73		wall stem weight
		4.05	0.00				0.00		base slab weight
		0.22	-3.50				0.77		P.S. soil weight
	0.70				-1.33		-0.94		P.S. lateral soil force
		0.26	1.75				-0.46		F.S. soil weight
	-0.30				-1.33		0.41		F.S. lateral soil force
	0.00				0.00		0.00		Unbalanced load, no water
Subtotal A	*0.40*	*7.23*				*0.00*	*4.50*	*0.00*	*Dry Soil Weight Subtotal*
		1.10	1.75				-1.93		F.S. Equipment Surcharge
		0.40	-3.50				1.40		P.S. Equipment Surcharge
SUM:	**0.40**	**8.73**				**0.00**	**3.98**	**0.00**	***LC 1 CPGA Forces***

LC 2: Construction + Wind on F.S., 1.33 allowable overstress								
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FOOT OF WALL LENGTH								
	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
		2.70	-1.75	0			4.73	0	wall stem weight
		4.050	0				0.00		base slab weight
	-0.75				-7.50	0	5.63	0	FS Wind Load
SUM:	**-0.75**	**6.75**				**0.00**	**10.35**	**0.00**	***LC 2 CPGA Forces***

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL EAST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00

References

LC 3: Water to SWL, Impervious, 1.0 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FOOT OF WALL LENGTH									
	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
		2.70	-1.75				4.73		wall stem weight
		4.05	0.00				0.00		base slab weight
		0.22	-3.50				0.77		P.S. soil weight
	0.70				-1.33		-0.94		P.S. lateral soil force
		0.26	1.75				-0.46		F.S. soil weight, saturated
	-0.30				-1.33		0.41		F.S. lateral soil force, saturated
	-5.27				-4.33		22.85		Lateral water force
		3.43	1.75				-6.01		Vertical water force
	0.00				0		0.00		Unbalanced load, water TOW
Subtotal B	*-4.87*	*10.66*				*0.00*	*21.35*	*0.00*	*SWL Subtotal*
		-3.65	2.25				8.21		Impervious FS hydrostatic uplift
		0.00					0.00		Impervious PS hydrostatic uplift
SUM:	**-4.87**	**7.01**				**0.00**	**29.56**	**0.00**	**LC 3 CPGA Forces**

LC 4: Water to SWL, Pervious, 1 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FOOT OF WALL LENGTH									
	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
Subtotal B	*-4.87*	*10.66*				*0.00*	*21.35*	*0.00*	*SWL Subtotal*
		-3.65	1.500				5.48		Pervious hydrostatic uplift
SUM:	**-4.87**	**7.01**				**0.00**	**26.82**	**0.00**	**LC 4 CPGA Forces**

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL EAST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00

References

LC 5: Water to SWL + Debris Load, Impervious, 1.0 allowable overstress								
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FT. OF WALL								
	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
Subtotal B	*-4.87*	*10.66*				*0.00*	*21.35*	*0.00*	*SWL Subtotal*
		-3.65	2.25				8.21		Impervious FS hydrostatic uplift
		0.00					0.00		Impervious PS hydrostatic uplift
	-0.50				-13.00		6.50		Debris Load
SUM:	**-5.37**	**7.01**				**0.00**	**36.06**	**0.00**	**LC 5 CPGA Forces**

LC 6: Water to T.O. Wall, Impervious, 1.33 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FT. OF WALL									
S NO.	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
		2.70	-1.75				4.73		wall stem weight
		4.05	0.00				0.00		base slab weight
		0.22	-3.50				0.77		P.S. soil weight
	0.70				-1.33		-0.94		P.S. lateral soil force
		0.26	1.75				-0.46		F.S. soil weight, saturated
	-0.30				-1.33		0.41		F.S. lateral soil force, saturated
	-7.02				-5.00		35.10		Lateral water force
		4.12	1.75				-7.21		Vertical water force
	0.00				0		0.00		Unbalanced load, water TOW
Subtotal B	*-6.62*	*11.35*				*0.00*	*32.40*	*0.00*	*TOW Subtotal*
		-4.21	2.25				9.48		Impervious FS hydrostatic uplift
		0.00					0.00		Impervious PS hydrostatic uplift
SUM:	**-6.62**	**7.14**				**0.00**	**41.87**	**0.00**	**LC 6 CPGA Forces**

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL EAST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
				References	

LC 7: Water to T.O. Wall, Pervious, 1.33 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FT. OF WALL									
S NO.	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
Subtotal B	-6.62	11.35				0.00	32.40	0.00	*TOW Subtotal*
		-4.21	1.500				6.32		Pervious hydrostatic uplift
SUM:	**-6.62**	**7.14**				**0.00**	**38.72**	**0.00**	**LC 7 CPGA Forces**

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL EAST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
				References	

Summary of Forces and Moments (For Full Length of Monolith):

LOAD CASE NUMBER	Fx	Fy	Fz	Mx	My	Mz
	kips	kips	kips	(kip-ft)	(kip-ft)	(kip-ft)
1	20.0	0.0	436.6	0.0	199.0	0.0
2	-37.5	0.0	337.5	0.0	517.5	0.0
3	-243.7	0.0	350.7	0.0	1478.0	0.0
4	-243.7	0.0	350.7	0.0	1341.1	0.0
5	-268.7	0.0	350.7	0.0	1803.0	0.0
6	-331.0	0.0	356.9	0.0	2093.7	0.0
7	-331.0	0.0	356.9	0.0	1935.8	0.0

AECOM

Job USACE Passaic River Flood Protection
Feasibility Level Flood Protection

Project No. 60442748

Description TYPICAL EAST OF KEARNY MONOLITH
TOW EL. 18; TOS EL 6.0
Soil & Pile Information Required for CPGA

Computed by RBJ Date Jan-16

Checked by 0 Date Jan-00

References

Pile Layout, SW-11:

Row 1			Row 2		
pile no.	x	y	pile no.	x	y
1	2.25	-20.00	6	-2.25	-20.00
2	2.25	-10.00	7	-2.25	-10.00
3	2.25	0.00	8	-2.25	0.00
4	2.25	10.00	9	-2.25	10.00
5	2.25	20.00	10	-2.25	20.00

Tip Elevation:

(For CPGA, need Tip Elevation as a function of CPGA Axis at B.O. Slab, +Z points downward)

B.O.S. Elevation = 4 NAVD88 * Socketed 12' min into bedrock
Bedrock EL = -45 NAVD89
"TIP" in CPGA = 61 ft

Pile Properties & Attributes: (See hand calculations for micropiles)

E_s = 3,605,000 psi
A = 181 in^2
$I_x = I_y$ = 1534 in^4
C_{33} = 1.2 (factor for method of axial load transfer from pile to soil; = 1 for full tip bearing, = 2 for full skin friction)

Allowable Compression (AC) = 160 kips
Allowable Tension (AT) = 100 kips
PO = 1597 kips
PT = 1010 kips
PB = 550 kips
MB = 2825 kip-in
MO = 2200 kip-in

Es Value for CPGA Run:

Monolith width = 50 ft
N_h = 30 pci = 0.03

GROUP FACTORS	
Pile Spacing in Direction of Loading	From EM1110-2-2906
	D
3B	0.33
4B	0.38
5B	0.45
6B	0.56
7B	0.71
8B	1

Group reduction is based on distance between piles in direction of loading. This includes distance due to battering and is taken over the distance 10*d_{pile} (point of fixety).

Assume a batter of 3
B = d_{pile} = 9.63 in = 0.803 ft

Distance between piles at B.O. Slab = 4.50 ft
Average distance between piles over 10*dpile = 9.85 ft

Average distance between piles in terms of pile width B = 12.274 B

Group Reduction "D" value for this distance = 1

Therefore, Es including group reduction = 0.0300 kci

AECOM

Job	USACE Passaic River Flood Protection		Project No.	60442748	
	Feasibility Level Flood Protection				
Description	TYPICAL EAST OF KEARNY MONOLITH		Computed by	RBJ	Date Jan-16
	TOW EL. 18; TOS EL 6.0				
	CPGA Input & Output Files		Checked by	0	Date Jan-00

TOM EL18, H-pile 10' O.C.

Input file:

```
100 EAST OF KEARNY, TOW EL18, FIX, 1:3 BATTER, HP14x73, 10'OC
200 PROP 29000 261 729 26.1 1.7 0 ALL
300 SOIL ES 0.03 TIP 60 0 ALL
400 FIX ALL
500 ALLOW H 200 53 535 498 895 2675 ALL
600 FOVSTR 1.17 1.17 1
700 FOVSTR 1.33 1.33 2 6 7
1000 BATTER 3 ALL
1100 ANGLE 180 6 TO 10
1200 PILE 1 2.5 -20 0
1300 PILE 6 -2.5 -20 0
1400 ROW Y 5 1 4 AT 10
1500 ROW Y 5 6 4 AT 10
4500 LOAD 1 20 0 436.6 0 199 0
4600 LOAD 2 -37.5 0 337.5 0 517.5 0
4700 LOAD 3 -243.7 0 350.7 0 1478 0
4800 LOAD 4 -243.7 0 350.7 0 1341 0
4900 LOAD 5 -268.7 0 350.7 0 1803 0
5000 LOAD 6 -331 0 356.9 0 2094 0
5100 LOAD 7 -331 0 356.9 0 1936 0
6000 FOUT 1 2 3 4 5 6 7 EL18HP10.doc
6100 PFO ALL
6200 PLB ALL
```

T-WALL

WEST OF KEARNY

USACE Passaic River Flood Protection

Feasibility Level Flood Protection

TYPICAL WEST OF KEARNY MONOLITH
TOW EL. 18; TOS EL 6.0

URS Project : 60442748

Monolith Foundations

1515 Poydras Street

Suite 2700

New Orleans, LA 70112

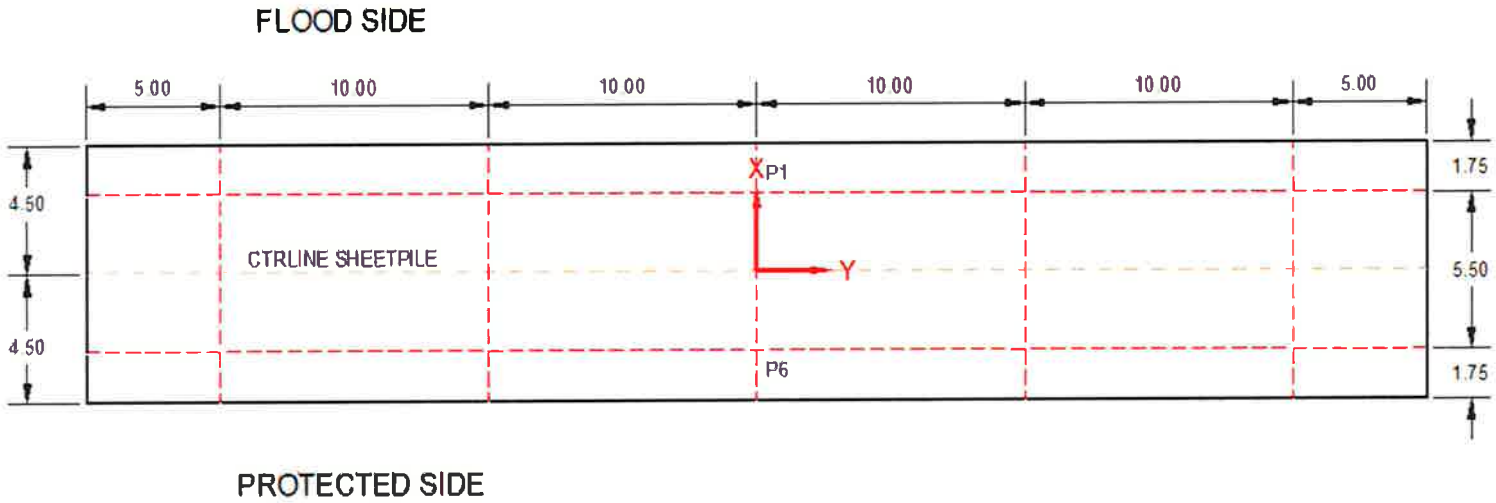
(504) 586-8111

Computed by:	RBJ	Checked by:	
Date:	Jan-16	Date:	

AECOM

Job	USACE Passaic River Flood Protection Feasibility Level Flood Protection	Project No.	60442748
Description	TYPICAL WEST OF KEARNY MONOLITH TOW EL. 18; TOS EL 6.0 Monolith Foundation Layout & Axis	Computed by	RBJ
		Date	Jan-16
		Checked by	0
		Date	Jan-00

TOW EL. 18; TOS EL 6.0



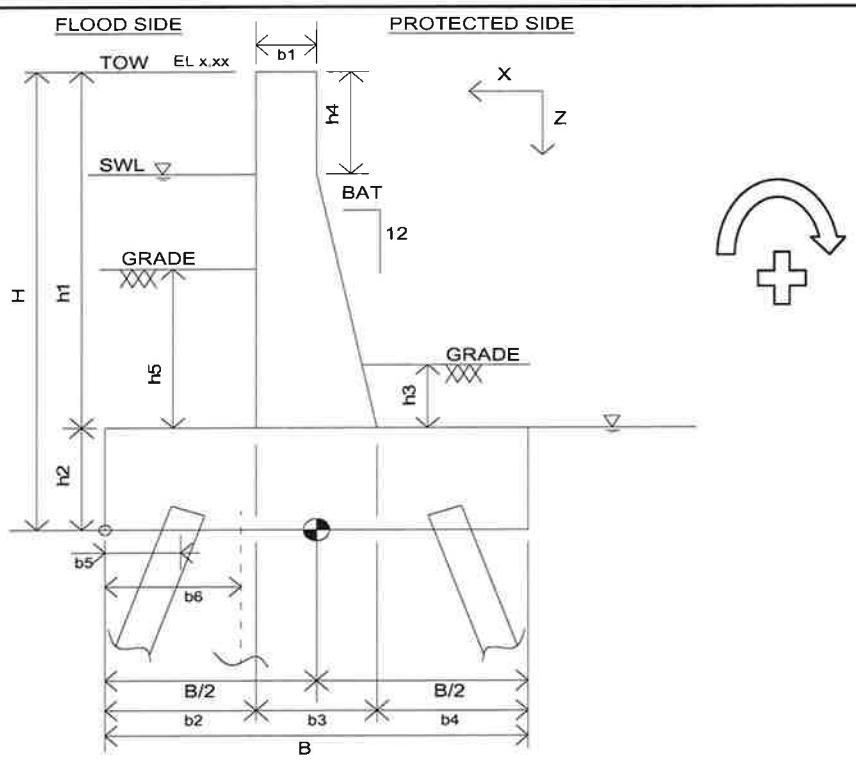
AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL WEST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
				References	

LOAD CALCULATIONS

TOW EL. 18; TOS EL 6.0

Top of Wall EL.	18.0	NAVD88
Normal Water El.	6.0	NAVD88
Still Water El.	16.0	NAVD88
Top of Slab EL.	6.0	NAVD88
H=	15.0	ft.
h1=	12.0	ft.
h2=	36.0	in. (Base Slab Height)
h3=	12.0	in. (P.S. Soil Height)
h4=	0.0	ft.
h5=	1.00	ft. (F.S. Soil Height, **T.O. Slab**)
B=	9.0	ft. (Base Slab Width)
b1=	18.0	in. (Wall Stem Width, top)
b2=	66.0	in. (F.S. Slab Width)
b3=	18.0	in. (Wall Stem Width, bottom)
b4=	24.0	in. (P.S. Slab Width)
b5=	21.0	in. (F.S. Pile Row Edge Space)
b6=	54.0	in. (Sheet Pile Edge Space)
BAT=	0.0	(Wall Batter, N/A)
PS Grade =	7.00	NAVD88 (Average of PS soil for all)
Monolith Length	50.0	ft
Bottom Of Slab =	3.0	NAVD88



T-WALL CROSS-SECTION

Notes: 1) positive 'Y' axis is into page
2) pile batters vary from those show in diagram

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL WEST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
				References	

ASSUMED UNIT WEIGHTS:

Unit Weight of Storm Water:
62.4 pcf

Wet Unit Weight of Soil: 100 pcf

Unit Weight of Riprap: 0 pcf

Sat Unit Weight of Soil:
37.6 pcf

Unit Weight of Concrete
150 pcf

Unbalanced Load for Stability Analysis:

F_{cap} (k/ft) = 0.00 (Operation Case; Force acts at bottom of slab)

F_{cap} (k/ft) = 0.00 (Water to TOW Case; Force acts at bottom of slab)

K_0, Clay fill = 0.80 (for lateral soil forces)

EM 1110-2-2502: $P_{hz} = K_0 * (\gamma * z_w + \gamma' * (z - z_w))$

- PS design water elevation <BOS elevation, no PS uplift or PS hydrostatic loads

FS Wind force above SWL= 50.0 psf

Construction Surcharge Pressure = 250 psf

Wave Point Load = 0 kip/ft

Dist from B.O. Slab to Wave Load = 0 ft

	LOAD CASES ANALYZED:	FS Water El.	PS Water El.	Overstress for Design	Notes
1	Construction	3.0	3.0	1.17	Temporary Construction Case
2	Construction + Wind on F.S.	3.0	3.0	1.33	Unusual Construction Case
3	Water to SWL, Impervious	16.0	6.0	1.00	Still Water Level Flood, Impervious uplift
4	Water to SWL, Pervious	16.0	6.0	1.00	Still Water Level Flood, Pervious uplift
5	Water to SWL + Debris Load, Impervious	16.0	6.0	1.00	Still Water Level Flood, Impervious uplift
6	Water to T.O. Wall, Impervious	18.0	6.0	1.33	TOW Flood, Impervious uplift
7	Water to T.O. Wall, Pervious	18.0	6.0	1.33	TOW Flood, Pervious uplift

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL WEST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
					References

All forces on this page are per foot of monolith length

Soil Forces:

Water EL.	FS Soil EL.	PS Soil EL.	Wt. of FS Soil (k/ft)	Wt. of PS Soil (k/ft)	FS Soil Lateral Force (k/ft)	PS Soil Lateral Force (k/ft)
7.0	7.00	7.00	**0.2068**	**0.200**	**-0.2406**	**0.6400**
16.0	7.00	7.00	**0.2068**	**0.200**	**-0.2406**	**0.6400**
18.0	7.00	7.00	**0.2068**	**0.200**	**-0.2406**	**0.6400**

Water Forces:

Water EL.	Wt. of FS Water (k/ft)	FS Water Lateral Force (k/ft)
7.0	**0.3432**	**-0.499**
16.0	**3.432**	**-5.273**
18.0	**4.1184**	**-7.020**

Wind Force: 50 psf * monolith height / 1000 = **-0.75 k/ft**

MDE Earthquake Force:

	Vertical (k-ft)	Lateral (k-ft)		
Soil		**0.116**	Z-coord = -2.67	
Concrete	**0.270**	**0.844**	Z-coord = -4.50	X-coord = -0.700

Surcharge Forces:

F.S. = 250 psf * F.S. width / 1000 = **1.375 k/ft**

P.S. = 250 psf * P.S. width / 1000 = **0.5 k/ft**

Unbalanced Load:

Operating: 0.000 k/ft in (+) X Direction, acting at bottom of slab (Z-coordinate = 0)

TOW: 0.000 k/ft in (+) X Direction, acting at bottom of slab (Z-coordinate = 0)

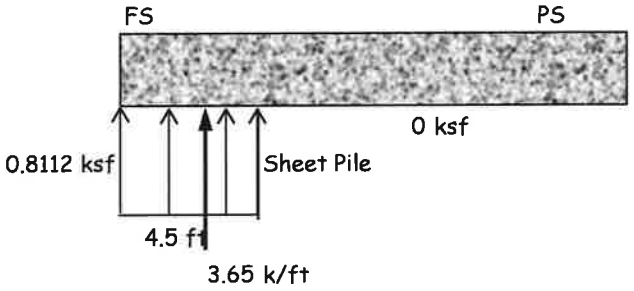
AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL WEST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
				References	

Uplift Loads:

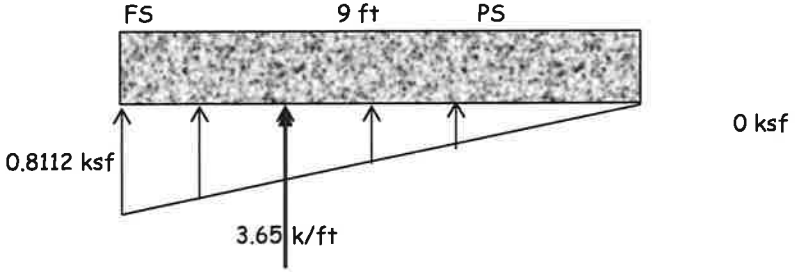
Water to SWL:

Impervious:



X-coordinate = 2.25

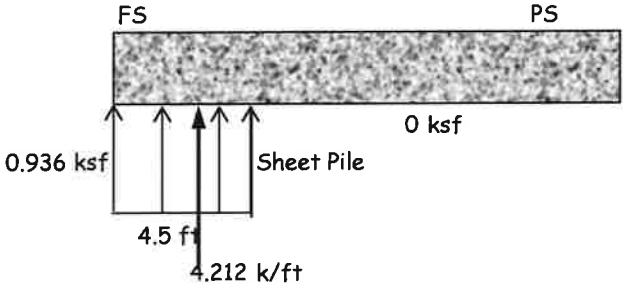
Pervious:



X-coordinate = 1.500

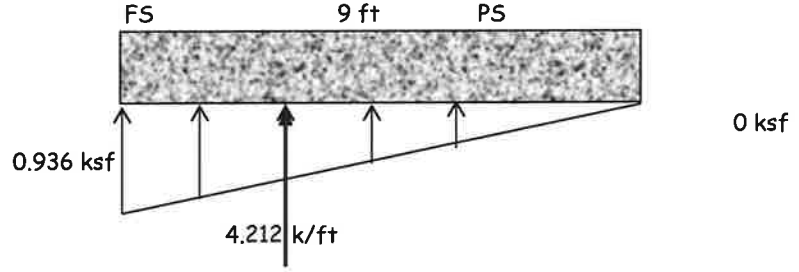
Water to TOW:

Impervious:



X-coordinate = 2.25

Pervious:



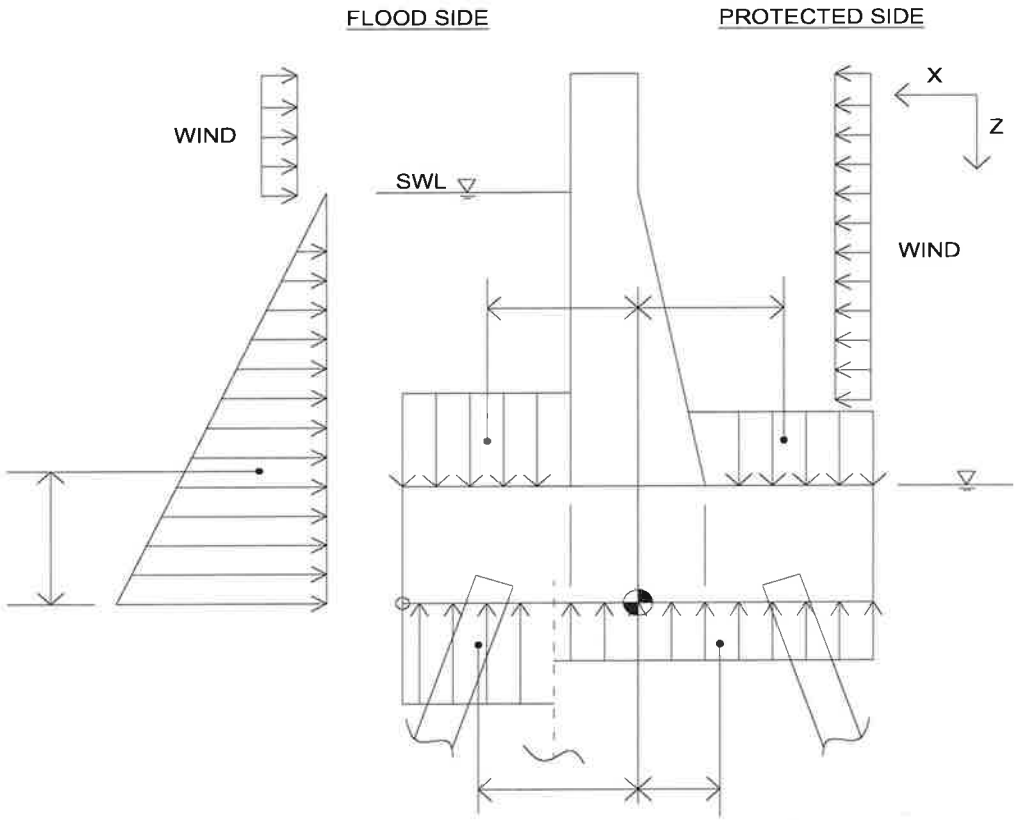
X-coordinate = 1.500

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL WEST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00

References

LOAD DIAGRAMS FOR IMPERVIOUS SHEET PILE CONDITIONS

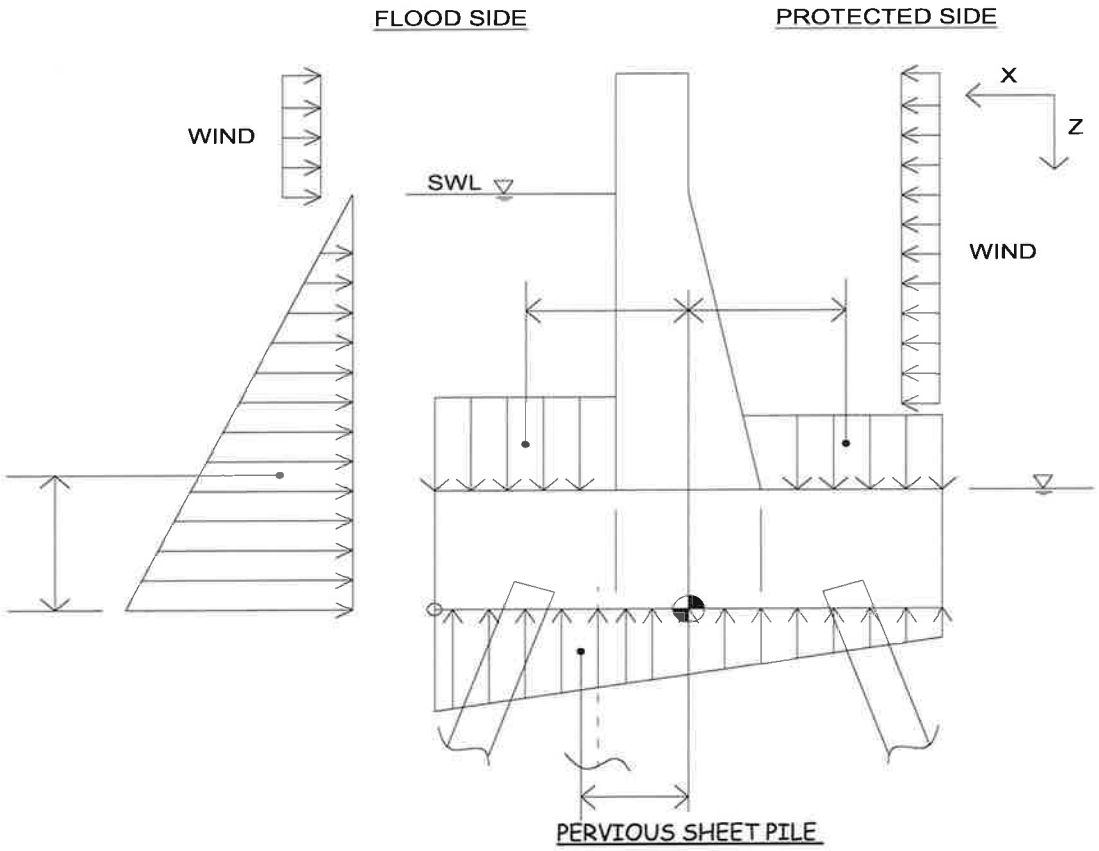


IMPERVIOUS SHEET PILE

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL WEST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
					References

LOAD DIAGRAMS FOR PERVIOUS SHEET PILE CONDITIONS



AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL WEST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00

References

LC 1: Construction, 1.17 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FOOT OF WALL LENGTH									
	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
		2.70	-1.75				4.73		wall stem weight
		4.05	0.00				0.00		base slab weight
		0.20	-3.50				0.70		P.S. soil weight
	0.64				-1.33		-0.85		P.S. lateral soil force
		0.21	1.75				-0.36		F.S. soil weight
	-0.24				-1.33		0.32		F.S. lateral soil force
	0.00				0.00		0.00		Unbalanced load, no water
Subtotal A	*0.40*	*7.16*				*0.00*	*4.53*	*0.00*	*Dry Soil Weight Subtotal*
		1.38	1.75				-2.41		F.S. Equipment Surcharge
		0.50	-3.50				1.75		P.S. Equipment Surcharge
SUM:	**0.40**	**9.03**				**0.00**	**3.87**	**0.00**	**LC 1 CPGA Forces**

LC 2: Construction + Wind on F.S., 1.33 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FOOT OF WALL LENGTH									
	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
		2.70	-1.75	0			4.73	0	wall stem weight
		4.050	0				0.00		base slab weight
	-0.75				-7.50	0	5.63	0	FS Wind Load
SUM:	**-0.75**	**6.75**				**0.00**	**10.35**	**0.00**	**LC 2 CPGA Forces**

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL WEST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00

References

LC 3: Water to SWL, Impervious, 1.0 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FOOT OF WALL LENGTH									
	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
		2.70	-1.75				4.73		wall stem weight
		4.05	0.00				0.00		base slab weight
		0.20	-3.50				0.70		P.S. soil weight
	0.64				-1.33		-0.85		P.S. lateral soil force
		0.21	1.75				-0.36		F.S. soil weight, saturated
	-0.24				-1.33		0.32		F.S. lateral soil force, saturated
	-5.27				-4.33		22.85		Lateral water force
		3.43	1.75				-6.01		Vertical water force
	0.00				0		0.00		Unbalanced load, water TOW
Subtotal B	*-4.87*	*10.59*				*0.00*	*21.37*	*0.00*	*SWL Subtotal*
		-3.65	2.25				8.21		Impervious FS hydrostatic uplift
		0.00					0.00		Impervious PS hydrostatic uplift
SUM:	**-4.87**	**6.94**				**0.00**	**29.59**	**0.00**	**LC 3 CPGA Forces**

LC 4: Water to SWL, Pervious, 1 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FOOT OF WALL LENGTH									
	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
Subtotal B	*-4.87*	*10.59*				*0.00*	*21.37*	*0.00*	*SWL Subtotal*
		-3.65	1.500				5.48		Pervious hydrostatic uplift
SUM:	**-4.87**	**6.94**				**0.00**	**26.85**	**0.00**	**LC 4 CPGA Forces**

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL WEST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00

References

LC 5: Water to SWL + Debris Load, Impervious, 1.0 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FT. OF WALL									
	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
Subtotal B	*-4.87*	*10.59*				*0.00*	*21.37*	*0.00*	*SWL Subtotal*
		-3.65	2.25				8.21		Impervious FS hydrostatic uplift
		0.00					0.00		Impervious PS hydrostatic uplift
	-0.50				-13.00		6.50		Debris Load
SUM:	**-5.37**	**6.94**				**0.00**	**36.09**	**0.00**	**LC 5 CPGA Forces**

LC 6: Water to T.O. Wall, Impervious, 1.33 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FT. OF WALL									
S NO.	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
		2.70	-1.75				4.73		wall stem weight
		4.05	0.00				0.00		base slab weight
		0.20	-3.50				0.70		P.S. soil weight
	0.64				-1.33		-0.85		P.S. lateral soil force
		0.21	1.75				-0.36		F.S. soil weight, saturated
	-0.24				-1.33		0.32		F.S. lateral soil force, saturated
	-7.02				-5.00		35.10		Lateral water force
		4.12	1.75				-7.21		Vertical water force
	0.00				0		0.00		Unbalanced load, water TOW
Subtotal B	*-6.62*	*11.28*				*0.00*	*32.42*	*0.00*	*TOW Subtotal*
		-4.21	2.25				9.48		Impervious FS hydrostatic uplift
		0.00					0.00		Impervious PS hydrostatic uplift
SUM:	**-6.62**	**7.06**				**0.00**	**41.90**	**0.00**	**LC 6 CPGA Forces**

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL WEST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
				References	

LC 7: Water to T.O. Wall, Pervious, 1.33 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FT. OF WALL									
S NO.	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
Subtotal B	-6.62	11.28				0.00	32.42	0.00	*TOW Subtotal*
		-4.21	1.500				6.32		Pervious hydrostatic uplift
SUM:	**-6.62**	**7.06**				**0.00**	**38.74**	**0.00**	**LC 7 CPGA Forces**

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL WEST OF KEARNY MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
					References

Summary of Forces and Moments (For Full Length of Monolith):

LOAD CASE NUMBER	Fx	Fy	Fz	Mx	My	Mz	
	kips	kips	kips	(kip-ft)	(kip-ft)	(kip-ft)	
1	20.0	0.0	451.6	0.0	193.7	0.0	Temporary Construction Case
2	-37.5	0.0	337.5	0.0	517.5	0.0	Unusual Construction Case
3	-243.7	0.0	346.9	0.0	1479.3	0.0	Still Water Level Flood, Impervious uplift
4	-243.7	0.0	346.9	0.0	1342.4	0.0	Still Water Level Flood, Pervious uplift
5	-268.7	0.0	346.9	0.0	1804.3	0.0	Still Water Level Flood, Impervious uplift
6	-331.0	0.0	353.2	0.0	2095.0	0.0	TOW Flood, Impervious uplift
7	-331.0	0.0	353.2	0.0	1937.1	0.0	TOW Flood, Pervious uplift

AECOM

Job USACE Passaic River Flood Protection
Feasibility Level Flood Protection

Project No. 60442748

Description TYPICAL WEST OF KEARNY MONOLITH
TOW EL. 18; TOS EL 6.0

Computed by RBJ

Checked by 0

Soil & Pile Information Required for CPGA

Date Jan-16

Date Jan-00

References

Pile Layout, SW-11:

Row 1			Row 2		
pile no.	x	y	pile no.	x	y
1	2.25	-20.00	6	-2.25	-20.00
2	2.25	-10.00	7	-2.25	-10.00
3	2.25	0.00	8	-2.25	0.00
4	2.25	10.00	9	-2.25	10.00
5	2.25	20.00	10	-2.25	20.00

Tip Elevation: (For CPGA, need Tip Elevation as a function of CPGA Axis at B.O. Slab, +Z points downward)

B.O.S. Elevation = 4 NAVD88 * Socketed 12' min into bedrock

Bedrock EL = -45 NAVD89

"TIP" in CPGA = 61 ft

Pile Properties & Attributes: (See hand calculations for micropiles)

E_s = 3,605,000 psi

A = 181 in^2

$I_x = I_y$ = 1534 in^4

C_{33} = 1.2 (factor for method of axial load transfer from pile to soil; = 1 for full tip bearing, = 2 for full skin friction)

Allowable Compression (AC) = 160 kips

Allowable Tension (AT) = 100 kips

PO = 1597 kips

PT = 1010 kips

PB = 550 kips

MB = 2825 kip-in

MO = 2200 kip-in

Es Value for CPGA Run:

Monolith width = 50 ft

N_h = 30 pci = 0.03

GROUP FACTORS	
Pile Spacing in Direction of Loading	From EM1110-2-2906
	D
3B	0.33
4B	0.38
5B	0.45
6B	0.56
7B	0.71
8B	1

Group reduction is based on distance between piles in direction of loading. This includes distance due to battering and is taken over the distance $10*d_{pile}$ (point of fixety).

Assume a batter of 3

$B = d_{pile}$ = 9.63 in = 0.803 ft

Distance between piles at B.O. Slab = 4.50 ft

Average distance between piles over 10*dpile = 9.85 ft

Average distance between piles in terms of pile width B = 12.274 B

Group Reduction "D" value for this distance = 1

Therefore, Es including group reduction = 0.0300 kci

AECOM

Job	USACE Passaic River Flood Protection		Project No.	60442748	
	Feasibility Level Flood Protection				
Description	TYPICAL WEST OF KEARNY MONOLITH		Computed by	RBJ	Date Jan-16
	TOW EL. 18; TOS EL 6.0				
	CPGA Input & Output Files		Checked by	0	Date Jan-00

TOM EL18, Micropile 5' O.C.

Input file:

```
100 WEST OF KEARNY, TOW EL18, FIX, 1:3 BATTER, MICROPILE, 5'OC
200 PROP 3605 1534 1534 181 1.2 0 ALL
300 SOIL ES 0.03 TIP 60 0 ALL
400 FIX ALL
500 TENSION 0.8 ALL
600 DLS R 160 100 1597 1010 550 2825 2200 H 15.18 ALL
700 FOVSTR 1.17 1.17 1
800 FOVSTR 1.33 1.33 2 6 7
1000 BATTER 3 ALL
1100 ANGLE 180 11 TO 20
1200 PILE 1 2.5 -22.5 0
1300 PILE 11 -2.5 -22.5 0
1400 ROW Y 10 1 9 AT 5
1500 ROW Y 10 11 9 AT 5
4500 LOAD 1 20 0 436.6 0 199 0
4600 LOAD 2 -37.5 0 337.5 0 517.5 0
4700 LOAD 3 -243.7 0 350.7 0 1478 0
4800 LOAD 4 -243.7 0 350.7 0 1341 0
4900 LOAD 5 -268.7 0 350.7 0 1803 0
5000 LOAD 6 -331 0 356.9 0 2094 0
5100 LOAD 7 -331 0 356.9 0 1936 0
6000 FOUT 1 2 3 4 5 6 7 EL18MP05.doc
6100 PFO ALL
6200 PLB ALL
```

RIVER FRONTING WALLS ALL-VERTICAL PILES

USACE Passaic River Flood Protection

Feasibility Level Flood Protection

TYPICAL FRONTING MONOLITH
TOW EL. 18; TOS EL 6.0

URS Project : 60442748

Monolith Foundations

1515 Poydras Street

Suite 2700

New Orleans, LA 70112

(504) 586-8111

Computed by:	RBJ	Checked by:	
Date:	Jan-16	Date:	

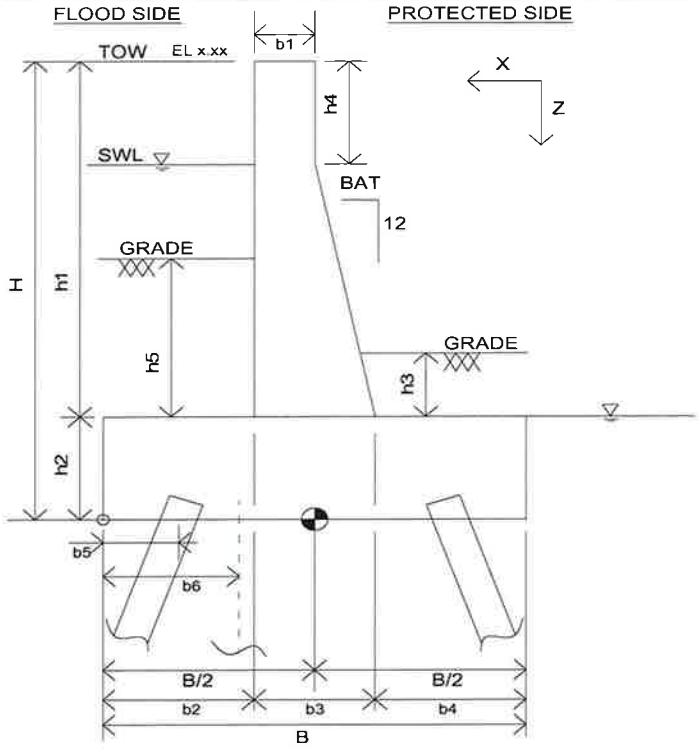
AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL FRONTING MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
				References	

LOAD CALCULATIONS

TOW EL. 18; TOS EL 6.0

Top of Wall El.	18.0	NAVD88
Normal Water El.	6.0	NAVD88
Still Water El.	16.0	NAVD88
Top of Slab EL.	6.0	NAVD88
H=	15.0	ft.
h1=	12.0	ft.
h2=	36.0	in. (Base Slab Height)
h3=	12.0	in. (P.S. Soil Height)
h4=	0.0	ft.
h5=	1.00	ft. (F.S. Soil Height, **T.O. Slab**)
B=	9.0	ft. (Base Slab Width)
b1=	18.0	in. (Wall Stem Width, top)
b2=	66.0	in. (F.S. Slab Width)
b3=	18.0	in. (Wall Stem Width, bottom)
b4=	24.0	in. (P.S. Slab Width)
b5=	21.0	in. (F.S. Pile Row Edge Space)
b6=	54.0	in. (Sheet Pile Edge Space)
BAT=	0.0	(Wall Batter, N/A)
PS Grade =	7.00	NAVD88 (Average of PS soil for all)
Monolith Length	50.0	ft
Bottom Of Slab =	3.0	NAVD88



T-WALL CROSS-SECTION

Notes: 1) positive 'Y' axis is into page
2) pile batters vary from those show in diagram

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL FRONTING MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
				References	

ASSUMED UNIT WEIGHTS:

Unit Weight of Storm Water:
62.4 pcf

Wet Unit Weight of Soil: 100 pcf

Unit Weight of Riprap: 0 pcf

Sat Unit Weight of Soil:
37.6 pcf

Unit Weight of Concrete
150 pcf

Unbalanced Load for Stability Analysis:

F_{cap} (k/ft) = 0.00 (Operation Case; Force acts at bottom of slab)

F_{cap} (k/ft) = 0.00 (Water to TOW Case; Force acts at bottom of slab)

K_0, Clay fill = 0.80 (for lateral soil forces)

EM 1110-2-2502: $P_{hz} = K_0 * (\gamma * z_w + \gamma' * (z - z_w))$

- PS design water elevation <BOS elevation, no PS uplift or PS hydrostatic loads

FS Wind force above SWL= 50.0 psf

Construction Surcharge Pressure = 250 psf

Wave Point Load = 0 kip/ft

Dist from B.O. Slab to Wave Load = 0 ft

	LOAD CASES ANALYZED:	FS Water El.	PS Water El.	Overstress for Design	Notes
1	Construction	3.0	3.0	1.17	Temporary Construction Case
2	Construction + Wind on F.S.	3.0	3.0	1.33	Unusual Construction Case
3	Water to SWL, Impervious	16.0	6.0	1.00	Still Water Level Flood, Impervious uplift
4	Water to SWL, Pervious	16.0	6.0	1.00	Still Water Level Flood, Pervious uplift
5	Water to SWL + Debris Load, Impervious	16.0	6.0	1.00	Still Water Level Flood, Impervious uplift
6	Water to T.O. Wall, Impervious	18.0	6.0	1.33	TOW Flood, Impervious uplift
7	Water to T.O. Wall, Pervious	18.0	6.0	1.33	TOW Flood, Pervious uplift

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL FRONTING MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
					References

All forces on this page are per foot of monolith length

Soil Forces:

Water EL.	FS Soil EL.	PS Soil EL.	Wt. of FS Soil (k/ft)	Wt. of PS Soil (k/ft)	FS Soil Lateral Force (k/ft)	PS Soil Lateral Force (k/ft)
7.0	7.00	7.00	**0.2068**	**0.200**	**-0.2406**	**0.6400**
16.0	7.00	7.00	**0.2068**	**0.200**	**-0.2406**	**0.6400**
18.0	7.00	7.00	**0.2068**	**0.200**	**-0.2406**	**0.6400**

Water Forces:

Water EL.	Wt. of FS Water (k/ft)	FS Water Lateral Force (k/ft)
7.0	**0.3432**	**-0.499**
16.0	**3.432**	**-5.273**
18.0	**4.1184**	**-7.020**

Wind Force: 50 psf * monolith height / 1000 = **-0.75 k/ft**

MDE Earthquake Force:

	Vertical (k-ft)	Lateral (k-ft)		
Soil		**0.116**	Z-coord = -2.67	
Concrete	**0.270**	**0.844**	Z-coord = -4.50	X-coord = -0.700

Surcharge Forces:

F.S. = 250 psf * F.S. width / 1000 = **1.375 k/ft**

P.S. = 250 psf * P.S. width / 1000 = **0.5 k/ft**

Unbalanced Load:

Operating: 0.000 k/ft in (+) X Direction, acting at bottom of slab (Z-coordinate = 0)

TOW: 0.000 k/ft in (+) X Direction, acting at bottom of slab (Z-coordinate = 0)

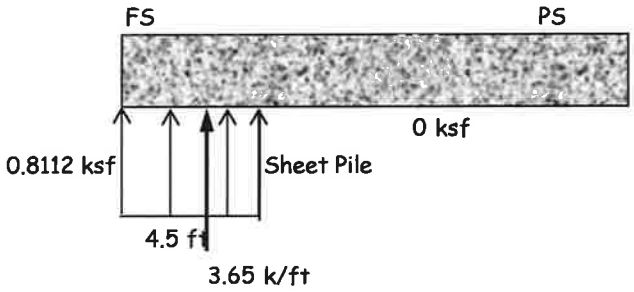
AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL FRONTING MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
				References	

Uplift Loads:

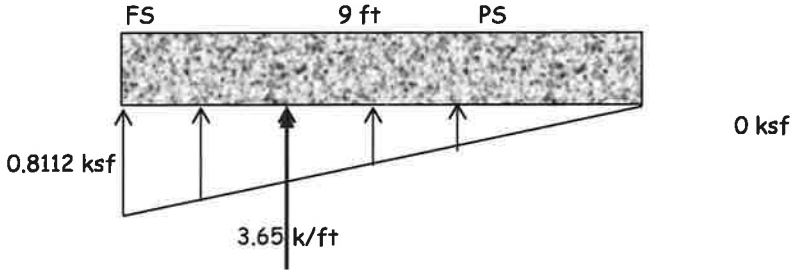
Water to SWL:

Impervious:



X-coordinate = 2.25

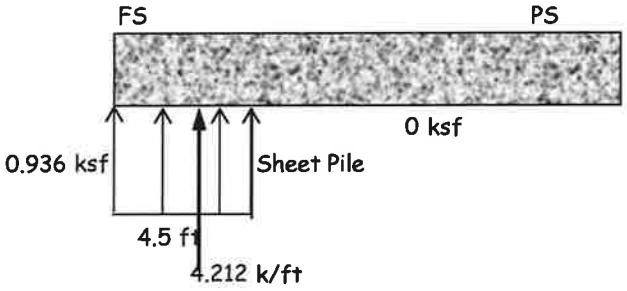
Pervious:



X-coordinate = 1.500

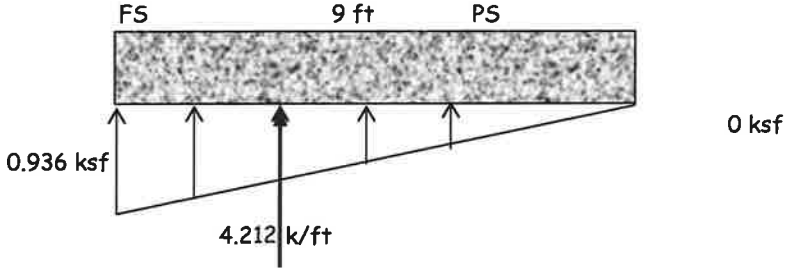
Water to TOW:

Impervious:



X-coordinate = 2.25

Pervious:



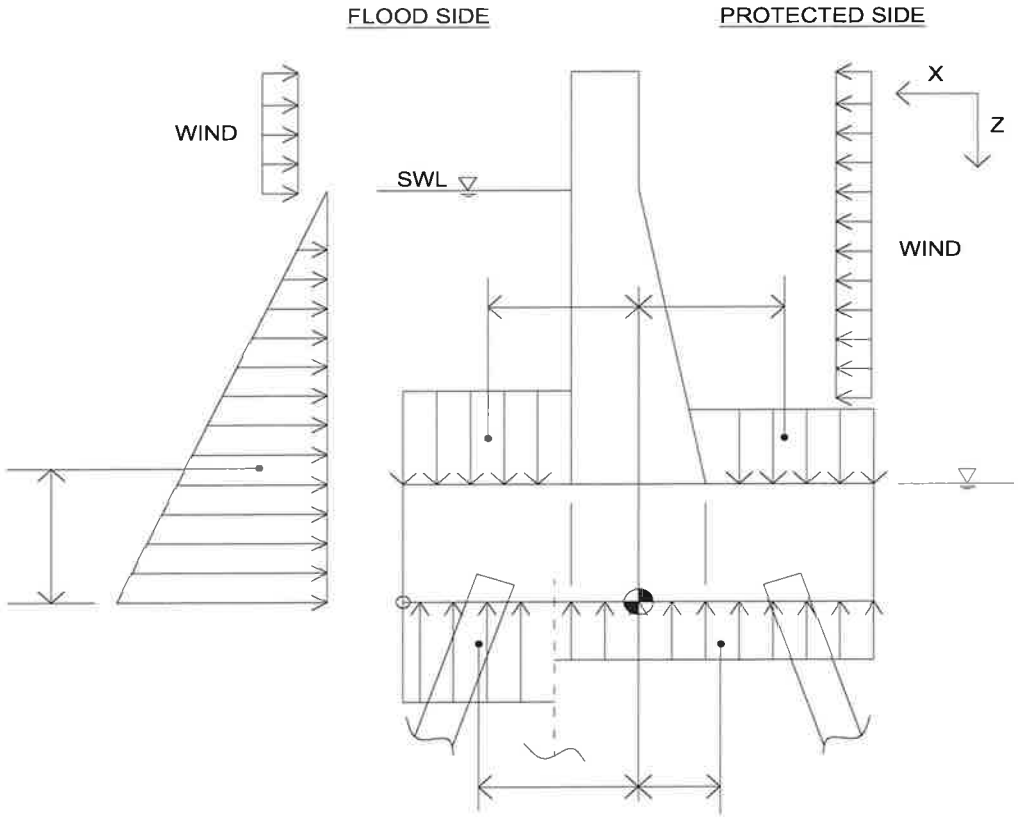
X-coordinate = 1.500

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL FRONTING MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00

References

LOAD DIAGRAMS FOR IMPERVIOUS SHEET PILE CONDITIONS



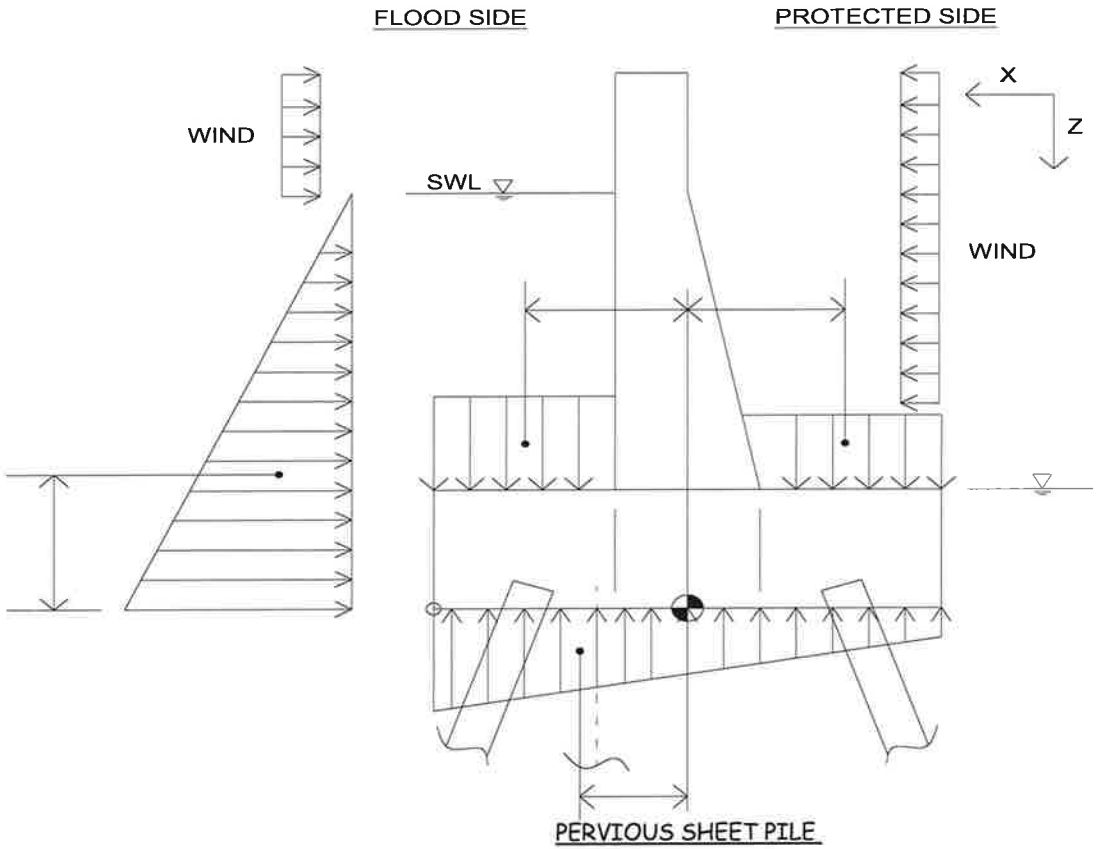
IMPERVIOUS SHEET PILE

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL FRONTING MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00

References

LOAD DIAGRAMS FOR PERVIOUS SHEET PILE CONDITIONS



AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL FRONTING MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
				References	

LC 1: Construction, 1.17 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FOOT OF WALL LENGTH									
	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
		2.70	-1.75				4.73		wall stem weight
		4.05	0.00				0.00		base slab weight
		0.20	-3.50				0.70		P.S. soil weight
	0.64				-1.33		-0.85		P.S. lateral soil force
		0.21	1.75				-0.36		F.S. soil weight
	-0.24				-1.33		0.32		F.S. lateral soil force
	0.00				0.00		0.00		Unbalanced load, no water
Subtotal A	*0.40*	*7.16*				*0.00*	*4.53*	*0.00*	*Dry Soil Weight Subtotal*
		1.38	1.75				-2.41		F.S. Equipment Surcharge
		0.50	-3.50				1.75		P.S. Equipment Surcharge
SUM:	**0.40**	**9.03**				**0.00**	**3.87**	**0.00**	**LC 1 CPGA Forces**

LC 2: Construction + Wind on F.S., 1.33 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FOOT OF WALL LENGTH									
	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
		2.70	-1.75	0			4.73	0	wall stem weight
		4.050	0				0.00		base slab weight
	-0.75				-7.50	0	5.63	0	FS Wind Load
SUM:	**-0.75**	**6.75**				**0.00**	**10.35**	**0.00**	**LC 2 CPGA Forces**

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL FRONTING MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
				References	

LC 3: Water to SWL, Impervious, 1.0 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FOOT OF WALL LENGTH									
	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
		2.70	-1.75				4.73		wall stem weight
		4.05	0.00				0.00		base slab weight
		0.20	-3.50				0.70		P.S. soil weight
	0.64				-1.33		-0.85		P.S. lateral soil force
		0.21	1.75				-0.36		F.S. soil weight, saturated
	-0.24				-1.33		0.32		F.S. lateral soil force, saturated
	-5.27				-4.33		22.85		Lateral water force
		3.43	1.75				-6.01		Vertical water force
	0.00				0		0.00		Unbalanced load, water TOW
Subtotal B	*-4.87*	*10.59*				*0.00*	*21.37*	*0.00*	*SWL Subtotal*
		-3.65	2.25				8.21		Impervious FS hydrostatic uplift
		0.00					0.00		Impervious PS hydrostatic uplift
SUM:	**-4.87**	**6.94**				**0.00**	**29.59**	**0.00**	**LC 3 CPGA Forces**

LC 4: Water to SWL, Pervious, 1 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FOOT OF WALL LENGTH									
	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
Subtotal B	*-4.87*	*10.59*				*0.00*	*21.37*	*0.00*	*SWL Subtotal*
		-3.65	1.500				5.48		Pervious hydrostatic uplift
SUM:	**-4.87**	**6.94**				**0.00**	**26.85**	**0.00**	**LC 4 CPGA Forces**

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL FRONTING MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
				References	

LC 5: Water to SWL + Debris Load, Impervious, 1.0 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FT. OF WALL									
	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
Subtotal B	*-4.87*	*10.59*				*0.00*	*21.37*	*0.00*	*SWL Subtotal*
		-3.65	2.25				8.21		Impervious FS hydrostatic uplift
		0.00					0.00		Impervious PS hydrostatic uplift
	-0.50				-13.00		6.50		Debris Load
SUM:	**-5.37**	**6.94**				**0.00**	**36.09**	**0.00**	**LC 5 CPGA Forces**

LC 6: Water to T.O. Wall, Impervious, 1.33 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FT. OF WALL									
S NO.	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
		2.70	-1.75				4.73		wall stem weight
		4.05	0.00				0.00		base slab weight
		0.20	-3.50				0.70		P.S. soil weight
	0.64				-1.33		-0.85		P.S. lateral soil force
		0.21	1.75				-0.36		F.S. soil weight, saturated
	-0.24				-1.33		0.32		F.S. lateral soil force, saturated
	-7.02				-5.00		35.10		Lateral water force
		4.12	1.75				-7.21		Vertical water force
	0.00				0		0.00		Unbalanced load, water TOW
Subtotal B	*-6.62*	*11.28*				*0.00*	*32.42*	*0.00*	*TOW Subtotal*
		-4.21	2.25				9.48		Impervious FS hydrostatic uplift
		0.00					0.00		Impervious PS hydrostatic uplift
SUM:	**-6.62**	**7.06**				**0.00**	**41.90**	**0.00**	**LC 6 CPGA Forces**

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL FRONTING MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
				References	

LC 7: Water to T.O. Wall, Pervious, 1.33 allowable overstress									
EXTERNAL FORCES & MOMENTS ABOUT ORIGIN PER FT. OF WALL									
S NO.	Fx	Fz	'X' Centroid	'Y' Centroid	'Z' Centroid	Mx	My	Mz	NOTES:
	(kip/ft)	(kip/ft)	(ft)	(ft)	(ft)	(kip-ft/ft)	(kip-ft/ft)	(kip-ft/ft)	
Subtotal B	-6.62	11.28				0.00	32.42	0.00	*TOW Subtotal*
		-4.21	1.500				6.32		Pervious hydrostatic uplift
SUM:	**-6.62**	**7.06**				**0.00**	**38.74**	**0.00**	**LC 7 CPGA Forces**

AECOM

Job	USACE Passaic River Flood Protection	Project No.	60442748		
	Feasibility Level Flood Protection				
Description	TYPICAL FRONTING MONOLITH	Computed by	RBJ	Date	Jan-16
	TOW EL. 18; TOS EL 6.0				
	Foundation Load Cases & Combinations	Checked by	0	Date	Jan-00
					References

Summary of Forces and Moments (For Full Length of Monolith):

LOAD CASE NUMBER	Fx	Fy	Fz	Mx	My	Mz	
	kips	kips	kips	(kip-ft)	(kip-ft)	(kip-ft)	
1	20.0	0.0	451.6	0.0	193.7	0.0	Temporary Construction Case
2	-37.5	0.0	337.5	0.0	517.5	0.0	Unusual Construction Case
3	-243.7	0.0	346.9	0.0	1479.3	0.0	Still Water Level Flood, Impervious uplift
4	-243.7	0.0	346.9	0.0	1342.4	0.0	Still Water Level Flood, Pervious uplift
5	-268.7	0.0	346.9	0.0	1804.3	0.0	Still Water Level Flood, Impervious uplift
6	-331.0	0.0	353.2	0.0	2095.0	0.0	TOW Flood, Impervious uplift
7	-331.0	0.0	353.2	0.0	1937.1	0.0	TOW Flood, Pervious uplift

AECOM

Job	USACE Passaic River Flood Protection		Project No.	60442748	
	Feasibility Level Flood Protection				
Description	TYPICAL WEST OF KEARNY MONOLITH		Computed by	RBJ	Date Jan-16
	TOW EL. 18; TOS EL 6.0				
	CPGA Input & Output Files		Checked by	0	Date Jan-00

TOM EL18, HP14x89 5' O.C. CERTICAL PILES

Input file:

```
100 FROPNTING WALL, 50' MONOLITH TOW EL18-
110 H-PILE, 5'OC, VERTICAL FS & PS
200 PROP 29000 326 905 26.1 1 0 ALL
300 SOIL ES 0.11 TIP 60 0 ALL
400 FIX ALL
500 TENSION 0.8 ALL
600 ALLOW H 200 60 653 607 1108 3275 ALL
700 FOVSTR 1.17 1.17 1
800 FOVSTR 1.33 1.33 2 6 7
1200 PILE 1 3 -22.5 0
1300 PILE 11 -3 -22.5 0
1400 ROW Y 10 1 9 AT 5
1500 ROW Y 10 11 9 AT 5
4500 LOAD 1 20 0 436.6 0 199 0
4600 LOAD 2 -37.5 0 337.5 0 517.5 0
4700 LOAD 3 -243.7 0 350.7 0 1478
4800 LOAD 4 -243.7 0 350.7 0 1341 0
4900 LOAD 5 -268.7 0 350.7 0 1803 0
5000 LOAD 6 -331 0 356.9 0 2094 0
5100 LOAD 7 -331 0 356.9 0 1936 0
6000 FOUT 1 2 3 4 5 6 7 FWHP.doc
6100 PFO ALL
6200 PLB ALL
6200 PLB ALL
```