NSL West Levee and Flood Wall

Hoquiam, WA

Structural Calculations

CALCULATIONS INCLUDED:

These Calculations cover this scope:

- **Structural Design of Steel Sheet Pile I-Walls**
- **Structural Design of Concrete T-Walls**

kpff

612 Woodland Square Loop
Suite 100
Lacey, WA 98503

KPFF Project No. 1600210

March 20, 2020

STRUCTURAL DESIGN CRITERIA

Datum:

NAVD88

Geotechnical:

Preliminary Design and Construction Recommendations by GeoEngineers, March 17, 2020.

Codes and References:

- 1998 Uniform Building Code (as noted by FEMA Form 086-0-27B)
- 2018 International Building Code
- US Army Corps of Engineers EM 1110-2-2502, *Retaining and Flood Walls* (for concrete T-Walls)
- US Army Corps of Engineers EC 1110-2-6066, *Design of I-Walls* (for steel sheet pile I-Walls)

DESIGN FLOOD CONDITIONS

Flood Levels

- Design Water Level: Elevation 13.2' (2' below top of wall). Return period = 100 years.
- 500-year flood Elevation 14.2' (1' below top of wall).
- Overtopping condition: Water to top of wall at Elevation 15.2'. Return period at least 750 years.

Design Water Level:

- Elevation 13.2'
- Recurrence: 100 years
- I-Walls:
    - Load Condition Probability for I-Walls per CM 1110-2-6066, Table 6-2: "Unusual" for 100-year return period.
    - Rotational Stability Factor of Safety for I-Walls for DWL Load for "Unusual" probability and "ordinary" soil definition (per EC 1110-2-6066, Table 6-2): 1.5.
    - Construction and earthquake load conditions for I-walls are highly unlikely to occur during a design flood, so these load conditions aren't considered.
- T-Walls:
    - Design water level of 14.2' conservatively used for T-Walls in lieu of 13.2'.
    - Sliding factor of safety: 1.5 (per EM 1110-2-2502, Table 4-2)
    - Overturning factor of safety: 100% of base width in compression (per EM 1110-2-2502, Table 4-2)
    - Additional overturning factor of safety requirement: 1.5 (set equal to sliding FS by design team)
    - Bearing factor of safety: 3.0 (per EM 1110-2-2502, Table 4-2)

Water to Top of Wall:

- Elevation 15.2'
- Recurrence: at least 750 years
- I-Walls
    - Load Condition Probability for I-Walls per CM 1110-2-6066, Table 6-2: "Extreme" for greater than 750-year return period. Factor of safety of 1.5 for "Unusual" condition conservatively used in lieu of the 1.3 factor of safety allowed for "Extreme" condition.
- T-Walls
    - Sliding: 1.33 (per EM 1110-2-2502, Table 4-2)
    - Overturning: 75% of base width in compression (per EM 1110-2-2502, Table 4-2)
    - Additional overturning requirement: 1.33 (set equal to sliding FS by design team)
    - Overturning for planter empty of soil: 1.1 (established by design team)
    - Bearing: 2.0 (per EM 1110-2-2502, Table 4-2)

SHEETPILE I-WALLS

SHEEPILE SUMMARY

Fy= 50 ksi E= 2.9E+07 psi

Region	Location ~Sta	Min Ground Elev [ft]	Shear Strength Condition	Load Condition	Required Embedment [ft]	Maximum Moment [k-ft]	Req'd Min Section Modulus [in^3] [Ref1]	Selected NZ Sheetpile Size	Section Modulus [in^3]	Moment Capacity/ Demand Ratio	Moment of Inertia [in^4]	Scaled Deflection at Grade [$lb\text{-}in^3$]	Deflection at Grade [in] [Ref2]
North Hoquiam Design Group [NHDG]	71+25 to 96+08	10	Short Term	OVT1	22.76	19.02	7.62	NZ14-770	25.65	3.4	171.7	4.786E+08	0.10
	71+25 to 96+08	10	Long Term	DWL	14.71	4.49	1.80	NZ14-771	25.65	14.3	171.7	4.984E+08	0.10
Grays Harbor Design Group [GHDG]	139+20 to 147+70	10	Short Term	OVT1	13.92	5.28	2.12	NZ14-772	25.65	12.1	171.7	5.164E+08	0.10
	139+20 to 147+70	10	Long Term	DWL	22.28	8.84	3.54	NZ14-773	25.65	7.2	171.7	2.260E+09	0.45
Grays Harbor Design Group [GHDG]	201+05 to 202+00	11	Short Term	OVT1	8.88	2.1	0.84	NZ14-774	25.65	30.5	171.7	8.330E+07	0.02
	201+05 to 202+00	11	Long Term	DWL	15.32	2.87	1.15	NZ14-775	25.65	22.3	171.7	3.472E+08	0.07

Note: FOR EACH REGION/LOCATION, SELECT THE LARGER OF THE EMBEDMENTS CALCULATED FOR THE DWL AND OVT1 LOAD CONDITIONS

Ref1: $M_a = M_n/\Omega$ = Sx*Fy/Ω Sx = Ω*Ma/Fy = (1.67)*Mmax/(50ksi)

Ref2: $Deflection = (Scaled\ Defection)$/(E * I)

kpff

project North Shore Levee West

location Hoquam, WA

client

Sheet Pile Wall Calculations

by DMR

date 2020/03/23

job no. 10181900007

sheet no. 1/29

kpff	project North Shore Levee West	by DMR	sheet no. 2/29
	location Hoquam, WA	date 2020/03/23	
	client		job no. 10181900007
	Sheet Pile Wall Calculations		

Location of Sheetpile "I-walls" and Geotechnical Information used in Analysis

Design Water Ht = 13.2 ft
Wall Ht (Over Topping Height) = 15.2 ft

TABLE 5. NORTH HOQUIAM ANALYSIS GROUP – SOIL PARAMETERS FOR I-WALL ANALYSIS

Geologic Layer	Bottom Elevation of Layer	Unit Weight (PCF)		Q-Strength Short Term Loading		S-Strength Long Term Loading	
		Saturated	Moist	Angle of Internal Friction (Deg.)	Cohesion (PSF)	Angle of Internal Friction (Deg.)	Cohesion (PSF)
Silty Sand Alluvium (24 Deg.)	El. -2 feet	108	108	24	0	24	0
Silt Alluvium with organic interbeds (400 psf)	El. -23 feet	114	114	0	400	23[1]	0
Silt and Clay Alluvium with organic interbeds (400 psf at top, increasing by 25 psf per foot of depth.)	El. -27 feet	114	114	0	500	25[1]	0
	El. -31 feet	114	114	0	600	24[1]	0
	El. -35 feet	114	114	0	700	24[1]	0

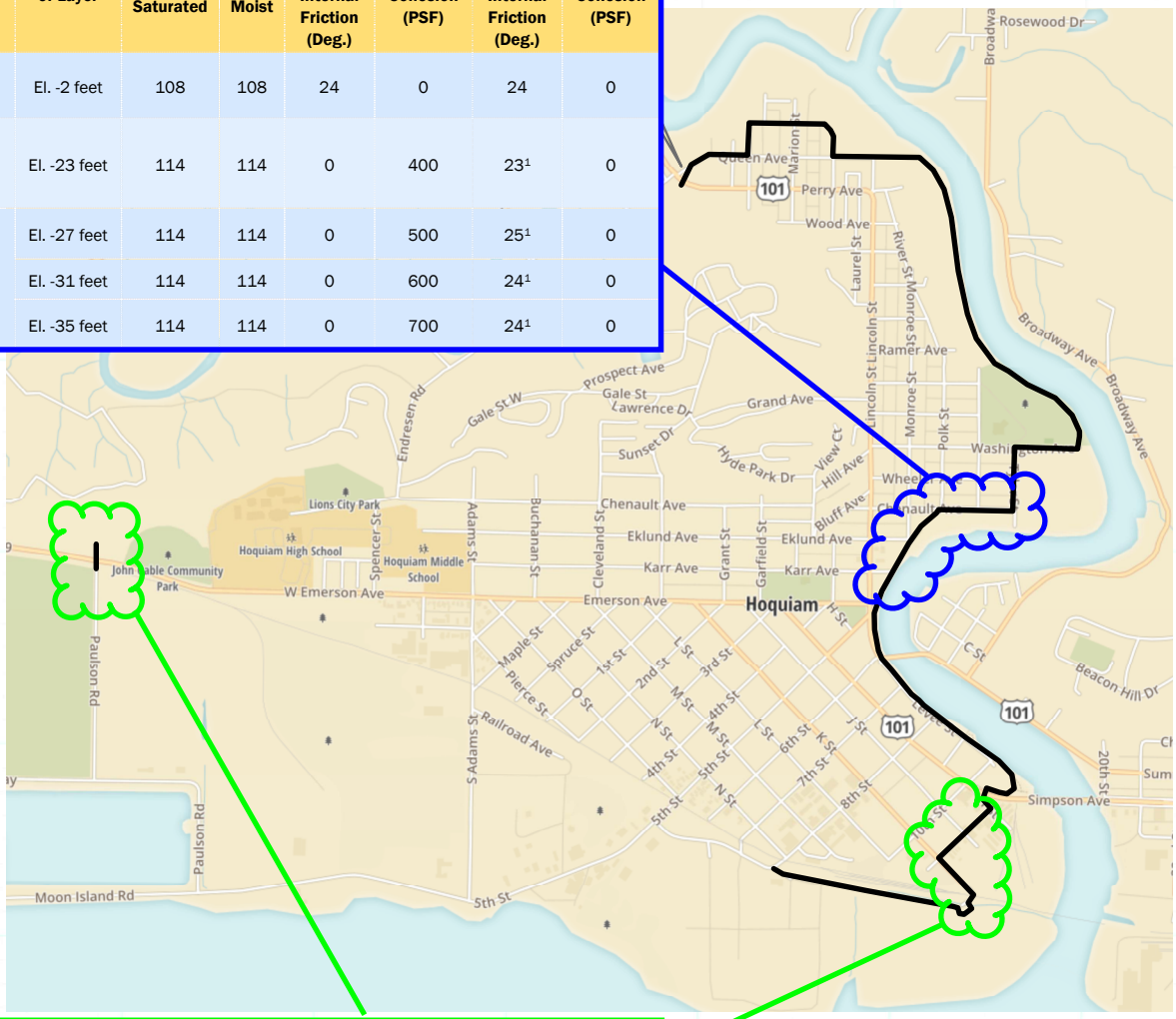


TABLE 6. GRAYS HARBOR DESIGN GROUP – SOIL PARAMETERS FOR I-WALL ANALYSIS

Geologic Layer	Bottom Elevation of Layer	Unit Weight (PCF)		Q-Strength Short Term Loading		S-Strength Long Term Loading	
		Saturated	Moist	Angle of Internal Friction (Deg.)	Cohesion (PSF)	Angle of Internal Friction (Deg.)	Cohesion (PSF)
Silt and Clay Alluvium (240[1] psf)	El. -30 feet	101[1]	101[1]	0	240[1]	18[2]	0
Silty Sand Alluvium (28 Deg.)	El. -70 feet	110[1]	110[1]	28	0	28	0

Soil Property Data from:

Preliminary Design and Construction Recommendations – Revised

Floodwalls and Embankment Levees
North Shore Levee West Segment
Hoquiam, Washington

for
KPFF Consulting Engineers, Inc.

March 17, 2020

****
* INPUT DATA *
****

I.--HEADING
'NSL-WEST (NORTH HOQUIAM) OVT1 LOAD CASE
'LOAD CONDITION (SHORT TERM)

II.--CONTROL
CANTILEVER WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.50
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

III.--WALL DATA
ELEVATION AT TOP OF WALL = 15.20 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.00

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.00

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.
108.00	108.00	24.00	0.00	0.00	0.00	-2.00	0.00	DEF	DEF
114.00	114.00	0.00	400.00	0.00	0.00	-23.00	0.00	DEF	DEF
114.00	114.00	0.00	500.00	0.00	0.00	-27.00	0.00	DEF	DEF
114.00	114.00	0.00	600.00	0.00	0.00	-31.00	0.00	DEF	DEF
114.00	114.00	0.00	700.00	0.00	0.00			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.
108.00	108.00	24.00	0.00	0.00	0.00	-2.00	0.00	DEF	DEF
114.00	114.00	0.00	400.00	0.00	0.00	-23.00	0.00	DEF	DEF
114.00	114.00	0.00	500.00	0.00	0.00	-27.00	0.00	DEF	DEF
114.00	114.00	0.00	600.00	0.00	0.00	-31.00	0.00	DEF	DEF
114.00	114.00	0.00	700.00	0.00	0.00			DEF	DEF

VI.--WATER DATA
UNIT WEIGHT = 62.40 (PCF)
RIGHTSIDE ELEVATION = 15.20 (FT)
LEFTSIDE ELEVATION = 10.00 (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: 16-MARCH-2020 TIME: 11:10:33

****
* SOIL PRESSURES FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (NORTH HOQUIAM) OVT1 LOAD CASE
'LOAD CONDITION (SHORT TERM)

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

				<------NET------>			
	NET	<---LEFTSIDE--->		(SOIL + WATER)		<--RIGHTSIDE--->	
ELEV.	WATER	PASSIVE	ACTIVE	ACTIVE	PASSIVE	ACTIVE	PASSIVE
(FT)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)
15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.2	62.4	0.0	0.0	62.4	62.4	0.0	0.0
13.2	124.8	0.0	0.0	124.8	124.8	0.0	0.0
12.2	187.2	0.0	0.0	187.2	187.2	0.0	0.0
11.2	249.6	0.0	0.0	249.6	249.6	0.0	0.0
10.2	312.0	0.0	0.0	312.0	312.0	0.0	0.0
10.0	324.5	0.0	0.0	324.5	324.5	0.0	0.0
9.2	324.5	65.5	20.3	279.3	369.7	20.3	65.5
9.0	324.5	81.9	25.4	268.0	381.0	25.4	81.9
8.2	324.5	147.4	45.7	222.8	426.1	45.7	147.4
7.2	324.5	229.2	71.1	166.4	482.6	71.1	229.2
6.2	324.5	311.1	96.5	109.9	539.1	96.5	311.1
5.2	324.5	393.0	121.9	53.4	595.6	121.9	393.0
4.3	324.5	470.4	145.9	0.0	649.0	145.9	470.4
4.2	324.5	474.9	147.3	-3.1	652.0	147.3	474.9
3.2	324.5	556.7	172.7	-59.5	708.5	172.7	556.7
2.2	324.5	638.6	198.1	-116.0	765.0	198.1	638.6
1.2	324.5	720.5	223.5	-172.5	821.5	223.5	720.5
0.2	324.5	802.3	248.9	-229.0	877.9	248.9	802.3
-0.8	324.5	884.2	274.3	-285.4	934.4	274.3	884.2
-1.8	324.5	966.1	299.7	-341.9	990.9	299.7	966.1
-2.0+	324.5	982.5	304.8	-547.7	1196.7	304.8	982.5
-2.0-	324.5	1080.5	13.9	-547.7	1196.7	13.9	1080.5
-2.8	324.5	1121.8	55.1	-742.2	1391.1	55.1	1121.8
-3.8	324.5	1173.4	106.7	-742.2	1391.1	106.7	1173.4
-4.8	324.5	1225.0	158.3	-742.2	1391.1	158.3	1225.0
-5.8	324.5	1276.6	209.9	-742.2	1391.1	209.9	1276.6
-6.8	324.5	1328.2	261.5	-742.2	1391.1	261.5	1328.2
-7.8	324.5	1379.8	313.1	-742.2	1391.1	313.1	1379.8
-8.8	324.5	1431.4	364.7	-742.2	1391.1	364.7	1431.4
-9.8	324.5	1483.0	416.3	-742.2	1391.1	416.3	1483.0
-10.8	324.5	1534.6	467.9	-742.2	1391.1	467.9	1534.6
-11.8	324.5	1586.2	519.5	-742.2	1391.1	519.5	1586.2
-12.8	324.5	1637.8	571.1	-742.2	1391.1	571.1	1637.8
-13.8	324.5	1689.4	622.7	-742.2	1391.1	622.7	1689.4
-14.8	324.5	1741.0	674.3	-742.2	1391.1	674.3	1741.0
-15.8	324.5	1792.6	725.9	-742.2	1391.1	725.9	1792.6
-16.8	324.5	1844.2	777.5	-742.2	1391.1	777.5	1844.2

-17.8	324.5	1895.8	829.1	-742.2	1391.1	829.1	1895.8
-18.8	324.5	1947.4	880.7	-742.2	1391.1	880.7	1947.4
-19.8	324.5	1999.0	932.3	-742.2	1391.1	932.3	1999.0
-20.8	324.5	2050.6	983.9	-742.2	1391.1	983.9	2050.6

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS
DATE: 16-MARCH-2020 TIME: 11:11:27

****
* SUMMARY OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (NORTH HOQUIAM) OVT1 LOAD CASE
'LOAD CONDITION (SHORT TERM)

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

WALL BOTTOM ELEV. (FT) : -12.76
PENETRATION (FT) : 22.76

MAX. BEND. MOMENT (LB-FT) : 1.9021E+04
AT ELEVATION (FT) : -2.98

MAX. SCALED DEFL. (LB-IN^3): 6.9550E+09
AT ELEVATION (FT) : 15.20

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: 16-MARCH-2020 TIME: 11:11:27

****
* COMPLETE OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (NORTH HOQUIAM) OVT1 LOAD CASE
'LOAD CONDITION (SHORT TERM)

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
15.20	0.0000E+00	0.	6.9550E+09	0.00
14.20	1.0400E+01	31.	6.5372E+09	62.40

13.20	8.3200E+01	125.	6.1194E+09	124.80
12.20	2.8080E+02	281.	5.7019E+09	187.20
11.20	6.6560E+02	499.	5.2848E+09	249.60
10.20	1.3000E+03	780.	4.8689E+09	312.00
10.00	1.4623E+03	844.	4.7859E+09	324.48
9.20	2.2363E+03	1085.	4.4553E+09	279.30
9.00	2.4588E+03	1140.	4.3730E+09	268.01
8.20	3.4517E+03	1336.	4.0456E+09	222.83
7.20	4.8899E+03	1531.	3.6419E+09	166.35
6.20	6.4945E+03	1669.	3.2467E+09	109.88
5.20	8.2089E+03	1751.	2.8627E+09	53.40
4.25	9.8802E+03	1776.	2.5126E+09	0.00
4.20	9.9768E+03	1776.	2.4929E+09	-3.07
3.20	1.1742E+04	1744.	2.1403E+09	-59.55
2.20	1.3447E+04	1657.	1.8080E+09	-116.02
1.20	1.5036E+04	1512.	1.4990E+09	-172.49
0.20	1.6453E+04	1312.	1.2159E+09	-228.97
-0.80	1.7640E+04	1054.	9.6118E+08	-285.44
-1.80	1.8543E+04	741.	7.3692E+08	-341.92
-2.00	1.8683E+04	652.	6.9587E+08	-547.70
-2.80	1.9008E+04	136.	5.4464E+08	-742.19
-3.80	1.8773E+04	-606.	3.8511E+08	-742.19
-4.80	1.7796E+04	-1349.	2.5791E+08	-742.19
-5.80	1.6076E+04	-2091.	1.6135E+08	-742.19
-5.96	1.5738E+04	-2208.	1.4876E+08	-742.19
-6.80	1.3645E+04	-2722.	9.2465E+07	-477.97
-7.80	1.0737E+04	-3043.	4.7091E+07	-164.39
-8.80	7.6643E+03	-3050.	2.0247E+07	149.18
-9.80	4.7408E+03	-2744.	6.6689E+06	462.75
-10.80	2.2801E+03	-2125.	1.3494E+06	776.33
-11.80	5.9562E+02	-1192.	8.1621E+04	1089.90
-12.76	0.0000E+00	0.	0.0000E+00	1391.15

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)
15.20	0.	0.	0.	0.	0.
14.20	62.	0.	0.	0.	0.
13.20	125.	0.	0.	0.	0.
12.20	187.	0.	0.	0.	0.
11.20	250.	0.	0.	0.	0.
10.20	312.	0.	0.	0.	0.
10.00	324.	0.	0.	0.	0.
9.20	324.	65.	20.	20.	65.
9.00	324.	82.	25.	25.	82.
8.20	324.	147.	46.	46.	147.
7.20	324.	229.	71.	71.	229.
6.20	324.	311.	97.	97.	311.
5.20	324.	393.	122.	122.	393.
4.25	324.	470.	146.	146.	470.
4.20	324.	475.	147.	147.	475.
3.20	324.	557.	173.	173.	557.
2.20	324.	639.	198.	198.	639.
1.20	324.	720.	223.	223.	720.
0.20	324.	802.	249.	249.	802.
-0.80	324.	884.	274.	274.	884.
-1.80	324.	966.	300.	300.	966.
-2.00+	324.	982.	305.	305.	982.
-2.00-	324.	1081.	14.	14.	1081.
-2.80	324.	1122.	55.	55.	1122.
-3.80	324.	1173.	107.	107.	1173.
-4.80	324.	1225.	158.	158.	1225.
-5.80	324.	1277.	210.	210.	1277.
-5.96	324.	1285.	218.	218.	1285.
-6.80	324.	1328.	262.	262.	1328.

-7.80	324.	1380.	313.	313.	1380.
-8.80	324.	1431.	365.	365.	1431.
-9.80	324.	1483.	416.	416.	1483.
-10.80	324.	1535.	468.	468.	1535.
-11.80	324.	1586.	520.	520.	1586.
-12.76	324.	1638.	571.	571.	1638.
-13.80	324.	1689.	623.	623.	1689.

****
* INPUT DATA *
****

I.--HEADING
'NSL-WEST (NORTH HOQUIAM) DWL LOAD CASE
'LOAD CONDITION (LONG TERM)

II.--CONTROL
CANTILEVER WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.50
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

III.--WALL DATA
ELEVATION AT TOP OF WALL = 15.20 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.00

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.00

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.
108.00	108.00	24.00	0.00	0.00	0.00	-2.00	0.00	DEF	DEF
114.00	114.00	23.00	0.00	0.00	0.00	-23.00	0.00	DEF	DEF
114.00	114.00	25.00	0.00	0.00	0.00	-27.00	0.00	DEF	DEF
114.00	114.00	24.00	0.00	0.00	0.00	-31.00	0.00	DEF	DEF
114.00	114.00	24.00	0.00	0.00	0.00			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.
108.00	108.00	24.00	0.00	0.00	0.00	-2.00	0.00	DEF	DEF
114.00	114.00	23.00	0.00	0.00	0.00	-23.00	0.00	DEF	DEF
114.00	114.00	25.00	0.00	0.00	0.00	-27.00	0.00	DEF	DEF
114.00	114.00	24.00	0.00	0.00	0.00	-31.00	0.00	DEF	DEF
114.00	114.00	24.00	0.00	0.00	0.00			DEF	DEF

VI.--WATER DATA
UNIT WEIGHT = 62.40 (PCF)
RIGHTSIDE ELEVATION = 13.20 (FT)
LEFTSIDE ELEVATION = 10.00 (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: 16-MARCH-2020 TIME: 11:27:30

****
* SOIL PRESSURES FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (NORTH HOQUIAM) DWL LOAD CASE
'LOAD CONDITION (LONG TERM)

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

				<------NET------>			
	NET	<---LEFTSIDE--->		(SOIL + WATER)		<--RIGHTSIDE--->	
ELEV.	WATER	PASSIVE	ACTIVE	ACTIVE	PASSIVE	ACTIVE	PASSIVE
(FT)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)
15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.2	62.4	0.0	0.0	62.4	62.4	0.0	0.0
11.2	124.8	0.0	0.0	124.8	124.8	0.0	0.0
10.2	187.2	0.0	0.0	187.2	187.2	0.0	0.0
10.0	199.7	0.0	0.0	199.7	199.7	0.0	0.0
9.2	199.7	65.5	20.3	154.5	244.9	20.3	65.5
9.0	199.7	81.9	25.4	143.2	256.2	25.4	81.9
8.2	199.7	147.4	45.7	98.0	301.3	45.7	147.4
7.2	199.7	229.2	71.1	41.6	357.8	71.1	229.2
6.5	199.7	289.5	89.8	0.0	399.4	89.8	289.5
6.2	199.7	311.1	96.5	-14.9	414.3	96.5	311.1
5.2	199.7	393.0	121.9	-71.4	470.8	121.9	393.0
4.2	199.7	474.9	147.3	-127.9	527.2	147.3	474.9
3.2	199.7	556.7	172.7	-184.3	583.7	172.7	556.7
2.2	199.7	638.6	198.1	-240.8	640.2	198.1	638.6
1.2	199.7	720.5	223.5	-297.3	696.7	223.5	720.5
0.2	199.7	802.3	248.9	-353.8	753.1	248.9	802.3
-0.8	199.7	884.2	274.3	-410.2	809.6	274.3	884.2
-1.8	199.7	966.1	299.7	-466.7	866.1	299.7	966.1
-2.0+	199.7	982.5	304.8	-461.0	860.4	304.8	982.5
-2.0-	199.7	956.7	313.0	-461.0	860.4	313.0	956.7
-2.8	199.7	1028.9	336.6	-492.6	892.0	336.6	1028.9
-3.8	199.7	1119.1	366.1	-553.3	952.7	366.1	1119.1
-4.8	199.7	1209.3	395.6	-614.0	1013.4	395.6	1209.3
-5.8	199.7	1299.5	425.1	-674.7	1074.1	425.1	1299.5
-6.8	199.7	1389.7	454.6	-735.4	1134.8	454.6	1389.7
-7.8	199.7	1479.9	484.2	-796.1	1195.5	484.2	1479.9
-8.8	199.7	1570.2	513.7	-856.8	1256.2	513.7	1570.2
-9.8	199.7	1660.4	543.2	-917.5	1316.9	543.2	1660.4
-10.8	199.7	1750.6	572.7	-978.2	1377.6	572.7	1750.6
-11.8	199.7	1840.8	602.2	-1038.9	1438.3	602.2	1840.8
-12.8	199.7	1931.0	631.7	-1099.6	1499.0	631.7	1931.0
-13.8	199.7	2021.2	661.2	-1160.3	1559.7	661.2	2021.2
-14.8	199.7	2111.4	690.8	-1221.0	1620.4	690.8	2111.4
-15.8	199.7	2201.7	720.3	-1281.7	1681.1	720.3	2201.7
-16.8	199.7	2291.9	749.8	-1342.4	1741.8	749.8	2291.9

-17.8	199.7	2382.1	779.3	-1403.1	1802.5	779.3	2382.1
-18.8	199.7	2472.3	808.8	-1463.8	1863.2	808.8	2472.3
-19.8	199.7	2562.5	838.3	-1524.5	1923.9	838.3	2562.5
-20.8	199.7	2652.7	867.8	-1585.2	1984.6	867.8	2652.7

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS
DATE: 16-MARCH-2020 TIME: 11:28:22

****
* SUMMARY OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (NORTH HOQUIAM) DWL LOAD CASE
'LOAD CONDITION (LONG TERM)

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

WALL BOTTOM ELEV. (FT) : -4.71
PENETRATION (FT) : 14.71

MAX. BEND. MOMENT (LB-FT) : 4.4905E+03
AT ELEVATION (FT) : 1.58

MAX. SCALED DEFL. (LB-IN^3): 8.4395E+08
AT ELEVATION (FT) : 15.20

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: 16-MARCH-2020 TIME: 11:28:22

****
* COMPLETE OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (NORTH HOQUIAM) DWL LOAD CASE
'LOAD CONDITION (LONG TERM)

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
15.20	0.0000E+00	0.	8.4395E+08	0.00
14.20	8.7311E-11	0.	7.7744E+08	0.00

13.20	8.7311E-11	0.	7.1092E+08	0.00
12.20	1.0400E+01	31.	6.4441E+08	62.40
11.20	8.3200E+01	125.	5.7792E+08	124.80
10.20	2.8080E+02	281.	5.1160E+08	187.20
10.00	3.4079E+02	319.	4.9838E+08	199.68
9.20	6.5546E+02	461.	4.4579E+08	154.50
9.00	7.5070E+02	491.	4.3274E+08	143.21
8.20	1.1845E+03	587.	3.8113E+08	98.03
7.20	1.8115E+03	657.	3.1853E+08	41.55
6.46	2.3025E+03	672.	2.7441E+08	0.00
6.20	2.4801E+03	671.	2.5907E+08	-14.92
5.20	3.1337E+03	627.	2.0389E+08	-71.40
4.20	3.7160E+03	528.	1.5412E+08	-127.87
3.20	4.1703E+03	372.	1.1075E+08	-184.35
2.20	4.4404E+03	159.	7.4563E+07	-240.82
1.20	4.4696E+03	-110.	4.6011E+07	-297.29
0.20	4.2015E+03	-436.	2.5140E+07	-353.77
-0.80	3.5797E+03	-818.	1.1479E+07	-410.24
-1.23	3.1923E+03	-998.	7.5977E+06	-434.36
-1.80	2.5624E+03	-1179.	3.9442E+06	-197.01
-2.00	2.3232E+03	-1210.	3.0297E+06	-114.15
-2.80	1.3541E+03	-1169.	8.0913E+05	217.31
-3.80	3.6319E+02	-744.	4.5293E+04	631.62
-4.71	0.0000E+00	0.	0.0000E+00	1007.77

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)
15.20	0.	0.	0.	0.	0.
14.20	0.	0.	0.	0.	0.
13.20	0.	0.	0.	0.	0.
12.20	62.	0.	0.	0.	0.
11.20	125.	0.	0.	0.	0.
10.20	187.	0.	0.	0.	0.
10.00	200.	0.	0.	0.	0.
9.20	200.	65.	20.	20.	65.
9.00	200.	82.	25.	25.	82.
8.20	200.	147.	46.	46.	147.
7.20	200.	229.	71.	71.	229.
6.46	200.	289.	90.	90.	289.
6.20	200.	311.	97.	97.	311.
5.20	200.	393.	122.	122.	393.
4.20	200.	475.	147.	147.	475.
3.20	200.	557.	173.	173.	557.
2.20	200.	639.	198.	198.	639.
1.20	200.	720.	223.	223.	720.
0.20	200.	802.	249.	249.	802.
-0.80	200.	884.	274.	274.	884.
-1.23	200.	919.	285.	285.	919.
-1.80	200.	966.	300.	300.	966.
-2.00+	200.	982.	305.	305.	982.
-2.00-	200.	957.	313.	313.	957.
-2.80	200.	1029.	337.	337.	1029.
-3.80	200.	1119.	366.	366.	1119.
-4.71	200.	1209.	396.	396.	1209.
-5.80	200.	1300.	425.	425.	1300.

****
* INPUT DATA *
****

I.--HEADING
'NSL-WEST (GRAYS HARBOR) OVT1 LOAD CASE
'LOAD CONDITION (SHORT TERM)
'Ground Elev 10ft

II.--CONTROL
CANTILEVER WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.50
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

III.--WALL DATA
ELEVATION AT TOP OF WALL = 15.20 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.00

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.00

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.
101.00	101.00	0.00	240.00	0.00	0.00	-30.00	0.00	DEF	DEF
110.00	110.00	28.00	0.00	0.00	0.00			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.
101.00	101.00	0.00	240.00	0.00	0.00	-30.00	0.00	DEF	DEF
110.00	110.00	28.00	0.00	0.00	0.00			DEF	DEF

VI.--WATER DATA
UNIT WEIGHT = 62.40 (PCF)
RIGHTSIDE ELEVATION = 15.20 (FT)
LEFTSIDE ELEVATION = 10.00 (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: 16-MARCH-2020 TIME: 11:52:22

****
* SOIL PRESSURES FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (GRAYS HARBOR) OVT1 LOAD CASE
'LOAD CONDITION (SHORT TERM)
'Ground Elev 10ft

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

				<------NET------>			
	NET	<---LEFTSIDE--->		(SOIL + WATER)		<--RIGHTSIDE--->	
ELEV.	WATER	PASSIVE	ACTIVE	ACTIVE	PASSIVE	ACTIVE	PASSIVE
(FT)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)
15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.2	62.4	0.0	0.0	62.4	62.4	0.0	0.0
13.2	124.8	0.0	0.0	124.8	124.8	0.0	0.0
12.2	187.2	0.0	0.0	187.2	187.2	0.0	0.0
11.2	249.6	0.0	0.0	249.6	249.6	0.0	0.0
10.2	312.0	0.0	0.0	312.0	312.0	0.0	0.0
10.0+	324.5	0.0	0.0	324.5	324.5	0.0	0.0
10.0-	324.5	320.0	0.0	4.5	644.5	0.0	320.0
9.9	324.5	324.5	0.0	0.0	649.0	0.0	324.5
9.2	324.5	350.9	0.0	-26.4	675.4	0.0	350.9
9.0	324.5	358.6	0.0	-34.1	683.1	0.0	358.6
8.2	324.5	389.5	0.0	-65.0	714.0	0.0	389.5
7.2	324.5	428.1	0.0	-103.6	752.6	0.0	428.1
6.2	324.5	466.7	0.0	-142.2	791.2	0.0	466.7
5.2	324.5	505.3	0.0	-180.8	829.8	0.0	505.3
4.2	324.5	543.9	0.0	-219.4	868.4	0.0	543.9
3.2	324.5	582.5	0.0	-258.0	907.0	0.0	582.5
2.2	324.5	621.1	0.0	-296.6	945.6	0.0	621.1
1.7	324.5	640.0	0.0	-315.5	964.5	0.0	640.0
1.2	324.5	659.7	19.7	-315.5	964.5	19.7	659.7
0.2	324.5	698.3	58.3	-315.5	964.5	58.3	698.3
-0.8	324.5	736.9	96.9	-315.5	964.5	96.9	736.9
-1.8	324.5	775.5	135.5	-315.5	964.5	135.5	775.5
-2.8	324.5	814.1	174.1	-315.5	964.5	174.1	814.1
-3.8	324.5	852.7	212.7	-315.5	964.5	212.7	852.7
-4.8	324.5	891.3	251.3	-315.5	964.5	251.3	891.3
-5.8	324.5	929.9	289.9	-315.5	964.5	289.9	929.9
-6.8	324.5	968.5	328.5	-315.5	964.5	328.5	968.5
-7.8	324.5	1007.1	367.1	-315.5	964.5	367.1	1007.1
-8.8	324.5	1045.7	405.7	-315.5	964.5	405.7	1045.7
-9.8	324.5	1084.3	444.3	-315.5	964.5	444.3	1084.3
-10.8	324.5	1122.9	482.9	-315.5	964.5	482.9	1122.9
-11.8	324.5	1161.5	521.5	-315.5	964.5	521.5	1161.5
-12.8	324.5	1200.1	560.1	-315.5	964.5	560.1	1200.1
-13.8	324.5	1238.7	598.7	-315.5	964.5	598.7	1238.7
-14.8	324.5	1277.3	637.3	-315.5	964.5	637.3	1277.3
-15.8	324.5	1315.9	675.9	-315.5	964.5	675.9	1315.9
-16.8	324.5	1354.5	714.5	-315.5	964.5	714.5	1354.5
-17.8	324.5	1393.1	753.1	-315.5	964.5	753.1	1393.1
-18.8	324.5	1431.7	791.7	-315.5	964.5	791.7	1431.7
-19.8	324.5	1470.3	830.3	-315.5	964.5	830.3	1470.3
-20.8	324.5	1508.9	868.9	-315.5	964.5	868.9	1508.9

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS
DATE: 16-MARCH-2020 TIME: 11:52:51

****
* SUMMARY OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (GRAYS HARBOR) OVT1 LOAD CASE
'LOAD CONDITION (SHORT TERM)
'Ground Elev 10ft

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

WALL BOTTOM ELEV. (FT) : -3.92
PENETRATION (FT) : 13.92

MAX. BEND. MOMENT (LB-FT) : 5.2805E+03
AT ELEVATION (FT) : 3.27

MAX. SCALED DEFL. (LB-IN^3): 9.5740E+08
AT ELEVATION (FT) : 15.20

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: 16-MARCH-2020 TIME: 11:52:51

****
* COMPLETE OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (GRAYS HARBOR) OVT1 LOAD CASE
'LOAD CONDITION (SHORT TERM)
'Ground Elev 10ft

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
15.20	0.0000E+00	0.	9.5740E+08	0.00
14.20	1.0400E+01	31.	8.7194E+08	62.40
13.20	8.3200E+01	125.	7.8650E+08	124.80
12.20	2.8080E+02	281.	7.0122E+08	187.20

11.20	6.6560E+02	499.	6.1646E+08	249.60
10.20	1.3000E+03	780.	5.3288E+08	312.00
10.00+	1.4623E+03	844.	5.1639E+08	324.48
10.00-	1.4623E+03	844.	5.1639E+08	4.48
9.88	1.5603E+03	844.	5.0687E+08	0.00
9.20	2.1354E+03	835.	4.5158E+08	-26.40
9.00	2.3018E+03	829.	4.3572E+08	-34.12
8.20	2.9506E+03	789.	3.7397E+08	-65.00
7.20	3.7009E+03	705.	3.0145E+08	-103.60
6.20	4.3475E+03	582.	2.3530E+08	-142.20
5.20	4.8520E+03	420.	1.7665E+08	-180.80
4.20	5.1756E+03	220.	1.2636E+08	-219.40
3.20	5.2799E+03	-18.	8.4982E+07	-258.00
2.20	5.1261E+03	-296.	5.2688E+07	-296.60
1.71	4.9448E+03	-446.	4.0115E+07	-315.52
1.20	4.6766E+03	-607.	2.9210E+07	-315.52
0.20	3.9123E+03	-922.	1.3768E+07	-315.52
-0.45	3.2457E+03	-1127.	7.4314E+06	-315.52
-0.80	2.8352E+03	-1215.	5.0402E+06	-186.79
-1.80	1.5881E+03	-1218.	1.1857E+06	181.64
-2.80	5.2273E+02	-852.	1.0160E+05	550.07
-3.80	7.3906E+00	-117.	1.6680E+01	918.50
-3.92	0.0000E+00	0.	0.0000E+00	964.48

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)
15.20	0.	0.	0.	0.	0.
14.20	62.	0.	0.	0.	0.
13.20	125.	0.	0.	0.	0.
12.20	187.	0.	0.	0.	0.
11.20	250.	0.	0.	0.	0.
10.20	312.	0.	0.	0.	0.
10.00+	324.	0.	0.	0.	0.
10.00-	324.	320.	0.	0.	320.
9.88	324.	324.	0.	0.	324.
9.20	324.	351.	0.	0.	351.
9.00	324.	359.	0.	0.	359.
8.20	324.	389.	0.	0.	389.
7.20	324.	428.	0.	0.	428.
6.20	324.	467.	0.	0.	467.
5.20	324.	505.	0.	0.	505.
4.20	324.	544.	0.	0.	544.
3.20	324.	582.	0.	0.	582.
2.20	324.	621.	0.	0.	621.
1.71	324.	640.	0.	0.	640.
1.20	324.	660.	20.	20.	660.
0.20	324.	698.	58.	58.	698.
-0.45	324.	723.	83.	83.	723.
-0.80	324.	737.	97.	97.	737.
-1.80	324.	775.	135.	135.	775.
-2.80	324.	814.	174.	174.	814.
-3.80	324.	853.	213.	213.	853.
-3.92	324.	891.	251.	251.	891.
-5.80	324.	930.	290.	290.	930.

****
* INPUT DATA *
****

I.--HEADING
'NSL-WEST (GRAYS HARBOR) DWL LOAD CASE
'LOAD CONDITION (LONG TERM)
'Ground Elev 10ft

II.--CONTROL
CANTILEVER WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.50
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

III.--WALL DATA
ELEVATION AT TOP OF WALL = 15.20 FT.

IV.--SURFACE POINT DATA

IV.A.--RIGHTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.00

IV.B.--LEFTSIDE

DIST. FROM WALL (FT)	ELEVATION (FT)
0.00	10.00

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.
101.00	101.00	18.00	0.00	0.00	0.00	-30.00	0.00	DEF	DEF
110.00	110.00	28.00	0.00	0.00	0.00			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.
101.00	101.00	18.00	0.00	0.00	0.00	-30.00	0.00	DEF	DEF
110.00	110.00	28.00	0.00	0.00	0.00			DEF	DEF

VI.--WATER DATA
UNIT WEIGHT = 62.40 (PCF)
RIGHTSIDE ELEVATION = 13.20 (FT)
LEFTSIDE ELEVATION = 10.00 (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: 16-MARCH-2020 TIME: 11:36:47

****
* SOIL PRESSURES FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (GRAYS HARBOR) DWL LOAD CASE
'LOAD CONDITION (LONG TERM)
'Ground Elev 10ft

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

				<------NET------>			
	NET	<---LEFTSIDE--->		(SOIL + WATER)		<--RIGHTSIDE--->	
ELEV.	WATER	PASSIVE	ACTIVE	ACTIVE	PASSIVE	ACTIVE	PASSIVE
(FT)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)
15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.2	62.4	0.0	0.0	62.4	62.4	0.0	0.0
11.2	124.8	0.0	0.0	124.8	124.8	0.0	0.0
10.2	187.2	0.0	0.0	187.2	187.2	0.0	0.0
10.0	199.7	0.0	0.0	199.7	199.7	0.0	0.0
9.2	199.7	47.5	20.1	172.3	227.1	20.1	47.5
9.0	199.7	59.3	25.1	165.5	233.9	25.1	59.3
8.2	199.7	106.8	45.2	138.1	261.3	45.2	106.8
7.2	199.7	166.1	70.3	103.9	295.5	70.3	166.1
6.2	199.7	225.5	95.4	69.6	329.7	95.4	225.5
5.2	199.7	284.8	120.5	35.4	363.9	120.5	284.8
4.2	199.7	344.1	145.6	1.2	398.2	145.6	344.1
4.2	199.7	346.2	146.5	0.0	399.4	146.5	346.2
3.2	199.7	403.5	170.8	-33.0	432.4	170.8	403.5
2.2	199.7	462.8	195.9	-67.2	466.6	195.9	462.8
1.2	199.7	522.1	221.0	-101.5	500.8	221.0	522.1
0.2	199.7	581.5	246.1	-135.7	535.0	246.1	581.5
-0.8	199.7	640.8	271.2	-169.9	569.3	271.2	640.8
-1.8	199.7	700.1	296.3	-204.1	603.5	296.3	700.1
-2.8	199.7	759.5	321.4	-238.3	637.7	321.4	759.5
-3.8	199.7	818.8	346.5	-272.6	671.9	346.5	818.8
-4.8	199.7	878.1	371.7	-306.8	706.1	371.7	878.1
-5.8	199.7	937.5	396.8	-341.0	740.4	396.8	937.5
-6.8	199.7	996.8	421.9	-375.2	774.6	421.9	996.8
-7.8	199.7	1056.1	447.0	-409.4	808.8	447.0	1056.1
-8.8	199.7	1115.5	472.1	-443.7	843.0	472.1	1115.5
-9.8	199.7	1174.8	497.2	-477.9	877.3	497.2	1174.8
-10.8	199.7	1234.1	522.3	-512.1	911.5	522.3	1234.1
-11.8	199.7	1293.5	547.4	-546.3	945.7	547.4	1293.5
-12.8	199.7	1352.8	572.6	-580.6	979.9	572.6	1352.8
-13.8	199.7	1412.1	597.7	-614.8	1014.1	597.7	1412.1
-14.8	199.7	1471.5	622.8	-649.0	1048.4	622.8	1471.5
-15.8	199.7	1530.8	647.9	-683.2	1082.6	647.9	1530.8
-16.8	199.7	1590.1	673.0	-717.4	1116.8	673.0	1590.1
-17.8	199.7	1649.4	698.1	-751.7	1151.0	698.1	1649.4
-18.8	199.7	1708.8	723.2	-785.9	1185.2	723.2	1708.8
-19.8	199.7	1768.1	748.3	-820.1	1219.5	748.3	1768.1
-20.8	199.7	1827.4	773.4	-854.3	1253.7	773.4	1827.4

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS
DATE: 16-MARCH-2020 TIME: 11:37:23

****
* SUMMARY OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (GRAYS HARBOR) DWL LOAD CASE
'LOAD CONDITION (LONG TERM)
'Ground Elev 10ft

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

WALL BOTTOM ELEV. (FT) : -12.28
PENETRATION (FT) : 22.28

MAX. BEND. MOMENT (LB-FT) : 8.8377E+03
AT ELEVATION (FT) : -3.10

MAX. SCALED DEFL. (LB-IN^3): 3.2599E+09
AT ELEVATION (FT) : 15.20

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: 16-MARCH-2020 TIME: 11:37:23

****
* COMPLETE OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (GRAYS HARBOR) DWL LOAD CASE
'LOAD CONDITION (LONG TERM)
'Ground Elev 10ft

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
15.20	0.0000E+00	0.	3.2599E+09	0.00
14.20	1.7462E-10	0.	3.0676E+09	0.00
13.20	1.7462E-10	0.	2.8753E+09	0.00
12.20	1.0400E+01	31.	2.6830E+09	62.40
11.20	8.3200E+01	125.	2.4907E+09	124.80
10.20	2.8080E+02	281.	2.2986E+09	187.20

10.00	3.4079E+02	319.	2.2602E+09	199.68
9.20	6.5736E+02	468.	2.1070E+09	172.30
9.00	7.5441E+02	502.	2.0688E+09	165.46
8.20	1.2061E+03	623.	1.9166E+09	138.08
7.20	1.8929E+03	744.	1.7283E+09	103.86
6.20	2.6836E+03	831.	1.5432E+09	69.64
5.20	3.5439E+03	884.	1.3628E+09	35.42
4.20	4.4396E+03	902.	1.1886E+09	1.20
4.16	4.4713E+03	902.	1.1826E+09	0.00
3.20	5.3366E+03	886.	1.0220E+09	-33.02
2.20	6.2005E+03	836.	8.6459E+08	-67.24
1.20	6.9971E+03	752.	7.1792E+08	-101.46
0.20	7.6924E+03	633.	5.8333E+08	-135.68
-0.80	8.2519E+03	480.	4.6200E+08	-169.90
-1.80	8.6415E+03	293.	3.5492E+08	-204.12
-2.80	8.8270E+03	72.	2.6273E+08	-238.35
-3.80	8.7742E+03	-183.	1.8577E+08	-272.57
-4.80	8.4488E+03	-473.	1.2392E+08	-306.79
-5.80	7.8166E+03	-797.	7.6636E+07	-341.01
-6.80	6.8434E+03	-1155.	4.2806E+07	-375.23
-7.40	6.0874E+03	-1385.	2.8381E+07	-395.62
-7.80	5.4984E+03	-1522.	2.0748E+07	-283.32
-8.80	3.8810E+03	-1666.	8.1498E+06	-5.51
-9.80	2.2582E+03	-1533.	2.2576E+06	272.30
-10.80	9.0767E+02	-1122.	3.0681E+05	550.11
-11.80	1.0724E+02	-433.	3.6803E+03	827.92
-12.28	0.0000E+00	0.	0.0000E+00	962.24

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)
15.20	0.	0.	0.	0.	0.
14.20	0.	0.	0.	0.	0.
13.20	0.	0.	0.	0.	0.
12.20	62.	0.	0.	0.	0.
11.20	125.	0.	0.	0.	0.
10.20	187.	0.	0.	0.	0.
10.00	200.	0.	0.	0.	0.
9.20	200.	47.	20.	20.	47.
9.00	200.	59.	25.	25.	59.
8.20	200.	107.	45.	45.	107.
7.20	200.	166.	70.	70.	166.
6.20	200.	225.	95.	95.	225.
5.20	200.	285.	121.	121.	285.
4.20	200.	344.	146.	146.	344.
4.16	200.	346.	147.	147.	346.
3.20	200.	403.	171.	171.	403.
2.20	200.	463.	196.	196.	463.
1.20	200.	522.	221.	221.	522.
0.20	200.	581.	246.	246.	581.
-0.80	200.	641.	271.	271.	641.
-1.80	200.	700.	296.	296.	700.
-2.80	200.	759.	321.	321.	759.
-3.80	200.	819.	347.	347.	819.
-4.80	200.	878.	372.	372.	878.
-5.80	200.	937.	397.	397.	937.
-6.80	200.	997.	422.	422.	997.
-7.40	200.	1032.	437.	437.	1032.
-7.80	200.	1056.	447.	447.	1056.
-8.80	200.	1115.	472.	472.	1115.
-9.80	200.	1175.	497.	497.	1175.
-10.80	200.	1234.	522.	522.	1234.
-11.80	200.	1293.	547.	547.	1293.
-12.28	200.	1353.	573.	573.	1353.
-13.80	200.	1412.	598.	598.	1412.

****
* INPUT DATA *
****

I.--HEADING
'NSL-WEST (GRAYS HARBOR) OVT1 LOAD CASE
'LOAD CONDITION (SHORT TERM)
'Ground Elev 11ft

II.--CONTROL
CANTILEVER WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.50
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

III.--WALL DATA
ELEVATION AT TOP OF WALL = 15.20 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	11.00

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.
101.00	101.00	0.00	240.00	0.00	0.00	-30.00	0.00	DEF	DEF
110.00	110.00	28.00	0.00	0.00	0.00			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.
101.00	101.00	0.00	240.00	0.00	0.00	-30.00	0.00	DEF	DEF
110.00	110.00	28.00	0.00	0.00	0.00			DEF	DEF

VI.--WATER DATA
UNIT WEIGHT = 62.40 (PCF)
RIGHTSIDE ELEVATION = 15.20 (FT)
LEFTSIDE ELEVATION = 11.00 (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: 16-MARCH-2020 TIME: 11:59:14

****
* SOIL PRESSURES FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (GRAYS HARBOR) OVT1 LOAD CASE
'LOAD CONDITION (SHORT TERM)
'Ground Elev 11ft

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

				<------NET------>			
	NET	<---LEFTSIDE--->		(SOIL + WATER)		<--RIGHTSIDE--->	
ELEV.	WATER	PASSIVE	ACTIVE	ACTIVE	PASSIVE	ACTIVE	PASSIVE
(FT)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)
15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.2	62.4	0.0	0.0	62.4	62.4	0.0	0.0
13.2	124.8	0.0	0.0	124.8	124.8	0.0	0.0
12.2	187.2	0.0	0.0	187.2	187.2	0.0	0.0
11.2	249.6	0.0	0.0	249.6	249.6	0.0	0.0
11.0+	262.1	0.0	0.0	262.1	262.1	0.0	0.0
11.0-	262.1	320.0	0.0	-57.9	582.1	0.0	320.0
10.2	262.1	350.9	0.0	-88.8	613.0	0.0	350.9
10.0	262.1	358.6	0.0	-96.5	620.7	0.0	358.6
9.2	262.1	389.5	0.0	-127.4	651.6	0.0	389.5
8.2	262.1	428.1	0.0	-166.0	690.2	0.0	428.1
7.2	262.1	466.7	0.0	-204.6	728.8	0.0	466.7
6.2	262.1	505.3	0.0	-243.2	767.4	0.0	505.3
5.2	262.1	543.9	0.0	-281.8	806.0	0.0	543.9
4.2	262.1	582.5	0.0	-320.4	844.6	0.0	582.5
3.2	262.1	621.1	0.0	-359.0	883.2	0.0	621.1
2.7	262.1	640.0	0.0	-377.9	902.1	0.0	640.0
2.2	262.1	659.7	19.7	-377.9	902.1	19.7	659.7
1.2	262.1	698.3	58.3	-377.9	902.1	58.3	698.3
0.2	262.1	736.9	96.9	-377.9	902.1	96.9	736.9
-0.8	262.1	775.5	135.5	-377.9	902.1	135.5	775.5
-1.8	262.1	814.1	174.1	-377.9	902.1	174.1	814.1
-2.8	262.1	852.7	212.7	-377.9	902.1	212.7	852.7
-3.8	262.1	891.3	251.3	-377.9	902.1	251.3	891.3
-4.8	262.1	929.9	289.9	-377.9	902.1	289.9	929.9
-5.8	262.1	968.5	328.5	-377.9	902.1	328.5	968.5
-6.8	262.1	1007.1	367.1	-377.9	902.1	367.1	1007.1
-7.8	262.1	1045.7	405.7	-377.9	902.1	405.7	1045.7
-8.8	262.1	1084.3	444.3	-377.9	902.1	444.3	1084.3
-9.8	262.1	1122.9	482.9	-377.9	902.1	482.9	1122.9
-10.8	262.1	1161.5	521.5	-377.9	902.1	521.5	1161.5
-11.8	262.1	1200.1	560.1	-377.9	902.1	560.1	1200.1
-12.8	262.1	1238.7	598.7	-377.9	902.1	598.7	1238.7
-13.8	262.1	1277.3	637.3	-377.9	902.1	637.3	1277.3
-14.8	262.1	1315.9	675.9	-377.9	902.1	675.9	1315.9
-15.8	262.1	1354.5	714.5	-377.9	902.1	714.5	1354.5
-16.8	262.1	1393.1	753.1	-377.9	902.1	753.1	1393.1
-17.8	262.1	1431.7	791.7	-377.9	902.1	791.7	1431.7
-18.8	262.1	1470.3	830.3	-377.9	902.1	830.3	1470.3
-19.8	262.1	1508.9	868.9	-377.9	902.1	868.9	1508.9

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS
DATE: 16-MARCH-2020 TIME: 11:59:53

****
* SUMMARY OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (GRAYS HARBOR) OVT1 LOAD CASE
'LOAD CONDITION (SHORT TERM)
'Ground Elev 11ft

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

WALL BOTTOM ELEV. (FT) : 2.12
PENETRATION (FT) : 8.88

MAX. BEND. MOMENT (LB-FT) : 2.0971E+03
AT ELEVATION (FT) : 6.95

MAX. SCALED DEFL. (LB-IN^3): 1.7819E+08
AT ELEVATION (FT) : 15.20

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: 16-MARCH-2020 TIME: 11:59:53

****
* COMPLETE OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (GRAYS HARBOR) OVT1 LOAD CASE
'LOAD CONDITION (SHORT TERM)
'Ground Elev 11ft

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
15.20	0.0000E+00	0.	1.7819E+08	0.00
14.20	1.0400E+01	31.	1.5532E+08	62.40
13.20	8.3200E+01	125.	1.3247E+08	124.80
12.20	2.8080E+02	281.	1.0979E+08	187.20
11.20	6.6560E+02	499.	8.7624E+07	249.60
11.00+	7.7052E+02	550.	8.3304E+07	262.08

11.00-	7.7052E+02	550.	8.3304E+07	-57.92
10.20	1.1890E+03	492.	6.6631E+07	-88.80
10.00	1.2855E+03	473.	6.2651E+07	-96.52
9.20	1.6298E+03	384.	4.7681E+07	-127.40
8.20	1.9433E+03	237.	3.1528E+07	-166.00
7.20	2.0907E+03	52.	1.8709E+07	-204.60
6.20	2.0336E+03	-172.	9.4737E+06	-243.20
5.20	1.7332E+03	-435.	3.7173E+06	-281.80
4.40	1.2928E+03	-672.	1.2832E+06	-312.63
4.20	1.1518E+03	-724.	9.1525E+05	-205.35
3.20	4.1360E+02	-663.	7.6715E+04	327.26
2.71	1.3821E+02	-439.	7.2265E+03	588.32
2.20	2.6178E+00	-70.	1.6127E+00	859.87
2.12	0.0000E+00	0.	0.0000E+00	902.08

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)
15.20	0.	0.	0.	0.	0.
14.20	62.	0.	0.	0.	0.
13.20	125.	0.	0.	0.	0.
12.20	187.	0.	0.	0.	0.
11.20	250.	0.	0.	0.	0.
11.00+	262.	0.	0.	0.	0.
11.00-	262.	320.	0.	0.	320.
10.20	262.	351.	0.	0.	351.
10.00	262.	359.	0.	0.	359.
9.20	262.	389.	0.	0.	389.
8.20	262.	428.	0.	0.	428.
7.20	262.	467.	0.	0.	467.
6.20	262.	505.	0.	0.	505.
5.20	262.	544.	0.	0.	544.
4.40	262.	575.	0.	0.	575.
4.20	262.	582.	0.	0.	582.
3.20	262.	621.	0.	0.	621.
2.71	262.	640.	0.	0.	640.
2.20	262.	660.	20.	20.	660.
2.12	262.	698.	58.	58.	698.
0.20	262.	737.	97.	97.	737.

****
* INPUT DATA *
****

I.--HEADING
'NSL-WEST (GRAYS HARBOR) DWL LOAD CASE
'LOAD CONDITION (LONG TERM)
'GROUND ELEV 11FT

II.--CONTROL
CANTILEVER WALL DESIGN
FACTOR OF SAFETY FOR ACTIVE PRESSURES = 1.50
FACTOR OF SAFETY FOR PASSIVE PRESSURES = 1.50

III.--WALL DATA
ELEVATION AT TOP OF WALL = 15.20 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	11.00

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.
101.00	101.00	18.00	0.00	0.00	0.00	-30.00	0.00	DEF	DEF
110.00	110.00	28.00	0.00	0.00	0.00			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.
101.00	101.00	18.00	0.00	0.00	0.00	-30.00	0.00	DEF	DEF
110.00	110.00	28.00	0.00	0.00	0.00			DEF	DEF

VI.--WATER DATA
UNIT WEIGHT = 62.40 (PCF)
RIGHTSIDE ELEVATION = 13.20 (FT)
LEFTSIDE ELEVATION = 11.00 (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: 16-MARCH-2020 TIME: 12:04:09

****
* SOIL PRESSURES FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (GRAYS HARBOR) DWL LOAD CASE
'LOAD CONDITION (LONG TERM)
'GROUND ELEV 11FT

II.--SOIL PRESSURES

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

				<------NET------>			
	NET	<---LEFTSIDE--->		(SOIL + WATER)		<--RIGHTSIDE--->	
ELEV.	WATER	PASSIVE	ACTIVE	ACTIVE	PASSIVE	ACTIVE	PASSIVE
(FT)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)
15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.2	62.4	0.0	0.0	62.4	62.4	0.0	0.0
11.2	124.8	0.0	0.0	124.8	124.8	0.0	0.0
11.0	137.3	0.0	0.0	137.3	137.3	0.0	0.0
10.2	137.3	47.5	20.1	109.9	164.7	20.1	47.5
10.0	137.3	59.3	25.1	103.1	171.5	25.1	59.3
9.2	137.3	106.8	45.2	75.7	198.9	45.2	106.8
8.2	137.3	166.1	70.3	41.5	233.1	70.3	166.1
7.2	137.3	225.5	95.4	7.2	267.3	95.4	225.5
7.0	137.3	238.0	100.7	0.0	274.6	100.7	238.0
6.2	137.3	284.8	120.5	-27.0	301.5	120.5	284.8
5.2	137.3	344.1	145.6	-61.2	335.8	145.6	344.1
4.2	137.3	403.5	170.8	-95.4	370.0	170.8	403.5
3.2	137.3	462.8	195.9	-129.6	404.2	195.9	462.8
2.2	137.3	522.1	221.0	-163.9	438.4	221.0	522.1
1.2	137.3	581.5	246.1	-198.1	472.6	246.1	581.5
0.2	137.3	640.8	271.2	-232.3	506.9	271.2	640.8
-0.8	137.3	700.1	296.3	-266.5	541.1	296.3	700.1
-1.8	137.3	759.5	321.4	-300.7	575.3	321.4	759.5
-2.8	137.3	818.8	346.5	-335.0	609.5	346.5	818.8
-3.8	137.3	878.1	371.7	-369.2	643.7	371.7	878.1
-4.8	137.3	937.5	396.8	-403.4	678.0	396.8	937.5
-5.8	137.3	996.8	421.9	-437.6	712.2	421.9	996.8
-6.8	137.3	1056.1	447.0	-471.8	746.4	447.0	1056.1
-7.8	137.3	1115.5	472.1	-506.1	780.6	472.1	1115.5
-8.8	137.3	1174.8	497.2	-540.3	814.9	497.2	1174.8
-9.8	137.3	1234.1	522.3	-574.5	849.1	522.3	1234.1
-10.8	137.3	1293.5	547.4	-608.7	883.3	547.4	1293.5
-11.8	137.3	1352.8	572.6	-643.0	917.5	572.6	1352.8
-12.8	137.3	1412.1	597.7	-677.2	951.7	597.7	1412.1
-13.8	137.3	1471.5	622.8	-711.4	986.0	622.8	1471.5
-14.8	137.3	1530.8	647.9	-745.6	1020.2	647.9	1530.8
-15.8	137.3	1590.1	673.0	-779.8	1054.4	673.0	1590.1
-16.8	137.3	1649.4	698.1	-814.1	1088.6	698.1	1649.4
-17.8	137.3	1708.8	723.2	-848.3	1122.8	723.2	1708.8
-18.8	137.3	1768.1	748.3	-882.5	1157.1	748.3	1768.1
-19.8	137.3	1827.4	773.4	-916.7	1191.3	773.4	1827.4

PROGRAM CWALSHT-DESIGN/ANALYSIS OF ANCHORED OR CANTILEVER SHEET PILE WALLS
BY CLASSICAL METHODS
DATE: 16-MARCH-2020 TIME: 12:04:32

****
* SUMMARY OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (GRAYS HARBOR) DWL LOAD CASE
'LOAD CONDITION (LONG TERM)
'GROUND ELEV 11FT

II.--SUMMARY

RIGHTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

LEFTSIDE SOIL PRESSURES DETERMINED BY COULOMB COEFFICIENTS
AND THEORY OF ELLASTICITY EQUATIONS FOR SURCHARGE LOADS.

WALL BOTTOM ELEV. (FT) : -4.32
PENETRATION (FT) : 15.32

MAX. BEND. MOMENT (LB-FT) : 2.8718E+03
AT ELEVATION (FT) : 2.00

MAX. SCALED DEFL. (LB-IN^3): 5.2753E+08
AT ELEVATION (FT) : 15.20

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: 16-MARCH-2020 TIME: 12:04:32

****
* COMPLETE OF RESULTS FOR *
* CANTILEVER WALL DESIGN *
****

I.--HEADING
'NSL-WEST (GRAYS HARBOR) DWL LOAD CASE
'LOAD CONDITION (LONG TERM)
'GROUND ELEV 11FT

II.--RESULTS

ELEVATION (FT)	BENDING MOMENT (LB-FT)	SHEAR (LB)	SCALED DEFLECTION (LB-IN^3)	NET PRESSURE (PSF)
15.20	0.0000E+00	0.	5.2753E+08	0.00
14.20	0.0000E+00	0.	4.8457E+08	0.00
13.20	1.7462E-10	0.	4.4161E+08	0.00
12.20	1.0400E+01	31.	3.9866E+08	62.40
11.20	8.3200E+01	125.	3.5572E+08	124.80
11.00	1.1074E+02	151.	3.4715E+08	137.28
10.20	2.7256E+02	250.	3.1295E+08	109.90

10.00	3.2468E+02	271.	3.0444E+08	103.06
9.20	5.7168E+02	343.	2.7067E+08	75.68
8.20	9.4650E+02	401.	2.2939E+08	41.46
7.20	1.3628E+03	426.	1.8974E+08	7.24
6.99	1.4529E+03	426.	1.8163E+08	0.00
6.20	1.7863E+03	416.	1.5246E+08	-26.98
5.20	2.1828E+03	372.	1.1825E+08	-61.20
4.20	2.5182E+03	293.	8.7812E+07	-95.42
3.20	2.7581E+03	181.	6.1709E+07	-129.64
2.20	2.8683E+03	34.	4.0353E+07	-163.86
1.20	2.8148E+03	-147.	2.3930E+07	-198.08
0.20	2.5631E+03	-362.	1.2342E+07	-232.30
-0.80	2.0791E+03	-612.	5.1500E+06	-266.52
-0.96	1.9781E+03	-655.	4.3590E+06	-271.99
-1.80	1.3595E+03	-785.	1.5141E+06	-38.52
-2.80	6.0154E+02	-685.	2.2174E+05	239.29
-3.80	8.2900E+01	-306.	3.3277E+03	517.10
-4.32	0.0000E+00	0.	0.0000E+00	661.54

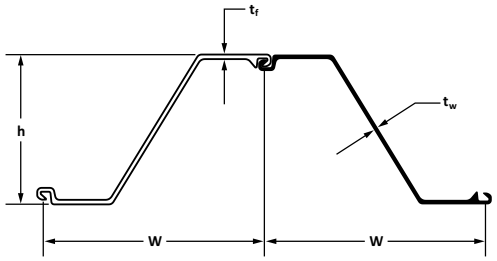
NOTE: DIVIDE SCALED DEFLECTION MODULUS OF ELLASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN IN^4 TO OBTAIN DEFLECTION IN INCHES.

III.--WATER AND SOIL PRESSURES

		<----------SOIL PRESSURES---------->			
	WATER	<----LEFTSIDE----->		<---RIGHTSIDE---->	
ELEVATION	PRESSURE	PASSIVE	ACTIVE	ACTIVE	PASSIVE
(FT)	(PSF)	(PSF)	(PSF)	(PSF)	(PSF)
15.20	0.	0.	0.	0.	0.
14.20	0.	0.	0.	0.	0.
13.20	0.	0.	0.	0.	0.
12.20	62.	0.	0.	0.	0.
11.20	125.	0.	0.	0.	0.
11.00	137.	0.	0.	0.	0.
10.20	137.	47.	20.	20.	47.
10.00	137.	59.	25.	25.	59.
9.20	137.	107.	45.	45.	107.
8.20	137.	166.	70.	70.	166.
7.20	137.	225.	95.	95.	225.
6.99	137.	238.	101.	101.	238.
6.20	137.	285.	121.	121.	285.
5.20	137.	344.	146.	146.	344.
4.20	137.	403.	171.	171.	403.
3.20	137.	463.	196.	196.	463.
2.20	137.	522.	221.	221.	522.
1.20	137.	581.	246.	246.	581.
0.20	137.	641.	271.	271.	641.
-0.80	137.	700.	296.	296.	700.
-0.96	137.	710.	300.	300.	710.
-1.80	137.	759.	321.	321.	759.
-2.80	137.	819.	347.	347.	819.
-3.80	137.	878.	372.	372.	878.
-4.32	137.	937.	397.	397.	937.
-5.80	137.	997.	422.	422.	997.

NZ

NZ Hot Rolled Steel Sheet Pile



NZ

SECTION	Width (w) in mm	Height (h) in mm	THICKNESS Flange (t_f) in mm	THICKNESS Web (t_w) in mm	Cross Sectional Area in²/ft cm²/m	WEIGHT Pile lb/ft kg/m	WEIGHT Wall lb/ft² kg/m²	SECTION MODULUS Elastic in³/ft cm³/m	SECTION MODULUS Plastic in³/ft cm³/m	Moment of Inertia in⁴/ft cm⁴/m	COATING AREA Both Sides ft²/ft of single m²/m	COATING AREA Wall Surface ft²/ft² m²/m²
NZ 14	30.31 770	13.39 340	0.375 9.5	0.375 9.5	6.40 135.4	55 81.26	21.77 106.30	25.65 1379	30.50 1640	171.7 23447	6.10 1.86	1.20 1.20
NZ 19	27.56 700	16.14 410	0.375 9.5	0.375 9.5	7.07 149.6	55 81.85	24.05 117.40	35.08 1886	41.33 2222	283.1 38659	6.18 1.88	1.35 1.35
NZ 20	27.56 700	16.16 411	0.394 10.0	0.394 10.0	7.34 155.4	57 85.37	24.82 122.00	36.24 1948	42.80 2301	292.8 39984	6.18 1.88	1.35 1.35
NZ 21	27.56 700	16.20 412	0.433 11.0	0.433 11.0	7.80 165.2	61 90.78	26.56 129.70	38.69 2080	45.85 2465	313.4 42797	6.18 1.88	1.35 1.35
NZ 26	27.56 700	17.32 440	0.500 12.7	0.500 12.7	9.08 192.2	71 105.66	30.99 151.30	48.50 2608	57.01 3065	419.9 57340	6.49 1.98	1.41 1.41
NZ 28	27.56 700	17.38 441	0.560 14.2	0.560 14.2	9.98 211.2	78 116.08	33.96 165.82	52.62 2829	62.16 3342	457.4 62461	6.49 1.98	1.41 1.41
NZ 38	27.56 700	19.69 500	0.689 17.5	0.500 12.7	11.00 232.9	86 127.99	37.45 182.83	70.84 3809	81.57 4386	697.3 95214	6.58 2.01	1.43 1.43

NZ

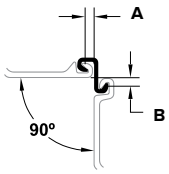
NZ Hot Rolled Steel Sheet Pile

Available Steel Grades

NZ		
ASTM	YIELD STRENGTH	
	ksi	MPa
A 328	39	270
A 572 Grade 50	50	345
A 572 Grade 60	60	415
A 572 Grade 65	65	450
A 588	50	345
A 690	50	345

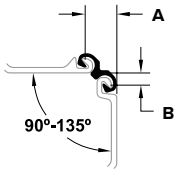
Highlighted fields represent the most commonly used and readily available steel grades.

NZ Corner Piles



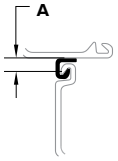
C 14/E 20

Gr: S 355 GP
Wt: 9.68 lb/ft 14.4 kg/m
A: ~0.98" 25 mm
B: ~0.98" 25 mm



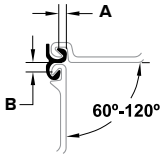
Omega 18

Gr: S 430 GP
Wt: 12.10 lb/ft 18.0 kg/m
A: ~2.76" ~70 mm
B: ~1.18" ~30 mm



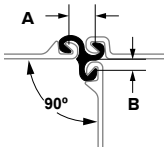
E 22

Gr: S 355 GP
Wt: 6.87 lb/ft 10.2 kg/m
A: ~1.18" ~30 mm



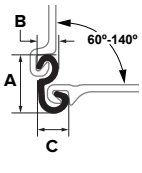
Delta 13

Gr: S 355 GP
Wt: 8.8 lb/ft 13.1 kg/m
A: ~0.59" ~15 mm
B: ~0.79" ~20 mm



Larssen T

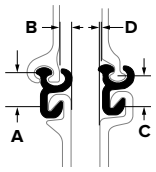
Gr: A 572 Gr. 60
Wt: 14.02 lb/ft 00 kg/m
A: 2.075" 5.27 mm
B: 0.914" 23.2 mm



SKLC 90

Gr: A 572 Gr. 60
Wt: 8.50 lb/ft 12.6 kg/m
A: 4.09" 103.9 mm
B: 1.10" 27.9 mm
C: 2.05" 52.1 mm

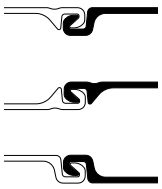
Transitional Piles



SKAP

Gr: A 572 Gr. 50/60
Wt: 8.95 lb/ft 13.3 kg/m
A: 1.97" 50.0 mm
B: 0.69" 17.5 mm
C: 1.61" 40.9 mm
D: 0.02" 0.5 mm

Interlock Combinations



Delivery Conditions & Tolerances

ASTM A 6		
Mass	± 2.5%	
Length	+ 5 inches	– 0 inches

Maximum Rolled Lengths*

NZ	105.0 feet	(32.0 m)

* Longer lengths may be possible upon request.

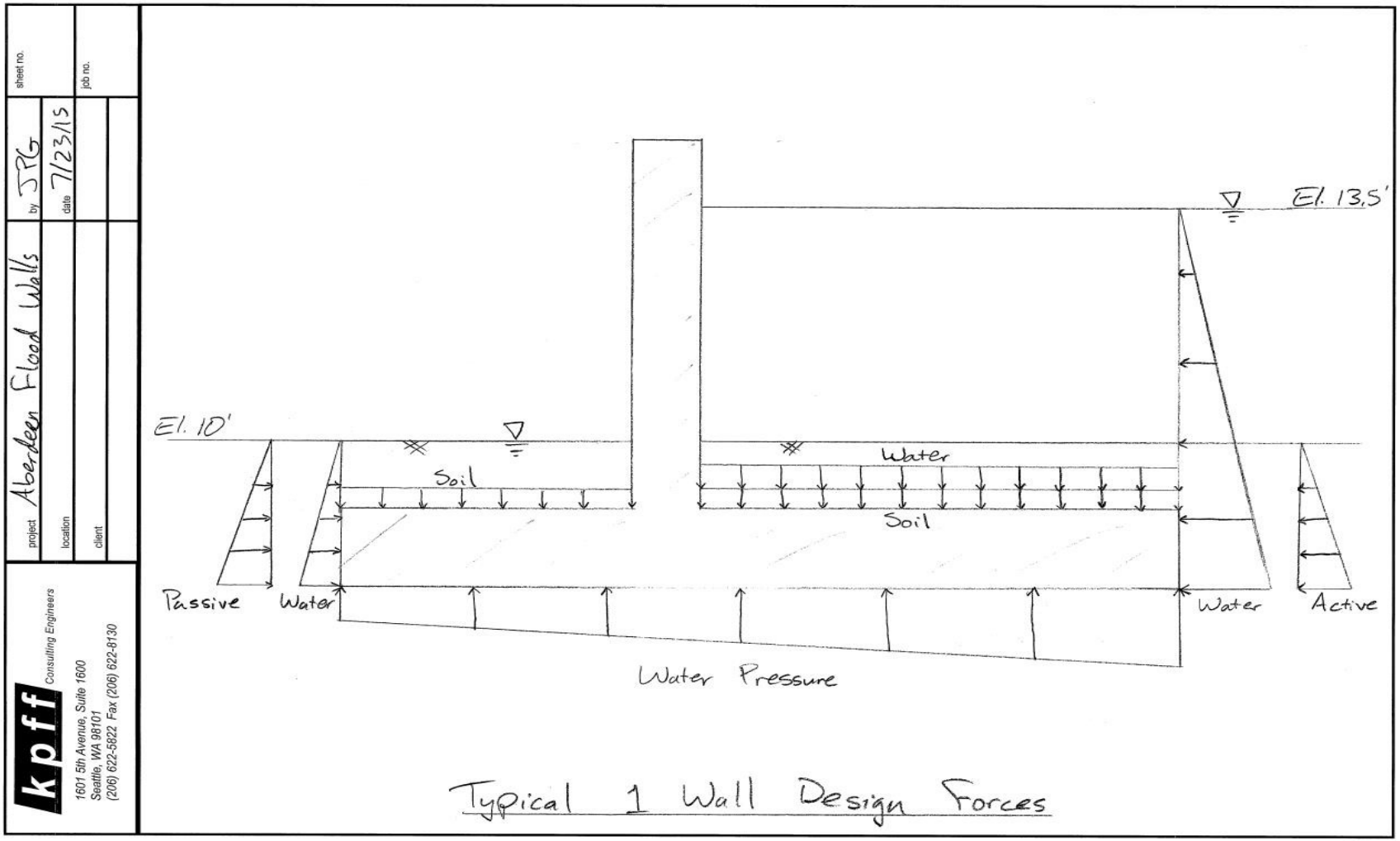
CONCRETE T-WALLS

APPROACH:

THE T-WALL CALCULATIONS FROM THE NORTH SHORE LEVEE PROJECT ARE USED HEREIN BECAUSE THE WALL DIMENSIONS AND SOIL PROPERTIES FROM THAT PROJECT ARE SO SIMILAR TO THIS ONE. THE LOWEST DESIGN ULTIMATE BEARING PRESSURES FOR NSL WEST ARE 1436 PSF FOR THE GRAYS HARBOR ALIGNMENT PER TABLE 3 IN GEOENGINEERS REPORT DATED MARCH 10, 2020. THIS COMPARES TO THE DESIGN ULTIMATE BEARING PRESSURE FOR NORTH SHORE LEVEE OF 1460 PSF, WHICH IS WITHIN 2%. BOTH PROJECTS HAVE A TOP OF WALL ELEVATION OF 15.2'.

THE NORTH SHORE LEVEE T-WALL CALCULATIONS USED HEREIN UTILIZE A SPREADSHEET THAT EVALUATES THE T-WALLS FOR THE FOLLOWING:

- SLIDING AND OVERTURNING STABILITY
- BEARING PRESSURE
- CONCRETE THICKNESS AND REINFORCING REQUIRED FOR STRUCTURAL STRENGTH


sheet no.
job no.
by JRG
date 7/23/15
project Aberdeen Flood Walls
location
client
kpff Consulting Engineers
1601 5th Avenue, Suite 1600
Seattle, WA 98101
(206) 622-5822 Fax (206) 622-8130
El. 13.5'
El. 10'
Soil
Water
Soil
Passive
Water
Water
Active
Water Pressure
Typical 1 Wall Design Forces

Concrete Flood Wall - Design Water Level (DWL)

Single Stem T-Wall Design

Dimensions

Wall Height	5.50	*ft*
Depth to T/Ftg	12	*in*
Wall Thickness	12	*in*
Footing Width	13	*ft*
Toe Width	5	*ft*
Heel Width	7.00	*ft*
Footing Thickness	16	*in*

Rebar	**Size**	**Spacing**	
Footing Primary	6	10	*in*
Footing Secondary	5	12	*in*
Wall Front	5	10	*in*
Wall Back	5	10	*in*
Wall Secondary	4	8	*in*

Design Flood (3.5' for DWL, 4.5' for OVT1)

Flood depth	3.5	*ft*

Depths to Bottom of Footing

Depth to Ftg Bot	2.33	*ft*
Flood Level	5.83	*ft*
Top of Wall	6.83	*ft*

Soil

Active	18	*psf/ft*
Passive	190	*psf/ft*
Bearing Capacity	1.46	*ksf*
Saturated Density	100	*pcf*
Cohesion	250	*psf*
Friction Coefficient	0.6	

Design C/D's		**Required**	
Wall Flexure	**11.61**	1	
Wall Shear	**14.52**	1	
Wall Steel	**1.02**	1	
Footing Flexure	**1.62**	1	
Footing Shear	**2.79**	1	
Footing Steel	**1.06**	1	
Overturning	**1.51**	1.5	EM Tbl 4-2
Sliding	**2.22**	1.5	EM Tbl 4-2
Bearing	**6.15**	3	EM Tbl 4-2

2-Stem (Planter) T-Wall Design

Dimensions

Wall Height	5.50	*ft*
Depth to T/Ftg	12	*in*
Wall Thickness	12	*in*
Footing Width	16	*ft*
Toe Width	1.75	*ft*
Planter Width	6	*ft*
Heel Width	6.25	*ft*
Footing Thickness	16	*in*

Rebar	**Size**	**Spacing**	
Footing Primary	6	10	*in*
Footing Secondary	5	12	*in*
Wall Front	5	10	*in*
Wall Back	5	10	*in*
Wall Secondary	4	8	*in*

Design Flood (3.5' for DWL, 4.5' for OVT1)

Flood depth	3.5	*ft*

Depths to Bottom of Footing

Depth to Ftg Bot	2.33	*ft*
Planter Level	1.33	*ft* (empty)
Flood Level	5.83	*ft*
Top of Wall	6.83	*ft*

Soil Pressures

Active	18	*psf/ft*
Passive	190	*psf/ft*
Bearing Capacity	1.46	*ksf*
Saturated Density	100	*pcf*
Cohesion	250	*psf*
Friction Coefficient	0.6	

Design C/D's		**Required**	
Wall Flexure	**11.09**	1	
Wall Shear	**11.66**	1	
Wall Steel	**1.02**	1	
Footing Flexure	**2.03**	1	
Footing Shear	**3.13**	1	
Footing Steel	**1.06**	1	
Overturning	**1.55**	1.5	EM Tbl 4-2
Sliding	**3.27**	1.5	EM Tbl 4-2
Bearing	**4.08**	3	EM Tbl 4-2

Strength design (wall and footing flexure, shear, and steel) was done using ACI 318-11. Stability checks (overturning, sliding, and bearing) were done using the US Army Corps of Engineers Retaining and Flood Walls Engineer Manual 1110-2-2502. Overturning considers both overturning moments and reaction resultant location.

The planter two wall case assumes a minimum of 3'-0" of soil in planter. The available depth is 5'-6".

Stability

Properties

Concrete

f'_c	4 *ksi*	
γ_c	155 *pcf*	
L_{unit}	1 *ft*	
h_{foot}	16 *in*	
b_{total}	13.0 *ft*	
b_{heel}	7.00 *ft*	
b_{toe}	5.00 *ft*	
t_{wall}	12 *in*	
h_{wall}	5.50 *ft*	

Soil

γ_{sat}	100 *pcf*	Assumed
C	250 *psf*	GeoEngineers Table 4
μ	0.6	GeoEngineers Table 4

Elevations

h_{flood}	14.2 *ft*
$h_{ground\ surface}$	10.7 *ft*
$h_{top\ foot}$	9.70 *ft*
$h_{bottom\ foot}$	8.37 *ft*
d_{water}	5.83 *ft*
d_{soil}	2.33 *ft*

Pressures

Flood Side Water

γ_{water}	62.4 *pcf*
$\sigma_{foot\ bot}$	364 *psf*
P_{water}	1.06 *k/ft*
$h_{P\text{-}water}$	1.94 *ft*

Active Earth

γ_{soil}	18 *psf*
$\sigma_{foot\ bot}$	42 *psf*
P_{soil}	0.05 *k/ft*
$h_{P\text{-}soil}$	0.78 *ft*

Protected Side Water

γ_{water}	62.4 *psf*
$\sigma_{foot\ bot}$	146 *psf*
P_{water}	0.17 *k/ft*
$h_{P\text{-}water}$	0.78 *ft*

Passive Earth

γ_{soil}	190 *psf*	
$\sigma_{foot\ bot}$	443 *psf*	
P_{soil}	0.52 *k/ft*	
$h_{P\text{-}soil}$	0.78 *ft*	

Water Under Footing

γ_{water}	62.4 *psf*	
$\sigma_{toe\ bot}$	146 *psf*	
$\sigma_{heel\ bot}$	364 *psf*	
P_{water}	3.31 *k/ft*	
$b_{P\text{-}water}$	7.43 *ft*	*From toe*

Overturning

Overturning Moments

Horizontal		
Flood Water	2.06 *k-ft/ft*	
Active Soil	0.04 *k-ft/ft*	
Vertical		
Footing Water	24.61 *k-ft/ft*	
	26.71 *k-ft/ft*	

Resisting Moments

Horizontal		
Protected Water	0.13 *k-ft/ft*	
Passive Soil	0.40 *k-ft/ft*	
Vertical		
Toe Soil	1.25 *k-ft/ft*	
Heel Soil	6.65 *k-ft/ft*	
Footing	17.46 *k-ft/ft*	
Wall	3.03 *k-ft/ft*	
Flood Water	11.47 *k-ft/ft*	
	40.39 *k-ft/ft*	
C/D	**1.51**	**OK**

Sliding

Driving

Active Soil	0.05 *k/ft*	
Flood Water	1.06 *k/ft*	
	1.11 *k/ft*	

Resisting

Passive Soil	0.52 *k/ft*	
Protected Water	0.17 *k/ft*	
Friction	1.77 *k/ft*	
	2.46 *k/ft*	
C/D	**2.22**	**OK**
Required	**1.50**	USACE EM 1110-2-2502 Table 4-2

Bearing

Vertical Forces

Concrete	3.54	*k/ft*
Soil	1.20	*k/ft*
Water Weight	1.53	*k/ft*
Footing Water	-3.31	*k/ft*
P_{total}	2.96	*k/ft*

Moments about Bottom Center of Footing

Vertical		
Wall	-0.85	*k-ft/ft*
Heel Soil	2.10	*k-ft/ft*
Toe Soil	-2.00	*k-ft/ft*
Flood Water	4.59	*k-ft/ft*
Footing Water	-3.08	*k-ft/ft*
Horizontal		
Passive Soil	0.40	*k-ft/ft*
Active Soil	-0.04	*k-ft/ft*
Protected Water	0.13	*k-ft/ft*
Flood Water	-2.06	*k-ft/ft*
M_{total}	0.81	*k-ft/ft*

Resultant Location and Maximum Pressure

e	**0.27**	***ft***	
σ_{max}	**0.24**	***ksf***	AASHTO 11.6.3.2
Max e (+-)	2.17	*ft*	USACE EM 1110-2-2502 Table 4-2 & Figure 4-4
e C/D	**7.91**	**OK**	
Max σ	1.46	*ksf*	GeoEngineers Table 3
σ C/D	**6.15**	**OK**	
Required	**3.00**		USACE EM 1110-2-2502 Table 4-2

Concrete Flood Wall - Water to Top of Wall (OVT1)

Single Stem T-Wall Design

Dimensions

Wall Height	5.50	*ft*
Depth to T/Ftg	12	*in*
Wall Thickness	12	*in*
Footing Width	13	*ft*
Toe Width	5	*ft*
Heel Width	7.00	*ft*
Footing Thickness	16	*in*

Rebar	**Size**	**Spacing**	
Footing Primary	6	10	*in*
Footing Secondary	5	12	*in*
Wall Front	5	10	*in*
Wall Back	5	10	*in*
Wall Secondary	4	8	*in*

Design Flood (3.5' for DWL, 4.5' for OVT1)

Flood depth	4.5	*ft*

Depths to Bottom of Footing

Depth to Ftg Bot	2.33	*ft*
Flood Level	6.83	*ft*
Top of Wall	6.83	*ft*

Soil

Active	18	*psf/ft*
Passive	190	*psf/ft*
Bearing Capacity	1.46	*ksf*
Saturated Density	100	*pcf*
Cohesion	250	*psf*
Friction Coefficient	0.6	

Design C/D's		**Required**	
Wall Flexure	**6.24**	1	
Wall Shear	**9.04**	1	
Wall Steel	**1.02**	1	
Footing Flexure	**1.45**	1	
Footing Shear	**2.50**	1	
Footing Steel	**1.06**	1	
Overturning	**1.39**	1.33	EM Tbl 4-2
Sliding	**1.65**	1.33	EM Tbl 4-2
Bearing	**5.82**	2	EM Tbl 4-2

2-Stem (Planter) T-Wall Design

Dimensions

Wall Height	5.50	*ft*
Depth to T/Ftg	12	*in*
Wall Thickness	12	*in*
Footing Width	16	*ft*
Toe Width	1.75	*ft*
Planter Width	6	*ft*
Heel Width	6.25	*ft*
Footing Thickness	16	*in*

Rebar	**Size**	**Spacing**	
Footing Primary	6	10	*in*
Footing Secondary	5	12	*in*
Wall Front	5	10	*in*
Wall Back	5	10	*in*
Wall Secondary	4	8	*in*

Design Flood (3.5' for DWL, 4.5' for OVT1)

Flood depth	4.5	*ft*

Depths to Bottom of Footing

Depth to Ftg Bot	2.33	*ft*	
Planter Level	1.33	*ft*	(empty)
Flood Level	6.83	*ft*	
Top of Wall	6.83	*ft*	

Soil Pressures

Active	18	*psf/ft*
Passive	190	*psf/ft*
Bearing Capacity	1.46	*ksf*
Saturated Density	100	*pcf*
Cohesion	250	*psf*
Friction Coefficient	0.6	

Design C/D's		**Required**	
Wall Flexure	**6.08**	1	
Wall Shear	**7.84**	1	
Wall Steel	**1.02**	1	
Footing Flexure	**1.82**	1	
Footing Shear	**2.80**	1	
Footing Steel	**1.06**	1	
Overturning	**1.37**	1.33	EM Tbl 4-2
Sliding	**2.37**	1.33	EM Tbl 4-2
Bearing	**4.07**	2	EM Tbl 4-2

Strength design (wall and footing flexure, shear, and steel) was done using ACI 318-11. Stability checks (overturning, sliding, and bearing) were done using the US Army Corps of Engineers Retaining and Flood Walls Engineer Manual 1110-2-2502. Overturning considers both overturning moments and reaction resultant location.

The planter two wall case assumes a minimum of 3'-0" of soil in planter. The available depth is 5'-6".

Stability

Properties

Concrete

f'_c	4 *ksi*	
γ_c	155 *pcf*	
L_{unit}	1 *ft*	
h_{foot}	16 *in*	
b_{total}	13.0 *ft*	
b_{heel}	7.00 *ft*	
b_{toe}	5.00 *ft*	
t_{wall}	12 *in*	
h_{wall}	5.50 *ft*	

Soil

γ_{sat}	100 *pcf*	Assumed
C	250 *psf*	GeoEngineers Table 4
μ	0.6	GeoEngineers Table 4

Elevations

h_{flood}	15.2 *ft*
$h_{ground\ surface}$	10.7 *ft*
$h_{top\ foot}$	9.70 *ft*
$h_{bottom\ foot}$	8.37 *ft*
d_{water}	6.83 *ft*
d_{soil}	2.33 *ft*

Pressures

Flood Side Water

γ_{water}	62.4 *pcf*
$\sigma_{foot\ bot}$	426 *psf*
P_{water}	1.46 *k/ft*
$h_{P\text{-}water}$	2.28 *ft*

Active Earth

γ_{soil}	18 *psf*
$\sigma_{foot\ bot}$	42 *psf*
P_{soil}	0.05 *k/ft*
$h_{P\text{-}soil}$	0.78 *ft*

Protected Side Water

γ_{water}	62.4 *psf*
$\sigma_{foot\ bot}$	146 *psf*
P_{water}	0.17 *k/ft*
$h_{P\text{-}water}$	0.78 *ft*

Passive Earth

γ_{soil}	190 *psf*	
$\sigma_{foot\ bot}$	443 *psf*	
P_{soil}	0.52 *k/ft*	
$h_{P\text{-}soil}$	0.78 *ft*	

Water Under Footing

γ_{water}	62.4 *psf*	
$\sigma_{toe\ bot}$	146 *psf*	
$\sigma_{heel\ bot}$	426 *psf*	
P_{water}	3.72 *k/ft*	
$b_{P\text{-}water}$	7.56 *ft*	*From toe*

Overturning

Overturning Moments

Horizontal		
Flood Water	3.32 *k-ft/ft*	
Active Soil	0.04 *k-ft/ft*	
Vertical		
Footing Water	28.12 *k-ft/ft*	
	31.48 *k-ft/ft*	

Resisting Moments

Horizontal		
Protected Water	0.13 *k-ft/ft*	
Passive Soil	0.40 *k-ft/ft*	
Vertical		
Toe Soil	1.25 *k-ft/ft*	
Heel Soil	6.65 *k-ft/ft*	
Footing	17.46 *k-ft/ft*	
Wall	3.03 *k-ft/ft*	
Flood Water	14.74 *k-ft/ft*	
	43.66 *k-ft/ft*	

C/D	**1.39**	**OK**

Sliding

Driving

Active Soil	0.05 *k/ft*	
Flood Water	1.46 *k/ft*	
	1.51 *k/ft*	

Resisting

Passive Soil	0.52 *k/ft*	
Protected Water	0.17 *k/ft*	
Friction	1.79 *k/ft*	
	2.48 *k/ft*	

C/D	**1.65**	**OK**
Required	**1.33**	USACE EM 1110-2-2502 Table 4-2

Bearing

Vertical Forces

Concrete	3.54	*k/ft*
Soil	1.20	*k/ft*
Water Weight	1.97	*k/ft*
Footing Water	-3.72	*k/ft*
P_{total}	2.99	*k/ft*

Moments about Bottom Center of Footing

Vertical		
Wall	-0.85	*k-ft/ft*
Heel Soil	2.10	*k-ft/ft*
Toe Soil	-2.00	*k-ft/ft*
Flood Water	5.90	*k-ft/ft*
Footing Water	-3.95	*k-ft/ft*
Horizontal		
Passive Soil	0.40	*k-ft/ft*
Active Soil	-0.04	*k-ft/ft*
Protected Water	0.13	*k-ft/ft*
Flood Water	-3.32	*k-ft/ft*
M_{total}	1.63	*k-ft/ft*

Resultant Location and Maximum Pressure

e	**0.55**	***ft***	
σ_{max}	**0.25**	***ksf***	AASHTO 11.6.3.2
Max e (+-)	3.25	*ft*	USACE EM 1110-2-2502 Table 4-2 & Figure 4-4
e C/D	**5.95**	**OK**	
Max σ	1.46	*ksf*	GeoEngineers Table 3
σ C/D	**5.82**	**OK**	
Required	**2.00**		USACE EM 1110-2-2502 Table 4-2

SEISMIC, WIND AND SOIL LOAD CONDITIONS

This section checks flood wall dimensions and reinforcing determined in the “Design Flood Condition” calculations for Reaches 1, 3 and 6, for load combinations that don’t include flood loads.

The following loads are considered for the wind condition:

- Dead
- Soil
- Wind

The following loads are considered for the soil only condition:

- Dead
- Soil

The following loads are considered for the seismic condition:

- Dead
- Soil
- Seismic

Discussion

By inspection, none of these load conditions controls over the flood condition. It is apparent from inspection of the footing sizes determined for the flood condition that neither wind nor seismic forces would require such wide footings for such a short wall.

However, for completeness, the following pages contain checks of the typical “T” wall for wind and seismic forces. These checks are accomplished by comparing the wind and seismic driving forces to those calculated for the flood conditions. It is found that flood loads exceed wind and seismic loads.

In addition, note that the hydrostatic uplift on the footing that occurs in the flood condition has a large effect on required footing size. Since this hydrostatic uplift doesn’t occur in the wind or seismic conditions, this makes those conditions even less severe compared to the flood condition than the simple comparison of driving forces shown on the following pages indicates.

Also, note that lower factors of safety would be required for the seismic condition than for the flood condition by EM 1110-2-2502 Table 4-2.

By inspection, the soil only condition won’t control because the soil active and passive forces are small compared to the flood forces.

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project NORTH LEVEE		by TE	sheet no.
location ABERDEEN		date 3/7/16	
client			job no.

WIND FORCE

CONSERVATIVELY USE 30 PSF PER EM 1110-2-2502 SECTION 3-25

$V = 4.5' (30\ PSF) = 135\ PLF$

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Seattle, WA 98101
(206) 622-5822 Fax (206) 622-8130

project | by BE | sheet no.
location | date 8/7/15
client | job no.

SEISMIC FORCE

PER ASCE 7-10

SITE CLASS - ASSUME CLASS E (SOFT CLAY)

$S_1 = 1.5$ PER ASCE FIG 22-1

$F_a = 1.0$ PER ASCE TABLE 11.4-1

$S_{MS} = F_a S_1 = 1.0(1.5) = 1.5$

$S_{DS} = \frac{2}{3} S_{MS} = 1.0$

$V = 0.30 S_{DS} W I_e$ PER ASCE 15.4-5

WHERE:

$W = 1'(155\ PLF)(4.5') = 698\ PLF$

↑ WALL THICKNESS ↑ WALL HEIGHT

$I_e = 1.25$ (RISK CATEGORY III) PER TABLE 1.5-2

"SUBSTANTIAL RISK TO HUMAN LIFE"

$V_u = 0.30(1.0)\,698\ PLF\,(1.25) = 262\ PLF$ ULTIMATE

TO CONVERT TO WORKING LEVEL TO COMPARE WITH OTHER FORCES, MULTIPLY BY 0.7 PER ASCE 2.4.1

$V = 0.7 V_u = 262\ PLF(0.7) = \underline{183\ PLF}$ FOR WALL MASS

SEISMIC ACTIVE PRESSURE FOR SOIL AT FOOTING LEVEL WILL BE NEGLIGIBLE

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project	by BE	sheet no.
location	date 8/7/15	
client		job no.

HYDROSTATIC

COMPUTE HYDROSTATIC ABOVE GROUND LEVEL ONLY (CONSERVATIVE)

$V = 62.4\ PCF \left(3.5'\right)\left(\frac{3.5'}{2}\right) = 382\ PLF$

$\longrightarrow$ GREATER THAN { WIND = 135 PLF ; JENNIL = 183 PLF

∴ HYDROSTATIC CONTROLS