

Summary:

All piles are HP 14x89 in 2.5' diameter shafts

Tiebacks are inclined at 20 degrees below horizontal

No tiebacks up to a 10' exposed height (Piles 1-4 and 18-22)

1 tieback up to a 21.5' exposed height (Piles 5-8 and 14-17)

2 tiebacks otherwise (Piles 9-13) with Piles 9-10 being the "culvert span" piles

For 2 tiebacks (main wall and culvert span):

@ 10', 6 strands to 64' total length

@ 20', 4 strands to 39' total length

Pile embedded 5' into bedrock

For 1 tieback:

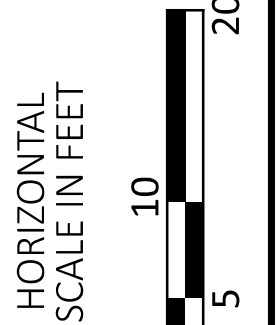
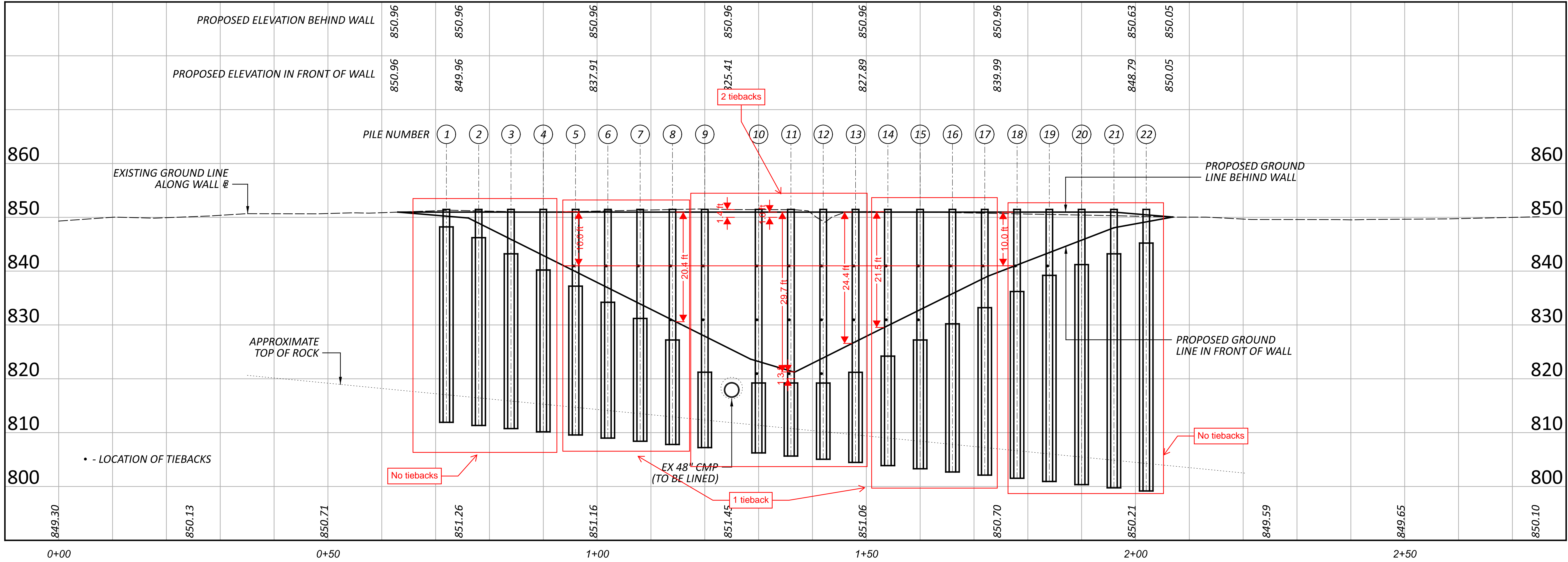
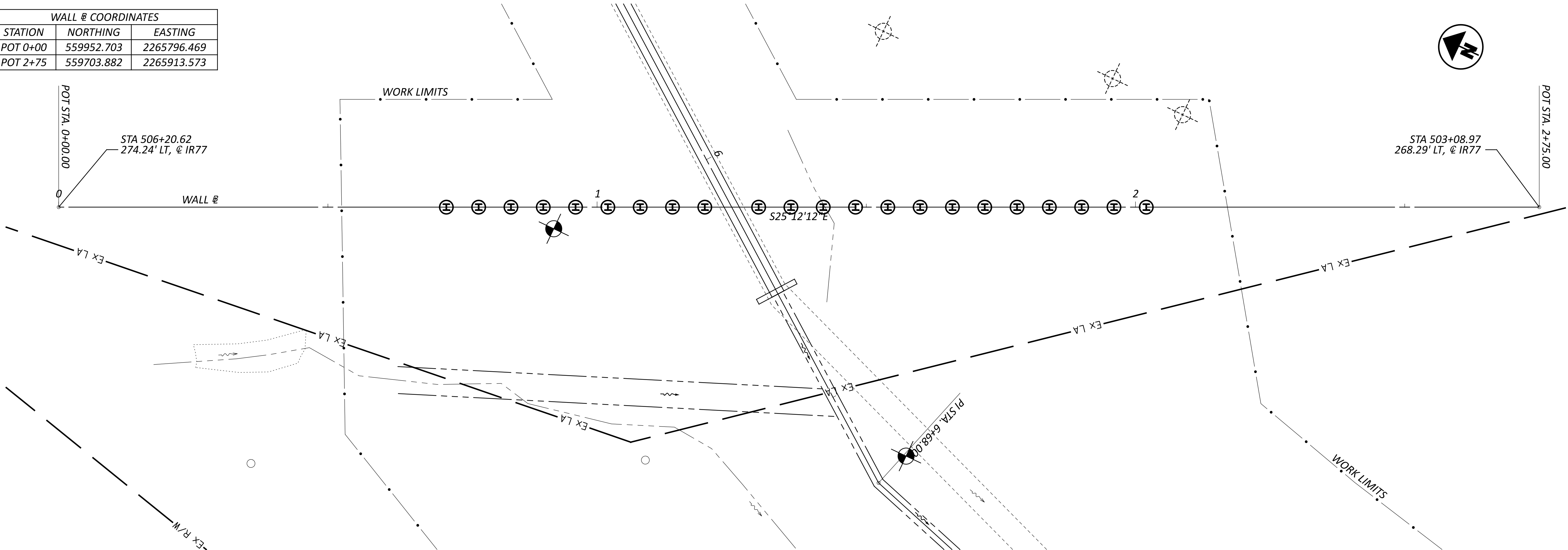
@ 10', 5 strands to 49' total length

Pile embedded 5' into bedrock

For no tiebacks:

Minimum pile length of 35' (25' embedment)

WALL @ COORDINATES		
STATION	NORTHING	EASTING
POT 0+00	559952.703	2265796.469
POT 2+75	559703.882	2265913.573



RETAINING WALL PLAN AND PROFILE

DESIGN AGENCY



DESIGNER

JPH

REVIEWER

XXX MM-DD-YY

PROJECT ID

115420

SHEET

P.0

TOTAL

0

2 Tiebacks



Earth Pressure Determination

Geometry

	Elevation (ft)			Horiz. Distance from C/L (ft)	
Top of Backfill =	860.0	at Bottom of Embankment	Start of Wall Backfill =	50.0	at Bottom of Embankment
Top of Wall =	851.0	at C/L of Wall	Wall =	0.0	at C/L of Wall
Existing Ground Surface =	851.4	at C/L of Wall			
Bottom of Wall =	821.3	at C/L of Wall	Backfill Slope Angle =	5.6	H:1V
Groundwater =	848.5	at C/L of Wall		10.2	degrees

Wall Loading Profile (B-005-0-23)

	Top Elev.	Thickness (ft)	Cohesion (psf)	Phi (deg)	Unit Wt (pcf)
Layer 2 Medium Stiff to Stiff Cohesive	851.0	0.8	115	23	140
Layer 1 Soft to Medium Stiff Cohesive	850.2	5.0	65	21	115
Layer 2 Medium Stiff to Stiff Cohesive	845.2	10.0	115	23	140
Layer 3 Stiff to Very Stiff Cohesive	835.2	13.9	175	25	135
Bottom of Wall/Maintenance Bench	821.3				
Weighted Value		29.7	135	24	135

Earth Pressure Coefficients

	Deg		
Shear Resistance, Φ =	26		
Wall Friction, δ^A =	0.0		
Wall Slope, θ =	90		
Backfill Slope, β =	10.20		
Revised Backfill Slope, β =	10.20		
Backfill Condition	INFINITE		
Horz. Backslope Dist.	50.0	feet	(C/L of Wall - Edge of Shoulder)
Wall Height (H)	29.7	feet	(Top of Wall - Maintenance Bench)
Slope Height (h)	9.0	feet	(Top of Backfill - Top of Wall)
I =	8.62	degrees	

Notes:

- Wall friction neglected
- Figure and Equation for Active Earth Pressure from AASHTO 3.11.5.3 (LRFD Design Manual).
- The wall retained soil will consist of existing cohesive overburden. Using the soil layer thicknesses and respective soil parameters, a weighted average was determined and assumed for the entire profile ($c' = 135$ psf and $\phi' = 24^\circ$). The parameters were converted to equivalent soil strength parameters $c' = 0$ psf and $\phi' = 26^\circ$ for checking tieback lengths based on a 1 degree increase in friction angle for every 50 psf decrease in cohesion up to 150 psf (Ref: Hall's Thesis).

Shoring Suite Design Profile

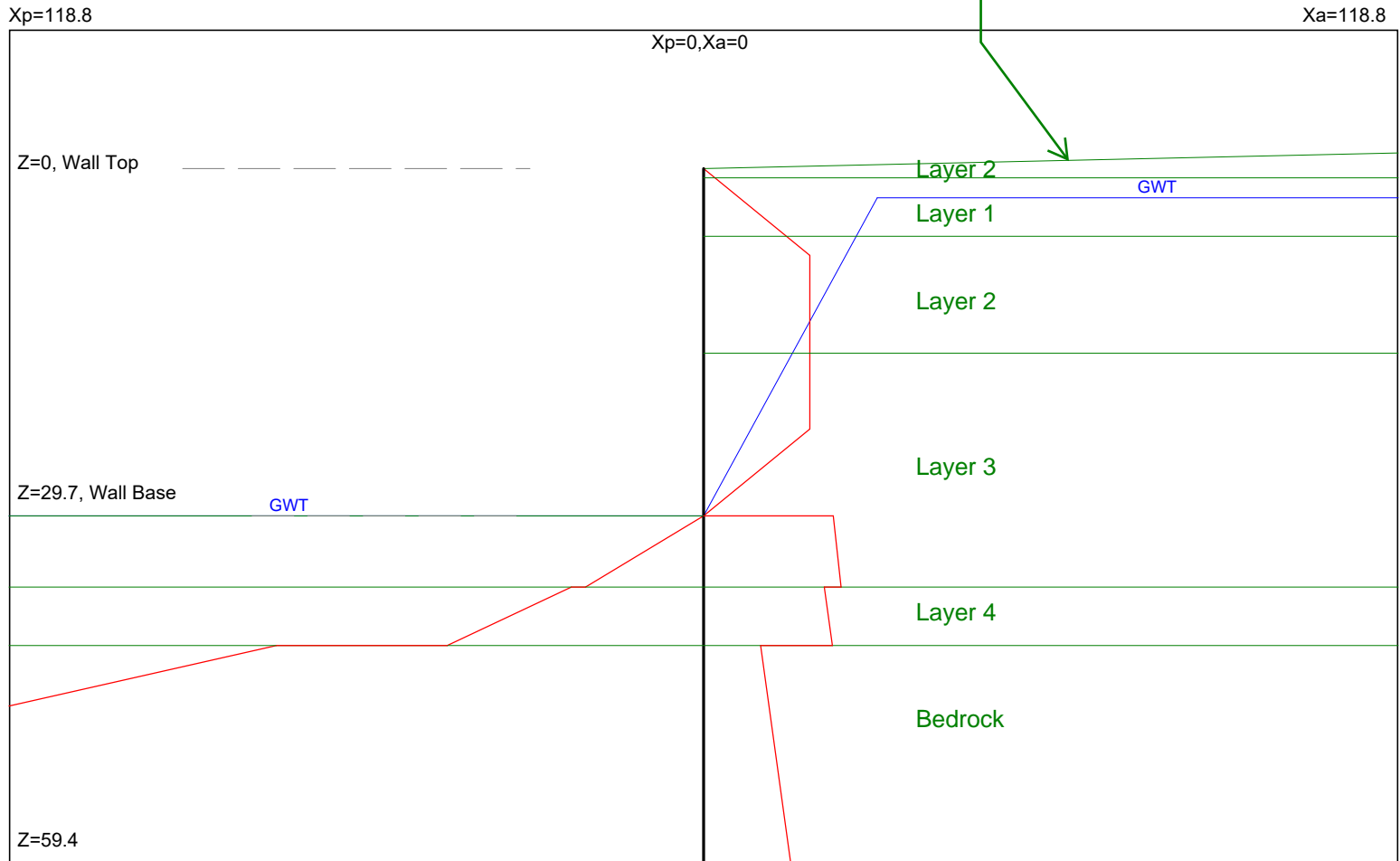
	Top Elev	Depth (ft)	Cohesion (psf)	Phi (deg)	Unit Wt (pcf)
Layer 2 Medium Stiff to Stiff Cohesive	851.0	0.0	0	25	140
Layer 1 Soft to Medium Stiff Cohesive	850.2	0.8	0	22	115
Layer 2 Medium Stiff to Stiff Cohesive	845.2	5.8	0	25	140
Layer 3 Stiff to Very Stiff Cohesive	835.2	15.8	0	28	135
Layer 4 Hard Cohesive	815.2	35.8	0	31	145
Bedrock	810.2	40.8	0	45	150

Depths referenced below the top of wall. Friction angles reflect adjustments made per Hall's Thesis. Bedrock modeled as very dense gravel.

Earth pressures generated using
service loading.

WAS-77-9.58

5.6H:1V Backslope



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UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf
Date: 10/17/2023 File: C:\Users\labaratta\Desktop\WAS-77-9.58 30' Wall Tieback.ep8

* INPUT DATA *

Wall Height=29.7 Total Soil Types= 5

Soil No.	Weight	Saturate	Phi	Cohesion	Nspt	Type	Description
1	115.0	120.0	22	0	5	1	1. Soft to M
2	140.0	145.0	25	0.0	11	1	2. Medium St
3	135.0	140.0	28	0.0	24	1	3. Stiff to
4	145.0	150.0	31	0.0	65	1	4. Hard Cohe
5	150.0	155.0	45	0.0	100	5	Bedrock

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.	Description
1	0.0	0.0	-9.0	800.0	2	2. Medium St
2	0.8	0.0	0.8	800.0	1	1. Soft to M
3	5.8	0.0	5.8	800.0	2	2. Medium St
4	15.8	0.0	15.8	800.0	3	3. Stiff to
5	35.8	0.0	35.8	800.0	4	4. Hard Cohe
6	40.8	0.0	40.8	800.0	5	Bedrock

Water Table at Active Side:

Point	Z-water	X-water
1	29.7	0.0
2	2.5	29.7
3	2.5	800.0

Bedrock modeled as
dense gravel to generate
active pressures.

Ground Surface at Passive Side:		Soil Layers in Front of Wall				
Line	Z1	Xp1	Z2	Xp2	Soil No.	Description
1	29.7	0.0	29.7	800.0	3	3. Stiff to
2	35.8	0.0	35.8	800.0	4	4. Hard Cohe
3	40.8	0.0	40.8	800.0	5	Bedrock

Water Table at Passive Side:		Water Depth in Front of Wall				
Point	Z-water	X-water				
1	29.7	0.0				
2	29.7	800.0				

Wall Friction Options: 1.* No wall friction

Wall Batter Angle = 0

Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*

Water Density = 62.4

Water Pressure: 1.* No seepage at wall tip

* OUTPUT RESULTS *

Total Force above Base= 21.90 per one linear foot (or meter) width along wall height

Total Static Force above Base= 21.90. Distributed in Apparent Envelope along wall height. Ignore soil layers and water line

Driving Pressure above Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Coef.
0.00	0.00	7.42	1.18	0.1589	1.1351
7.42	1.18	22.27	1.18	0.0000	0.0000
22.27	1.18	29.70	0.00	-0.1589	-1.1772

Driving Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Ka or Ko
29.70	1.44	35.80	1.53	0.0141	0.1818
35.80	1.34	40.80	1.43	0.0180	0.2055
40.80	0.63	59.40	0.97	0.0180	0.1946

Passive Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pp1	Z2	Pp2	Slope	Kp
29.70	0.00	35.80	1.31	0.215	2.7698
35.80	1.47	40.80	2.85	0.275	3.1431
40.80	4.74	59.40	15.42	0.574	6.1996

Passive pressures below 45.8 feet manually adjusted in shoring module to reflect claystone strength.

UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

Date: 10/17/2023 File Name: C:\Users\labaratta\Desktop\WAS-77-9.58 30' Wall Tieback.ep8

EARTH PRESSURE ANALYSIS SUMMARY

<EarthPres>

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Date: 10/17/2023 File: C:\Users\abaratta\Desktop\WAS-77-9.58 30' Wall Tieback.ep8

Title 1: WAS-77-9.58

Title 2:

Input data: *****

Wall Height = 29.70

Depth of Ground at Active Side = 0.00

Depth of Ground at Passive Side = 29.70

Apparent Pressure Envelope: 4. 2-Trapezoid Envelope (Braced, Stiff Clay)

Pressure Type: 1.* Active, Ka

Earthquake Loading Apply to: 1. No Earthq. Loads

Earthquake Horizontal Acceleration, Kh = 0

Earthquake Vertical Acceleration, Kv = 0

Calculation Methods: 1.* Numerical Solution (Wedge Analysis)

Wall Friction Options: 1.* No wall friction

Wall Batter Angle = 0

Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*

Water Density = 62.4

Water Pressure: 1.* No seepage at wall tip

User's Settings

Ignore Passive from Depth = 0

Multiplier of Active Pressure = 1

Multiplier of Passive Pressure = 1

Multiplier of Water Pressure = 1

Multiplier of Earthq. Pressure = 1

Estimated Embedment: Very Shallow: 2H

Program's Settings

Max. Height, Hmax = 297.00

Analysis Segment, dz = 0.74

No. of Active Segment at H, nz0 = 4

No. of Active Segment at Hmax, nz = 7

No. of Passive Segment, nzp = 3

Active Depth at H, Zh = 29.70

Active Depth at Hmax, Z = 297.00

Passive Depth at Hmax, Zp = 297.00

Max. Pressure = 143.67

Total Soil Types= 5

Soil	Weight	W(S)	Phi	Cohesion	Nspt	Type	Description
1	115.0	120.0	22	0	5	1	1. Soft to M
>	115.0	120.0	22.0	0.0	5	1	Converted
2	140.0	145.0	25	0.0	11	1	2. Medium St
>	140.0	145.0	25.0	0.0	11	1	Converted
3	135.0	140.0	28	0.0	24	1	3. Stiff to

>	135.0	140.0	28.0	0.0	24	1	Converted
4	145.0	150.0	31	0.0	65	1	4. Hard Cohe
>	145.0	150.0	31.0	0.0	65	1	Converted
5	150.0	155.0	45	0.0	100	5	Bedrock

Soil Type: 1 Equivalent Clay; 2 Clay; 3 Silt; 4 Sand; 5 Gravel

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.
1	0.0	0.0	-9.0	800.0	2
2	0.8	0.0	0.8	800.0	1
3	5.8	0.0	5.8	800.0	2
4	15.8	0.0	15.8	800.0	3
5	35.8	0.0	35.8	800.0	4
6	40.8	0.0	40.8	800.0	5

Water Table at Active Side:

Point	Z-water	X-water
1	29.7	0.0
2	2.5	29.7
3	2.5	800.0

Ground Surface at Passive Side:

Line	Z1	Xp1	Z2	Xp2	Soil No.
1	29.7	0.0	29.7	800.0	3
2	35.8	0.0	35.8	800.0	4
3	40.8	0.0	40.8	800.0	5

Water Table at Passive Side:

Point	Z-water	X-water
1	29.7	0.0
2	29.7	800.0

Output data: *****

Total Force above Base= 21.90 per one linear foot (or meter) width along wall height
 Static Force above Base= 21.90. Distributed in Apparent Envelope along wall height.
 Ignore soil layers and water line

Apparent Pressure above Base - Output to Shoring

Active/At-Rest Force above Base, Ea = 21.90

No	Z1	P1	Z2	P2	Slope	Coef.
0	0.0	0.00	7.4	1.18	0.1589	1.1351
1	7.4	1.18	22.3	1.18	0.0000	0.0000
2	22.3	1.18	29.7	0.00	-0.1589	-1.1772

Driving Pressure below Base - Output to Shoring

No	Z1	P1	Z2	P2	Slope	Ka or Ko
0	29.7	1.44	35.8	1.53	0.0141	0.1818
1	35.8	1.34	40.8	1.43	0.0180	0.2055
2	40.8	0.66	297.0	4.87	0.0164	0.1771

Passive Pressure below Base - Output to Shoring

No	Z1	P1	Z2	P2	Slope	Kp
----	----	----	----	----	-------	----

0	29.7	0.00	35.8	1.31	0.2149	2.7698
1	35.8	1.47	40.8	2.85	0.2753	3.1431
2	40.8	5.25	297.0	143.67	0.5403	5.8348

Passive pressures below 45.8 feet manually adjusted in shoring module to reflect claystone strength.

DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

Z, Xa, Xp - Coordinates of ground lines

Z- Depth measured from wall top

Xa - Distance measure from wall to active side.

Xp - Distance measure from wall to passive side

Z1, P1, Z2, P2 - Four values to define a pressure diagram

Z1- Top depth of the diagram

P1- Top pressure of the diagram

Z2- Bottom depth of the diagram

P2- Bottom pressure of the diagram

Slope - $(P2-P1)/(Z2-Z1)$, Slope of the diagram. It also called Equivalent fluid density.

Coef. - Pressure Coefficient = Slope/Unit Weight

Ka - Active Earth Pressure Coefficient

Ko - At-Rest Earth Pressure Coefficient

Kp - Passive Earth Pressure Coefficient

Steel Beam and Cross-Section Properties

Assumed Pile Shape **HP 14x89**

Pile Availability

AISC Member Producers	3
Non-Member Producers	0

Shaft Geometry

Shaft Diameter	30	in
Longest Beam Dimension	20.162589	in
Clear Distance	4.9187054	in

Steel Beam Geometry

Beam Depth (D)	13.8	in
Web Thickness (t _w)	0.615	in
Flange Width (B _f)	14.7	in
Flange Thickness (t _f)	0.615	in
Area of Steel (A _s)	26.1	in ²

Steel Properties

Yield Strength of Steel	50	ksi
Moment of Inertia (I _{xx}) of Steel	904	in ⁴
Modulus of Elasticity of Steel (E)	29000	ksi
Modulus of Elasticity of Steel (E)	29000000	psi
EI (Steel Only)	2.622E+10	lb*in ²
Section Modulus (S _x)	131	in ³
Section Modulus (Z _x)	146	in ³
Shear-Buckling Coefficient (k)	5	
Ratio of Shear-Buckling Resistance (C)	1	
D/t _w	22.439024	
1.12VEk/F _{yw}	60.313846	
1.40VEk/F _{yw}	75.392307	

Determined by AASHTO LRFD Bridge Specifications
Eqn's 6.10.9.3.2-4, 6.10.9.3.2-5, and 6.10.9.3.2-6

Shear Capacity Calculation

$$V_u \leq \phi V_{cr}$$
$$\phi_b = \boxed{1} \text{ AASHTO LRFD Bridge Design Spec's 6.5.4.2}$$
$$V_u = \text{shear in web due to factored permanent and construction loads applied to noncompact section (kips)}$$
$$V_{cr} = \text{shear buckling resistance determined from Equation 6.10.9.3.3-1 (AASHTO LRFD Bridge Design Spec's)}$$
$$V_n = V_{cr} = C V_p$$
$$V_p = 0.58 F_{yw} D t_w$$
$$V_p = \text{plastic shear force (kips)}$$
$$C = \text{ratio of shear-buckling resistance to shear yield strength determined by AASHTO Eqn's 6.10.9.3.2-4, 6.10.9.3.2-5, 6.10.9.3.2-5, or 6.10.9.3.2-6}$$
$$V_p = 0.58 * 50 * 13.8 * 0.615$$
$$V_p = \boxed{246.1} \text{ kips}$$
$$\phi V_{cr} = \phi * C * V_p$$
$$\phi V_{cr} = 1 * 1 * 246.1$$
$$\phi V_{cr} = \boxed{246.1} \text{ kips}$$
$$V_u = \boxed{88.76} \text{ kips (from Shoring Suite)}$$
$$\boxed{} \text{ kips (from PYWALL)}$$
$$V_u < \phi V_{cr} \quad \text{OK}$$

Flexure Capacity Calculation

$$M_u \leq \phi M_n$$
$$\phi_b = \boxed{1} \text{ AASHTO LRFD Bridge Design Spec's 6.5.4.2}$$
$$M_u = \text{Moment due to the factored loads}$$
$$M_n = \text{Nominal flexural resistance of a section}$$
$$S_x = \text{Elastic section modulus about the x-axis}$$
$$\phi M_n = \phi * F_y * S_x$$
$$\phi M_n = 1 * 50 * 131$$
$$\phi M_n = \boxed{6550} \text{ in*kips}$$
$$M_u = \boxed{3681.7} \text{ in*kips (from Shoring Suite)}$$
$$M_u = \boxed{} \text{ in*kips (from PYWALL)}$$
$$M_u < \phi M_n \quad \text{OK}$$

Deflection Criteria

Pile Length Above Rock = 40.8	ft	Exposed Wall Height = 29.7	ft
Pile Length Above Rock = 40.8	in	Exposed Wall Height = 356.4	in

1.)

Per the ODOT GDM, pile-head deflection in the service limit state limited to 1% or less of the shaft length above bedrock, or 1% of total drilled shaft length if not embedded in bedrock.

2.)

Following industry acceptance criteria, limit wall deflection to 1% of exposed wall height where ODOT landslide criteria does not govern. Alternatively, limit wall deflection to 1.5% of the exposed wall height in accordance with NCDOT guidelines. Use 1.5% wall deflection for PYWALL software.

ODOT Landslide Criteria Governs

NO

OK

1% Wall Height OR 2 inches- LPILE

3.564

in

$\delta = \boxed{0.4}$ in (from Shoring Suite)

1.5% Wall Height - PYWALL

5.346

in

$\delta = \boxed{}$ in (from PYWALL)

Drilled Shafts Located Within 10 feet of Edge of Pavement

NO

Tieback Loading Computations

Design Tieback Load, TF1 = 196.2 kips / shaft
Design Tieback Load, TF2 = 102.5 kips / shaft

Horizontal values determined from Shoring Suite calculations.

1) Determine Tiebacks

Strands

0.6 GUTS per strand = 35.2 kips per strand (FHWA-NHI-07-071: Table 8-16)

(GUTS = guaranteed ultimate tensile strength)

Tieback	Inclin.	Required Anchor Load**	Strands	
No.	deg	kips	Required	Selected
1	20	208.8	5.9	6.0
2	20	109.1	3.1	4.0

**Required Anchor Load = (TF) / [Cos (Inclin. Angle)]

2) Check Pull-Out Capacity and Bond Length

Pullout Resistance Factor ϕ_{pr} = 0.7

Per AASHTO LRFD Table 11.5.7-1 for "Pullout resistance of anchors, cohesive soils"

Soil Friction Angle ϕ = 26

Table 8-16. Properties of 0.6 in. Diameter Prestressing Steel Strands (ASTM A416, Grade 270).

Number of 0.6 in. diameter strands	Cross section area	Ultimate strength (=GUTS)	Prestressing force		
			0.8 $f_{pu}A_{ps}$	0.7 $f_{pu}A_{ps}$	0.6 $f_{pu}A_{ps}$
	(in. ²)	(kips)	(kips)	(kips)	(kips)
1	0.217	58.6	46.9	41.0	35.2

Tieback	Height Above Bottom of Wall	Tieback Length to Active Wedge	Total Unbonded Length	Ultimate Bond Strength	Tieback Drill Hole Diameter	Surface Area per Foot of Tieback	Allowable Bond Strength per Foot of Tieback	Required Anchor Load	Required Bond Length	Total Tieback Length
No.	ft	ft	ft	ksf	in	in ² /ft	kips/ft	kips	ft	ft
1	20	10.7	21	3	9	339.3	4.95	208.8	43	64
2	10	5.3	16	3	9	339.3	4.95	109.1	23	39

Total unbonded length = Tieback length to active wedge + greater of 5 feet or H/3, with a 15 foot minimum, per AASHTO LRFD Figure 11.9.1-1

Ultimate bond strength per AASHTO LRFD Table C11.9.4.2-1. Tieback lengths assume entire bond length is in clay.

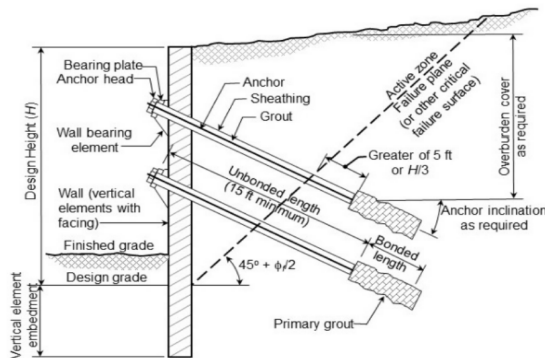


Figure 11.9.1-1—Anchored Wall Nomenclature and Anchor Embedment Guidelines

Table C11.9.4.2-1—Presumptive Ultimate Unit Bond Stress for Anchors in Cohesive Soils

Anchor/Soil Type (Grout Pressure)	Soil Stiffness or Unconfined Compressive Strength (tsf)	Presumptive Ultimate Unit Bond Stress, τ_u (ksf)
Gravity Grouted Anchors (<50 psi)		
Silt-Clay Mixtures	Stiff to Very Stiff 1.0-4.0	0.6 to 1.5
Pressure Grouted Anchors (50 psi-400 psi)		
High Plasticity Clay	Stiff 1.0-2.5 V. Stiff 2.5-4.0	0.6 to 2 1.5 to 3.6
Medium Plasticity Clay	Stiff 1.0-2.5 V. Stiff 2.5-4.0	2.0 to 5.2 2.9 to 7.3
Medium Plasticity Sandy Silt	V. Stiff 2.5-4.0	5.8 to 7.9



Service Limit Analysis (Soldier Pile and Lagging Wall with Tiebacks)

Date: 10/27/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 30' Wall Surcharge Service.lp8

Wall Height, H= 29.7 Load Depth, D= 0
Load Factor of Surcharge Loading = 1
Rigid Wall Condition -- No movement or deflection of the wall are allowed.
Max. Pressure = 0.140 at depth = 0.00

Infinite Surcharge, Q=.250 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

SURCHARGE LOADS CALCULATION SUMMARY
<Surcharge>
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Reference: Foundation Design, Wayne C. Teng, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1962

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Wall Surcharge Service.lp8

WAS-77-9.58
Traffic Loading

Height of Wall = 29.7
Depth of Load = 0
Load Factor of Surcharge Loading = 1

Wall Condition:
Rigid Wall Condition -- No movement or deflection of the wall are allowed.

*****Loading*****

INFINITE SURCHARGE LOADING: Q=.250
Active Wedge Approach * (recommend)

*****Total Pressure Distribution*****

Max. Pressure =0.140 at depth =0.00

Depth	Pressure
0.00	0.140
1.49	0.140
2.97	0.140
4.45	0.140
5.94	0.140
7.43	0.140
8.91	0.140
10.39	0.140
11.88	0.140
13.36	0.140
14.85	0.140
16.33	0.140
17.82	0.140
19.31	0.140
20.79	0.140
22.28	0.140
23.76	0.140

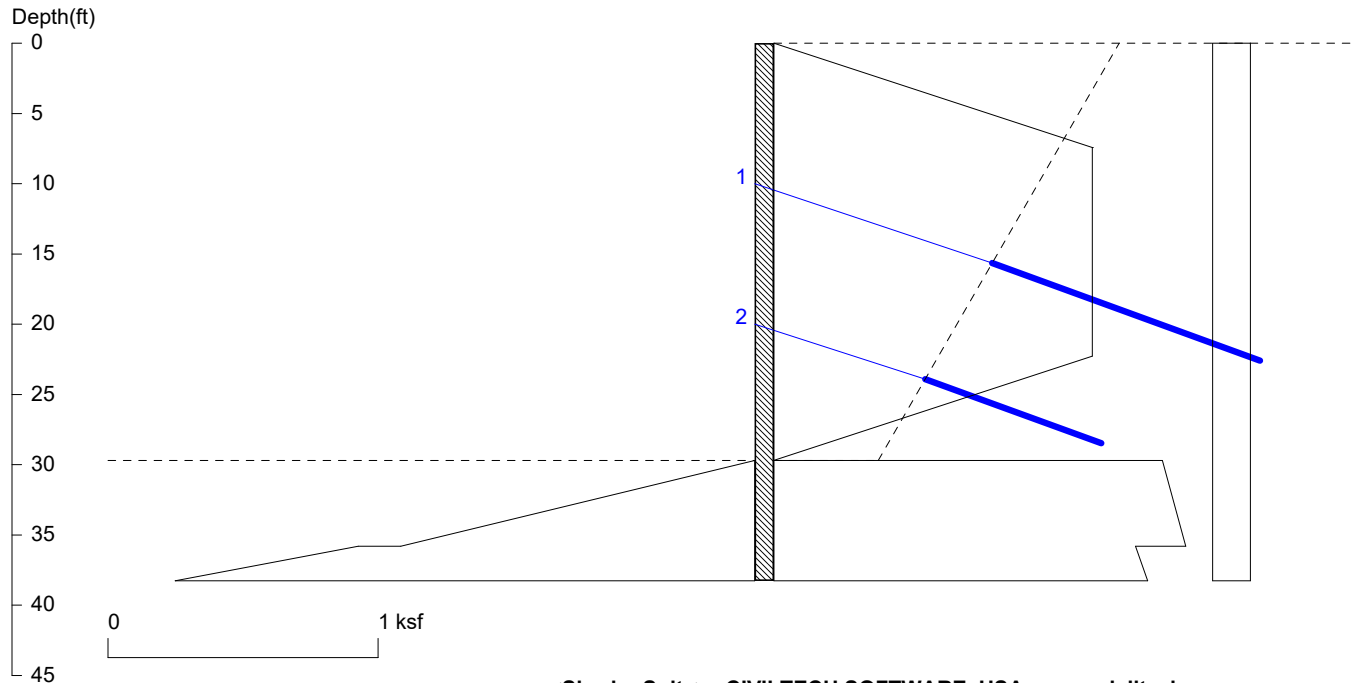
25.25	0.140
26.73	0.140
28.22	0.140
29.70	0.140
32.67	0.140
35.64	0.140
38.61	0.140
<hr/>	
41.58	0.140
44.55	0.140
47.52	0.140
50.49	0.140
53.46	0.140
56.43	0.140
59.40	0.140
65.34	0.140
71.28	0.140
77.22	0.140
83.16	0.140
89.10	0.140
95.04	0.140
100.98	0.140
106.92	0.140
112.86	0.140
118.80	0.000

Surcharge loading cut off at top of rock (40.8 feet) in shoring module.

Depth Is Measured From Top of the Wall

LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

WAS-77-9.58



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Date: 10/30/2023

File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 30' Main Wall Tieback Service.sh8

Wall Height=29.7

Pile Diameter=2.5

Pile Spacing=6.0

Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=8.56 Min. Pile Length=38.26

MOMENT IN PILE: Max. Moment=198.02 per Pile Spacing=6.0 at Depth=10.00

PILE SELECTION:

Request Min. Section Modulus = 47.5 in³/pile=778.81 cm³/pile, F_y= 50 ksi = 345 MPa, F_b/F_y=1

HP14X89 has Section Modulus = 131.0 in³/pile=2146.70 cm³/pile. It is greater than Min. Requirements!

Top Deflection = 0.40(in) based on E (ksi)=29000.00 and I (in⁴)/pile=904.0

BRACE FORCE: Strut, Tieback, Plate Anchor, Deadman, Sheet Pile as Anchor

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	L _{free}	Fixed Length
1. Tieback	10.0	20.0	6.0	137.5*	129.2	47.0	16.5	27.8
2. Tieback	20.0	20.0	6.0	66.0	62.0	22.6	11.5	13.3

* Top Brace increased by 15% (DM7.2-103)

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	7.425	1.180	0.158920
7.425	1.180	22.27	1.180	0.000000
22.27	1.180	29.70	0.000	-0.15892
*	Below	Base		
29.70	1.439	35.80	1.525	0.014108
35.80	1.340	40.80	1.430	0.017999
*	Sur-	charg		
0.000	0.140	1.485	0.140	0.000000
1.485	0.140	2.970	0.140	0.000000
2.970	0.140	4.455	0.140	0.000000

4.455	0.140	5.940	0.140	0.000000
5.940	0.140	7.425	0.140	0.000000
7.425	0.140	8.910	0.140	0.000000
8.910	0.140	10.39	0.140	0.000000
10.39	0.140	11.88	0.140	0.000000
11.88	0.140	13.36	0.140	0.000000
13.36	0.140	14.85	0.140	0.000000
14.85	0.140	16.33	0.140	0.000000
16.33	0.140	17.82	0.140	0.000000
17.82	0.140	19.30	0.140	0.000000
19.30	0.140	20.79	0.140	0.000000
20.79	0.140	22.27	0.140	0.000000
22.27	0.140	23.76	0.140	0.000000
23.76	0.140	25.24	0.140	0.000000
25.24	0.140	26.73	0.140	0.000000
26.73	0.140	28.21	0.140	0.000000
28.21	0.140	29.70	0.140	0.000000
29.70	0.140	32.67	0.140	0.000000
32.67	0.140	35.64	0.140	0.000000
35.64	0.140	38.61	0.140	0.000000

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
29.70	0.000	35.80	1.311	0.214939
35.80	1.469	40.80	2.846	0.275337

ACTIVE SPACING:

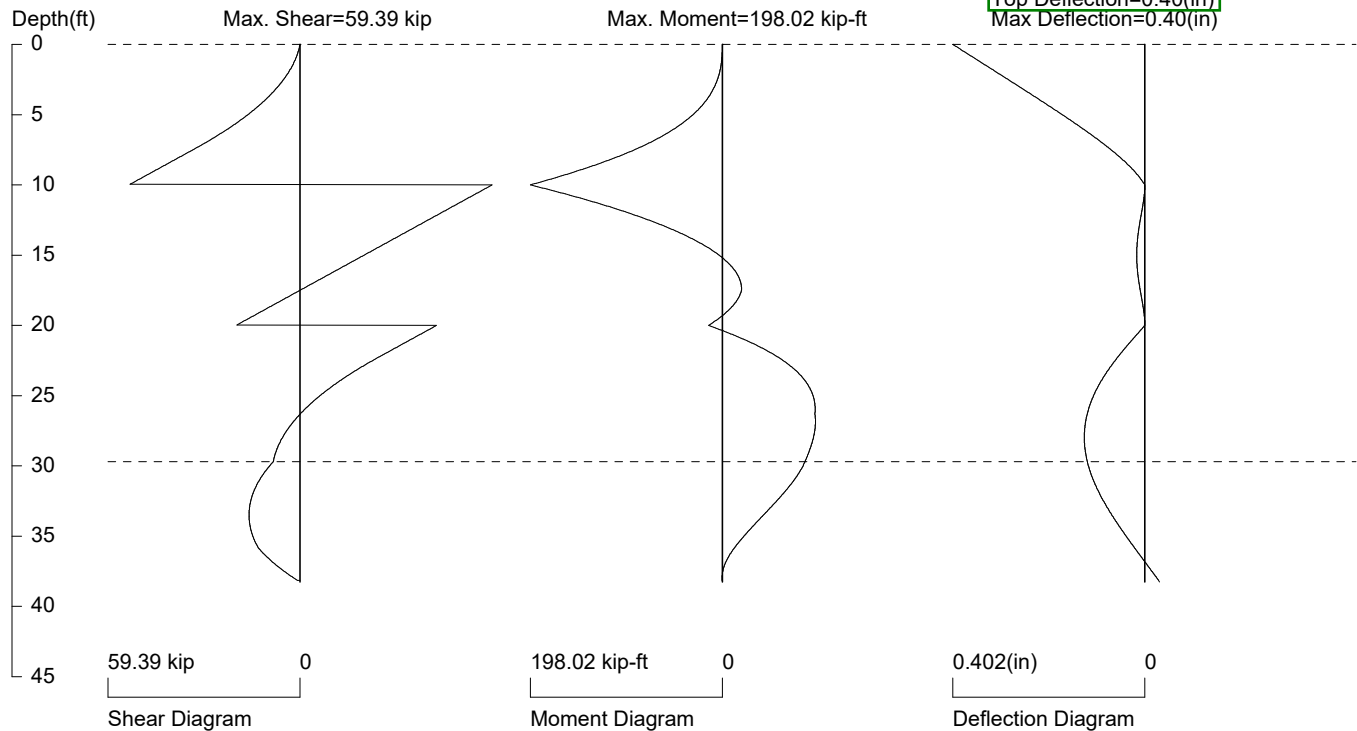
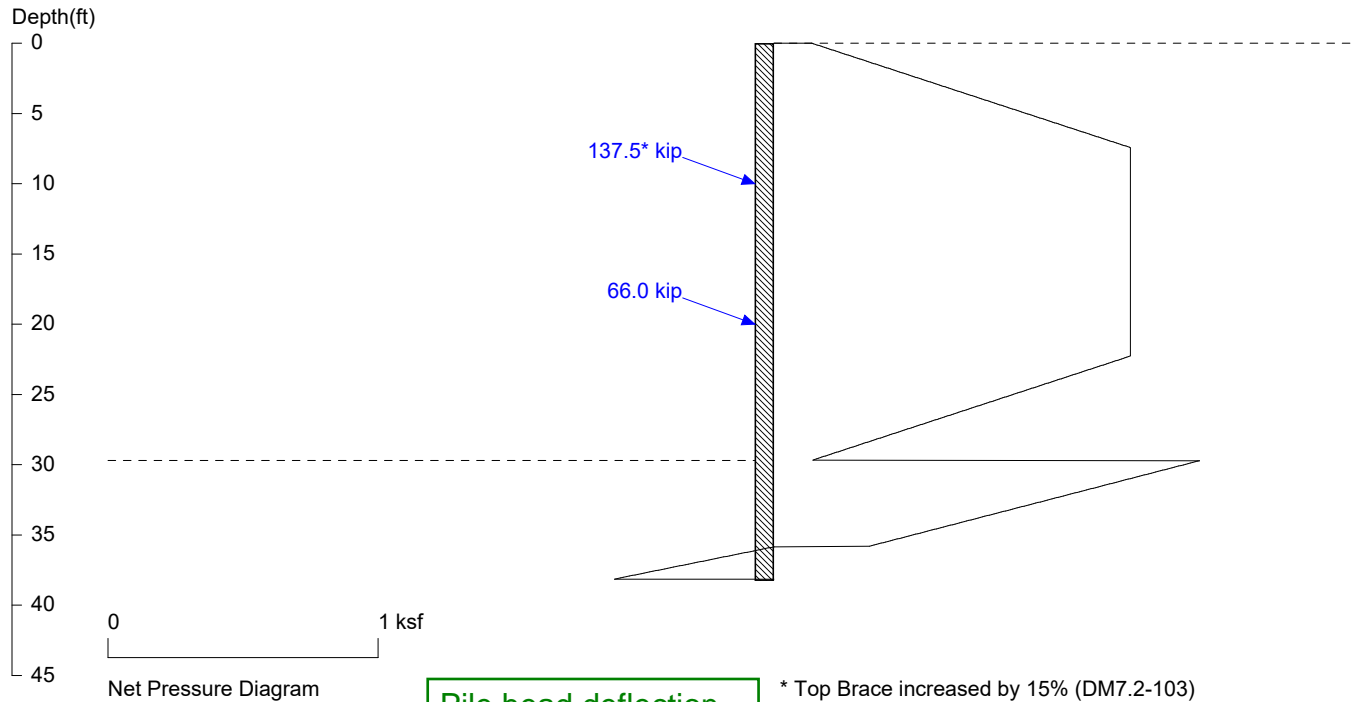
No.	Z depth	Spacing
1	0.00	6.00
2	29.70	2.50

PASSIVE SPACING:

No.	Z depth	Spacing
1	29.70	5.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft³; Deflection - in

WAS-77-9.58



PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 6.0 foot or meter

User Input Pile, HP14X89: E (ksi)=29000.0, I (in4)/pile=904.0

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SHORING WALL CALCULATION SUMMARY
The leading shoring design and calculation software
Software Copyright by CivilTech Software
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ShoringSuite Software is developed by CivilTech Software, Bellevue, WA, USA.

The calculation method is based on the following references:

1. FHWA 98-011, FHWA-RD-97-130, FHWA SA 96-069, FHWA-IF-99-015
2. STEEL SHEET PILING DESIGN MANUAL by Pile Buck Inc., 1987
3. DESIGN MANUAL DM-7 (NAVFAC), Department of the Navy, May 1982
4. TRENCHING AND SHORING MANUAL Revision 12, California Department of Transportation, January 2000
6. EARTH SUPPORT SYSTEM & RETAINING STRUCTURES, Pile Buck Inc. 2002
5. DESIGN OF SHEET PILE WALLS, EM 1110-2-2504, U.S. Army Corps of Engineers, 31 March 1994
7. EARTH RETENTION SYSTEMS HANDBOOK, Alan Macnab, McGraw-Hill. 2002
8. Temporary Structures in Construction, Robert T. Ratay (Co-author of Chapter 7: John J. Peirce), McGraw-Hill. 2012
9. AASHTO HB-17, American Association of State and Highway Transportation Officials, 2 September 2002

UNITS: Width/Spacing/Diameter/Length/Depth - ft, Force - kip, Moment - kip-ft, Friction/Bearing/Pressure - ksf, Pres.
Slope - kip/ft³, Deflection - in

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Date: 11/3/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 30' Main Wall Tieback Service.sh8

Title: WAS-77-9.58

Subtitle:

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

Wall Type: 2. Soldier Pile, Drilled

Wall Height: 29.70

Pile Diameter: 2.50

Pile Spacing: 6.00

Factor of Safety (F.S.): 1.00

As Continuous Span Beam

Lateral Support Type (Braces): 3. Tieback

Top Brace Increase (Multi-Bracing): Add 15%*

No-Load Zone:

Vertical Depth for No-Load Zone: 29.70

H-Distance (Input H/V ratio) for No-Load Zone: 0.25

Angle from H. Line for No-Load Zone: 60.00
Embedment Option: 1. Yes
Friction at Pile Tip: No
Pile Properties:
Steel Strength, Fy: 50 ksi = 345 MPa
Allowable Fb/Fy: 1
Elastic Module, E: 29000.00
Moment of Inertia, I: 904.00
User Input Pile: HP14X89

* DRIVING PRESSURE (ACTIVE, WATER, & SURCHARGE) *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Above	Base		
2	0.000	0.000	7.425	1.180	0.158920
3	7.425	1.180	22.27	1.180	0.000000
4	22.27	1.180	29.70	0.000	-0.15892
5	*	Below	Base		
6	29.70	1.439	35.80	1.525	0.014108
7	35.80	1.340	40.80	1.430	0.017999
8	40.80	0.622	207.9	3.455	0.016954
9	*	Sur-	charg		
10	0.000	0.140	1.485	0.140	0.000000
11	1.485	0.140	2.970	0.140	0.000000
12	2.970	0.140	4.455	0.140	0.000000
13	4.455	0.140	5.940	0.140	0.000000
14	5.940	0.140	7.425	0.140	0.000000
15	7.425	0.140	8.910	0.140	0.000000
16	8.910	0.140	10.39	0.140	0.000000
17	10.39	0.140	11.88	0.140	0.000000
18	11.88	0.140	13.36	0.140	0.000000
19	13.36	0.140	14.85	0.140	0.000000
20	14.85	0.140	16.33	0.140	0.000000
21	16.33	0.140	17.82	0.140	0.000000
22	17.82	0.140	19.30	0.140	0.000000
23	19.30	0.140	20.79	0.140	0.000000
24	20.79	0.140	22.27	0.140	0.000000
25	22.27	0.140	23.76	0.140	0.000000
26	23.76	0.140	25.24	0.140	0.000000
27	25.24	0.140	26.73	0.140	0.000000
28	26.73	0.140	28.21	0.140	0.000000
29	28.21	0.140	29.70	0.140	0.000000

30	29.70	0.140	32.67	0.140	0.000000
31	32.67	0.140	35.64	0.140	0.000000
32	35.64	0.140	38.61	0.140	0.000000
33	38.61	0.140	40.8	0.140	0.000000

* PASSIVE PRESSURE *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Below	Base		
2	29.70	0.000	35.80	1.311	0.214939
3	35.80	1.469	40.80	2.846	0.275337
4	40.80	47	207.9	47	0.0000

Surcharge loading terminated at top of rock (40.8 feet).

* ACTIVE SPACE *

No.	Z depth	Spacing
1	0.00	6.00
2	29.70	2.50

Passive pressure for bedrock adjusted to 47 ksf based on an unconfined strength of 330 psi.

* PASSIVE SPACE *

No.	Z depth	Spacing
1	29.70	5.00

Hole diameter in feet (9 inches).

Allowable bond strength = resistance factor * ultimate bond strength = 0.7*3 ksf

* BRACE: STRUT, TIEBACK, ANCHOR PLATE, DEADMAN, OR SHEET PILE AS ANCHOR*

No.	Z brace	Angle	Spacing	Input1*	Input2*	Type
1	10.00	20.0	6.00	0.75	2.10	Tieback
2	20.00	20.0	6.00	0.75	2.10	Tieback

*For Tieback: Input1 = Diameter; Input2 = Bond Strength

*For Plate: Input1 = Diameter; Input2 = Allowable Pressure

*For Deadman: Input1 = Horz. Width; Input2 = Passive Pressure;

*For Sheet Pile Anchor: Input1 = Horz. Width; Input2 = Passive Slope;

*****CALCULATION*****

The calculated moment and shear are per pile spacing. Sheet piles are per one foot or meter; Soldier piles are per pile.

Top Pressures start at depth = 0.00

* CALCULATE REQUEST EMBEDMENT *

```
| <-- D1=20.00
|
==|== D2=29.70
|
| D3=38.26
```

D1 - TOP DEPTH R1 - TOP REACTION
D2 - EXCAVATION BASE
D3 - PILE TIP

TOTAL REACTION: R1 = 42.23

TOTAL PRESSURES ACTING ON WALL = 42.23

Total Reactions = Total Pressures, OK!

The Calculated Embedment, Yend = 8.56

-----MULTIPLE BRACE / TIEBACK CASE-----

** Use the calculated embedment, Yend = 8.56 for graphics and analysis.

NUMBER OF BRACE LEVEL= 2

* CANTILEVER SPAN, N0.0 *

```
| D1=0.00
|
|
| <-- D2=10.00                      R2=52.92, with Cantilever Moment=198.21
```

D1 - TOP DEPTH
D2 - BOTTOM DEPTH R2 - BOTTOM REACTION

TOTAL REACTION: R2 = 52.92

TOTAL PRESSURES ACTING ON WALL = 52.92

Total Reactions = Total Pressures, OK!

BRACE NO.1 AT DEPTH = 10.00
R2 of Span No.0
R1 of Last Span } Sum of Reaction = Brace Load = 112.33

* LAST SPAN *

```

| <-- D1=10.00      R1=59.42
|
| <-- D2=20.00      R2=62.02
|
|      D3=38.26

```

D1 - TOP DEPTH R1 - TOP REACTION
D2 - LAST BRACE DEPTH R2 - LAST BRACE REACTION
D3 - BOTTOM DEPTH

TOTAL REACTION: R1+R2 = 121.44
TOTAL PRESSURES ACTING ON WALL = 121.44
Total Reactions >= Total Pressures, OK!

BRACE NO.2 AT DEPTH = 20.00
R2 of Last Span = Brace Load = 62.02

*****RESULTS*****

* EMBEDMENT *

MINIMUM EMBEDMENT = 8.56, TOTAL MINIMUM PILE LENGTH = 38.26

* MOMENT IN PILE (per pile spacing)*

Pile Spacing: sheet piles are one foot or one meter; soldier piles are one pile.

No.	Depth	M @ Brace	Mmax in Span	Depth of Mmax
1	10.00	198.02	19.76	17.41

2	20.00	14.17	95.96	26.86
---	-------	-------	-------	-------

Overall Maximum Moment = 198.02 at 10.00

Maximum Shear = 59.39

Moment and Shear are per pile spacing: 6.0 foot or meter

-> Top Brace Increase 15%. (Horizontal) From 112.33 to 129.18

* BRACE: STRUT, TIEBACK, ANCHOR PLATE, DEADMAN, OR SHEET PILE AS ANCHOR*

The calculated brace force are per brace spacing.

No.	DEPTH	Tangle	SPACING	HORIZONTAL	VERTICAL	TOTAL LOAD
1	10.00	20.0	6.00	129.18	47.02	137.47
2	20.00	20.0	6.00	62.02	22.57	66.00

No.	DEPTH	Free length	Brace Type
1	10.00	16.53	Tieback, Bond length = 27.78
2	20.00	11.45	Tieback, Bond length = 13.34

* VERTICAL LOADING *

Vertical Loading from Braces = 69.59

Vertical Loading from External Load = 0.00

Total Vertical Loading = 69.59

*****SPECIFIED PILE *****

Overall Maximum Moment = 198.02 at 10.00

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

Request Min. Section Modulus = 47.53 in³/pile = 778.81 cm³/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=1

HP14X89 has been found in Soldier Pile list!

(English Units):

Area= 26.1 in. Depth= 13.8 in. Width= 14.7 in. Height= 14 in.

Flange thickness= 0.615 in. Web thickness= 0.615 in.

Ix= 904 in⁴/pile Sx= 131 in³/pile Iy= 326 in⁴/pile Sy= 44.3 in³/pile

(Metric Units):

Ix= 376.24 x100cm⁴/pile Sx= 2146.70 cm³/pile Iy= 135.68 x100cm⁴/pile Sy= 725.94 cm³/pile

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

HP14X89 is capable to support the shoring!

Top deflection = 0.402(in)

Max. deflection = 0.402(in)

***** LAGGING SIZE ESTIMATION *****

Max. Pressure above base = 1.32

Piles are more rigid than timber lagging, due to arching, only portion of pressures are acting to lagging, 30-50% loading is suggested.

If 50% loading is used for lagging design, Design Pressure = 0.66

Pile Spacing = 6.0, Max. Moment in lagging = 2.97

For 4"x12" Timber, Section Modules $S=23.47 \text{ in}^3$. The request allowable bending strength, $fb=M/S=1.52$

For 6"x12" Timber, Section Modules $S=57.98 \text{ in}^3$. The request allowable bending strength, $fb=M/S=0.61$

If 30% loading is used for lagging design, Design Pressure = 0.40

Pile Spacing = 6.0, Max. Moment in lagging = 1.78

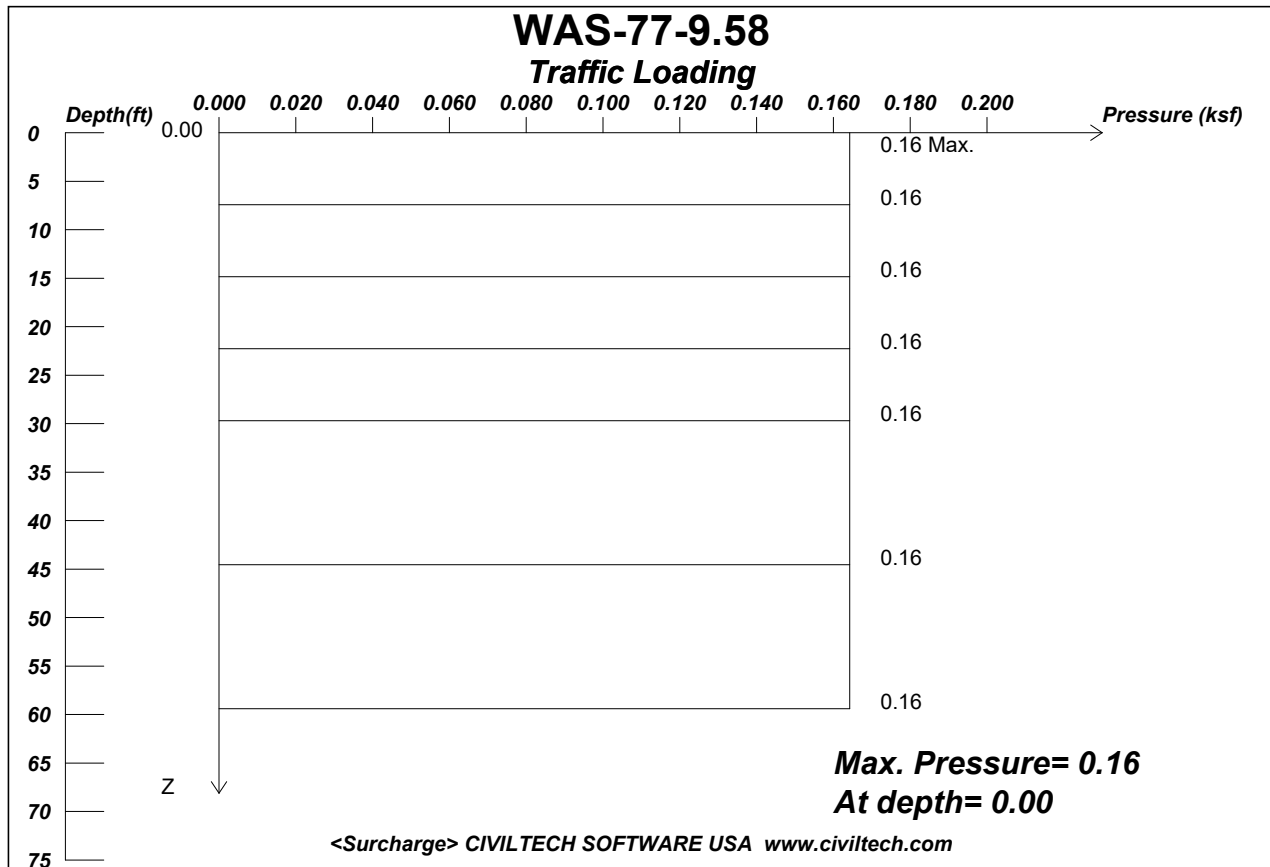
For 4"x12" Timber, Section Modules $S=23.47 \text{ in}^3$. The request allowable bending strength, $fb=M/S=0.91$

For 6"x12" Timber, Section Modules $S=57.98 \text{ in}^3$. The request allowable bending strength, $fb=M/S=0.37$

Unit: Pressure: ksf, Spacing: ft, Moment: kip-ft, Bending Strength, fb: ksi



Strength Limit Analysis (Soldier Pile and Lagging Wall with Tiebacks)



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Date: 10/27/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 30' Wall Surcharge Strength.lp8

Wall Height, H= 29.7

Load Depth, D= 0

Load Factor of Surcharge Loading = 1.17

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

Max. Pressure = 0.164 at depth = 0.00

A load factor of 1.5 is applied to all active loading in the wall analysis. As traffic loading uses 1.75, an extra factor has been applied here ($1.75/1.5 = 1.17$).

Infinite Surcharge, Q=.250

Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

SURCHARGE LOADS CALCULATION SUMMARY
<Surcharge>
Software Copyright by CivilTech Software
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Reference: Foundation Design, Wayne C. Teng, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1962

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Date: 10/27/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 30'
Wall Surcharge Strength.lp8

WAS-77-9.58
Traffic Loading

Height of Wall = 29.7
Depth of Load = 0
Load Factor of Surcharge Loading = 1.17

Wall Condition:
Rigid Wall Condition -- No movement or deflection of the wall are allowed.

*****Loading*****

INFINITE SURCHARGE LOADING: Q=.250
Active Wedge Approach * (recommend)

*****Total Pressure Distribution*****

Max. Pressure =0.164 at depth =0.00

Depth	Pressure
0.00	0.164
1.49	0.164
2.97	0.164
4.45	0.164
5.94	0.164
7.43	0.164
8.91	0.164
10.39	0.164
11.88	0.164
13.36	0.164
14.85	0.164
16.33	0.164
17.82	0.164
19.31	0.164
20.79	0.164
22.28	0.164
23.76	0.164

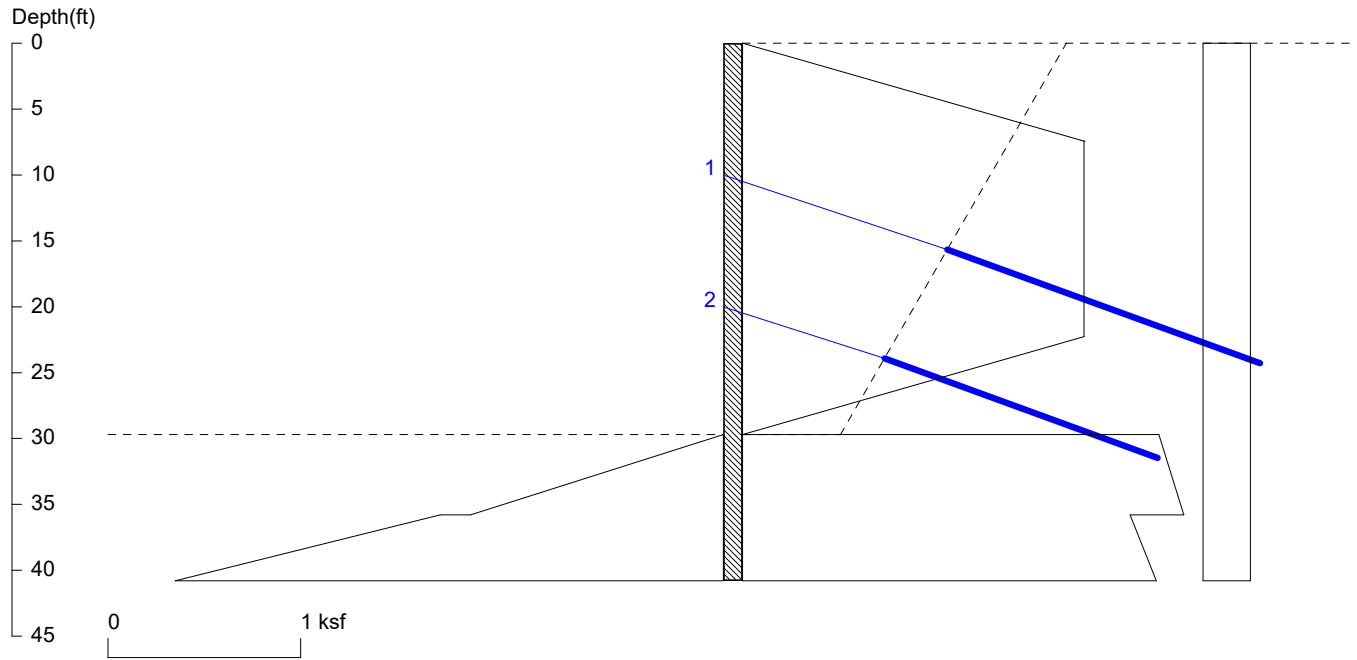
25.25	0.164
26.73	0.164
28.22	0.164
29.70	0.164
32.67	0.164
35.64	0.164
38.61	0.164
41.58	0.164
44.55	0.164
47.52	0.164
50.49	0.164
53.46	0.164
56.43	0.164
59.40	0.164
65.34	0.164
71.28	0.164
77.22	0.164
83.16	0.164
89.10	0.164
95.04	0.164
100.98	0.164
106.92	0.164
112.86	0.164
118.80	0.000

Surcharge loading cut off at top of rock (40.8 feet) in shoring module.

Depth Is Measured From Top of the Wall

LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

WAS-77-9.58



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Wall Height=29.7

Pile Diameter=2.5

Pile Spacing=6.0

Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=11.09 Min. Pile Length=40.79

MOMENT IN PILE: Max. Moment=306.81 per Pile Spacing=6.0 at Depth=9.98

PILE SELECTION:

Request Min. Section Modulus = 73.6 in³/pile=1206.64 cm³/pile, F_y= 50 ksi = 345 MPa, F_b/F_y=1

HP14X89 has Section Modulus = 131.0 in³/pile=2146.70 cm³/pile. It is greater than Min. Requirements!

Top Deflection = 0.65(in) based on E (ksi)=29000.00 and I (in⁴)/pile=904.0

BRACE FORCE: Strut, Tieback, Plate Anchor, Deadman, Sheet Pile as Anchor

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	Unbonded Length	Bonded Length
							L _{free}	Fixed Length
1. Tieback	10.0	20.0	6.0	208.8*	196.2	71.4	16.5	42.2
2. Tieback	20.0	20.0	6.0	109.1	102.5	37.3	11.5	22.0

* Top Brace increased by 15% (DM7.2-103)

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE): Pressures below will be multiplied by a Factor =1.5

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	7.425	1.180	0.158920
7.425	1.180	22.27	1.180	0.000000
22.27	1.180	29.70	0.000	-0.15892
*	Below	Base		
29.70	1.439	35.80	1.525	0.014108
35.80	1.340	40.80	1.430	0.017999
*	Sur-	charg		
0.000	0.164	1.485	0.164	0.000000
1.485	0.164	2.970	0.164	0.000000
2.970	0.164	4.455	0.164	0.000000

Anchor loads and lengths

Unbonded Length Bonded Length

Applied 1.5 load factor for active earth pressures.

4.455	0.164	5.940	0.164	0.000000
5.940	0.164	7.425	0.164	0.000000
7.425	0.164	8.910	0.164	0.000000
8.910	0.164	10.39	0.164	0.000000
10.39	0.164	11.88	0.164	0.000000
11.88	0.164	13.36	0.164	0.000000
13.36	0.164	14.85	0.164	0.000000
14.85	0.164	16.33	0.164	0.000000
16.33	0.164	17.82	0.164	0.000000
17.82	0.164	19.30	0.164	0.000000
19.30	0.164	20.79	0.164	0.000000
20.79	0.164	22.27	0.164	0.000000
22.27	0.164	23.76	0.164	0.000000
23.76	0.164	25.24	0.164	0.000000
25.24	0.164	26.73	0.164	0.000000
26.73	0.164	28.21	0.164	0.000000
28.21	0.164	29.70	0.164	0.000000
29.70	0.164	32.67	0.164	0.000000
32.67	0.164	35.64	0.164	0.000000
35.64	0.164	38.61	0.164	0.000000
38.61	0.164	40.8	0.164	0.000000

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
29.70	0.000	35.80	1.311	0.214939
35.80	1.469	40.80	2.846	0.275337

ACTIVE SPACING:

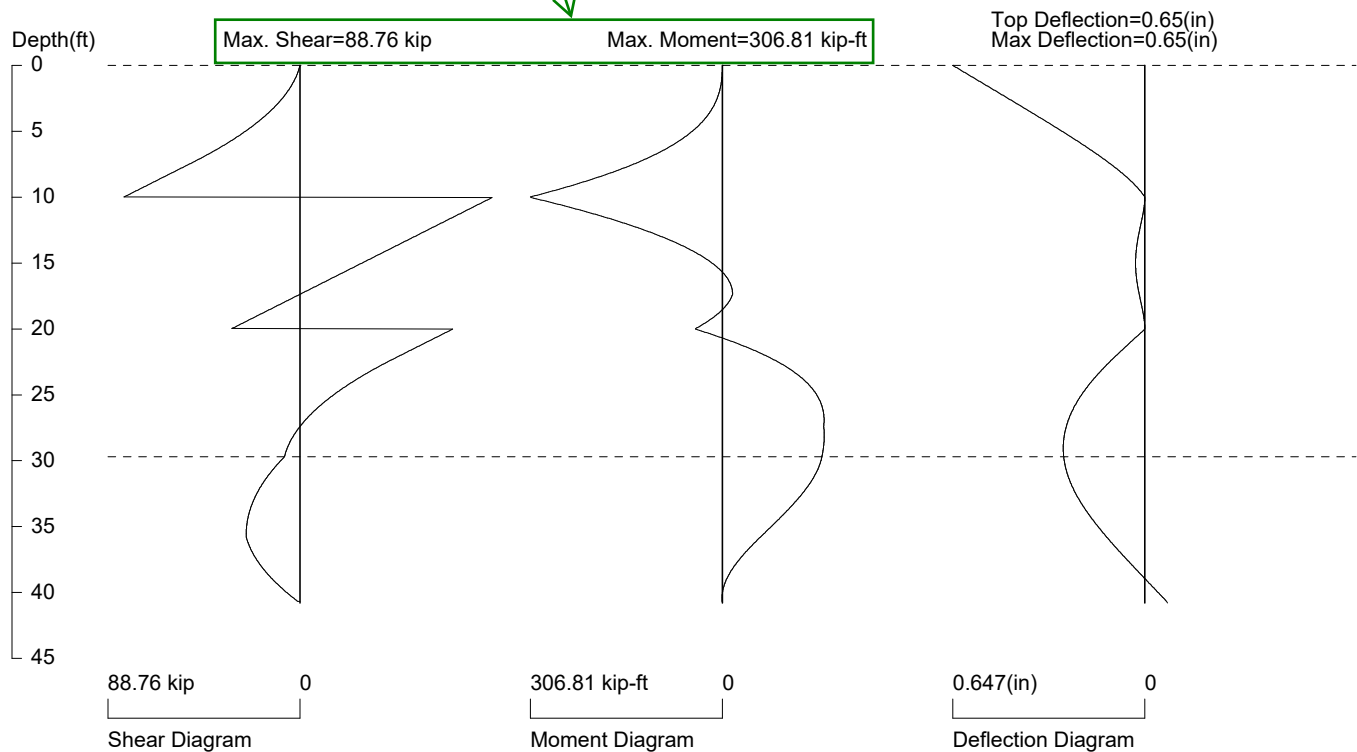
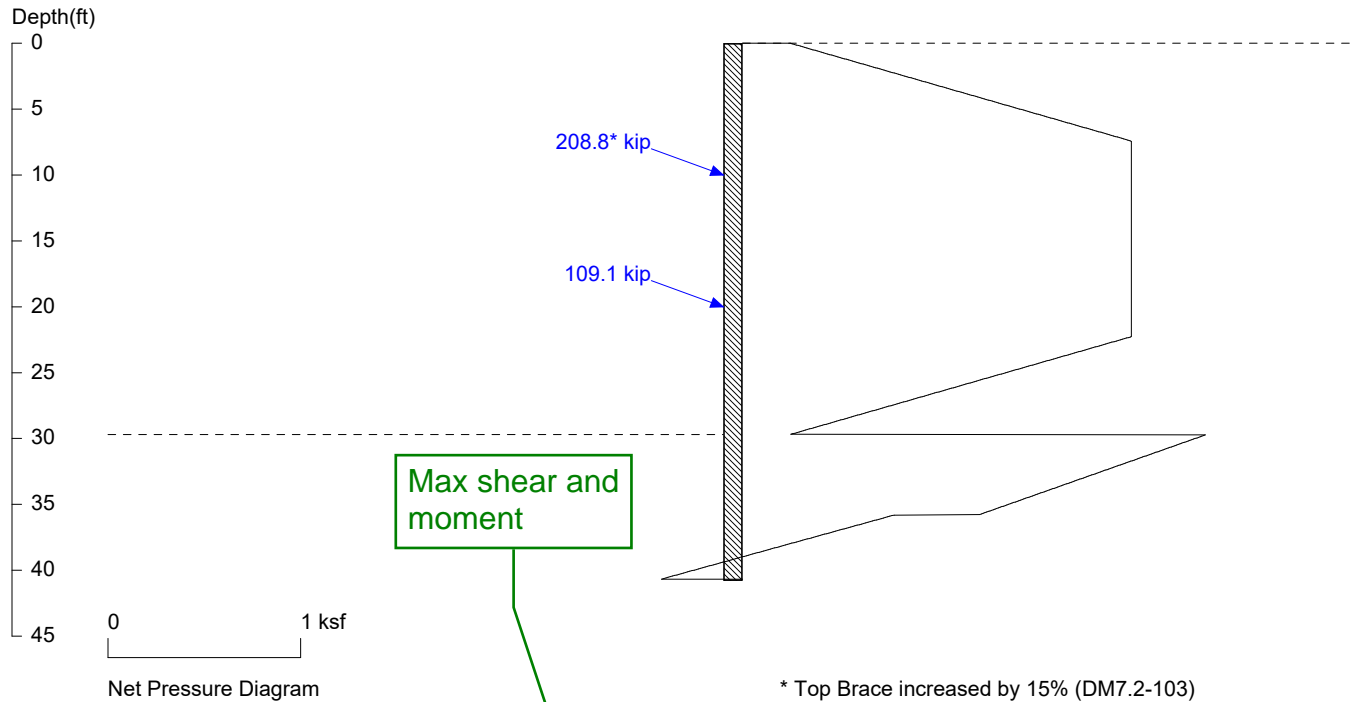
No.	Z depth	Spacing
1	0.00	6.00
2	29.70	2.50

PASSIVE SPACING:

No.	Z depth	Spacing
1	29.70	5.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft³; Deflection - in

WAS-77-9.58



PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 6.0 foot or meter

User Input Pile, HP14X89: E (ksi)=29000.0, I (in4)/pile=904.0

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SHORING WALL CALCULATION SUMMARY
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The calculation method is based on the following references:

1. FHWA 98-011, FHWA-RD-97-130, FHWA SA 96-069, FHWA-IF-99-015
2. STEEL SHEET PILING DESIGN MANUAL by Pile Buck Inc., 1987
3. DESIGN MANUAL DM-7 (NAVFAC), Department of the Navy, May 1982
4. TRENCHING AND SHORING MANUAL Revision 12, California Department of Transportation, January 2000
6. EARTH SUPPORT SYSTEM & RETAINING STRUCTURES, Pile Buck Inc. 2002
5. DESIGN OF SHEET PILE WALLS, EM 1110-2-2504, U.S. Army Corps of Engineers, 31 March 1994
7. EARTH RETENTION SYSTEMS HANDBOOK, Alan Macnab, McGraw-Hill. 2002
8. Temporary Structures in Construction, Robert T. Ratay (Co-author of Chapter 7: John J. Peirce), McGraw-Hill. 2012
9. AASHTO HB-17, American Association of State and Highway Transportation Officials, 2 September 2002

UNITS: Width/Spacing/Diameter/Length/Depth - ft, Force - kip, Moment - kip-ft, Friction/Bearing/Pressure - ksf, Pres. Slope - kip/ft³, Deflection - in

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Date: 11/3/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 30' Main Wall Tieback Strength.sh8

Title: WAS-77-9.58

Subtitle:

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

Wall Type: 2. Soldier Pile, Drilled

Wall Height: 29.70

Pile Diameter: 2.50

Pile Spacing: 6.00

Factor of Safety (F.S.): 1.00

As Continuous Span Beam

Lateral Support Type (Braces): 3. Tieback

Top Brace Increase (Multi-Bracing): Add 15%*

No-Load Zone:

Vertical Depth for No-Load Zone: 29.70

H-Distance (Input H/V ratio) for No-Load Zone: 0.25

Angle from H. Line for No-Load Zone: 60.00

Embedment Option: 1. Yes

Friction at Pile Tip: No

Pile Properties:

Steel Strength, F_y : 50 ksi = 345 MPa

Allowable F_b/F_y : 1

Elastic Module, E : 29000.00

Moment of Inertia, I : 904.00

User Input Pile: HP14X89

* DRIVING PRESSURE (ACTIVE, WATER, & SURCHARGE) *

The pressures below will be multiplied by a Factor =1.5

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Above	Base		
2	0.000	0.000	7.425	1.180	0.158920
3	7.425	1.180	22.27	1.180	0.000000
4	22.27	1.180	29.70	0.000	-0.15892
5	*	Below	Base		
6	29.70	1.439	35.80	1.525	0.014108
7	35.80	1.340	40.80	1.430	0.017999
8	40.80	0.622	207.9	3.455	0.016954
9	*	Sur-	charg		
10	0.000	0.164	1.485	0.164	0.000000
11	1.485	0.164	2.970	0.164	0.000000
12	2.970	0.164	4.455	0.164	0.000000
13	4.455	0.164	5.940	0.164	0.000000
14	5.940	0.164	7.425	0.164	0.000000
15	7.425	0.164	8.910	0.164	0.000000
16	8.910	0.164	10.39	0.164	0.000000
17	10.39	0.164	11.88	0.164	0.000000
18	11.88	0.164	13.36	0.164	0.000000
19	13.36	0.164	14.85	0.164	0.000000
20	14.85	0.164	16.33	0.164	0.000000
21	16.33	0.164	17.82	0.164	0.000000
22	17.82	0.164	19.30	0.164	0.000000
23	19.30	0.164	20.79	0.164	0.000000
24	20.79	0.164	22.27	0.164	0.000000
25	22.27	0.164	23.76	0.164	0.000000
26	23.76	0.164	25.24	0.164	0.000000
27	25.24	0.164	26.73	0.164	0.000000
28	26.73	0.164	28.21	0.164	0.000000

29	28.21	0.164	29.70	0.164	0.000000
30	29.70	0.164	32.67	0.164	0.000000
31	32.67	0.164	35.64	0.164	0.000000
32	35.64	0.164	38.61	0.164	0.000000
33	38.61	0.164	40.8	0.164	0.000000

* PASSIVE PRESSURE *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Below	Base		
2	29.70	0.000	35.80	1.311	0.214939
3	35.80	1.469	40.80	2.846	0.275337
4	40.80	47	207.9	47	0.0000

Surcharge loading terminated at top of rock (40.8 feet).

* ACTIVE SPACE *

No.	Z depth	Spacing
1	0.00	6.00
2	29.70	2.50

Passive pressure for bedrock adjusted to 47 ksf based on an unconfined strength of 330 psi.

* PASSIVE SPACE *

No.	Z depth	Spacing
1	29.70	5.00

Hole diameter in feet (9 inches).

Allowable bond strength = resistance factor * ultimate bond strength = 0.7*3 ksf

* BRACE: STRUT, TIEBACK, ANCHOR PLATE, DEADMAN, OR SHEET PILE AS ANCHOR*

No.	Z brace	Angle	Spacing	Input1*	Input2*	Type
1	10.00	20.0	6.00	0.75	2.10	Tieback
2	20.00	20.0	6.00	0.75	2.10	Tieback

*For Tieback: Input1 = Diameter; Input2 = Bond Strength

*For Plate: Input1 = Diameter; Input2 = Allowable Pressure

*For Deadman: Input1 = Horz. Width; Input2 = Passive Pressure;

*For Sheet Pile Anchor: Input1 = Horz. Width; Input2 = Passive Slope;

*****CALCULATION*****

The calculated moment and shear are per pile spacing. Sheet piles are per one foot or meter; Soldier piles are per pile.

Top Pressures start at depth = 0.00

* CALCULATE REQUEST EMBEDMENT *

```
|<-- D1=20.00
|
==|== D2=29.70
|
| D3=40.79
```

D1 - TOP DEPTH R1 - TOP REACTION
D2 - EXCAVATION BASE
D3 - PILE TIP

TOTAL REACTION: R1 = 69.63

TOTAL PRESSURES ACTING ON WALL = 69.63

Total Reactions = Total Pressures, OK!

The Calculated Embedment, Yend = 11.09

-----MULTIPLE BRACE / TIEBACK CASE-----

** Use the calculated embedment, Yend = 11.09 for graphics and analysis.

NUMBER OF BRACE LEVEL= 2

* CANTILEVER SPAN, N0.0 *

```
| D1=0.00
|
|<-- D2=10.00                      R2=81.53, with Cantilever Moment=308.11
```

D1 - TOP DEPTH
D2 - BOTTOM DEPTH R2 - BOTTOM REACTION

TOTAL REACTION: R2 = 81.53

TOTAL PRESSURES ACTING ON WALL = 81.53

Total Reactions = Total Pressures, OK!

BRACE NO.1 AT DEPTH = 10.00
 R2 of Span No.0
 R1 of Last Span } Sum of Reaction = Brace Load = 170.65

* LAST SPAN *

<--	D1=10.00	R1=89.12
<--	D2=20.00	R2=102.52
	D3=40.79	

D1 - TOP DEPTH R1 - TOP REACTION
 D2 - LAST BRACE DEPTH R2 - LAST BRACE REACTION
 D3 - BOTTOM DEPTH

TOTAL REACTION: R1+R2 = 191.64
 TOTAL PRESSURES ACTING ON WALL = 191.64
 Total Reactions >= Total Pressures, OK!

BRACE NO.2 AT DEPTH = 20.00
 R2 of Last Span = Brace Load = 102.52

*****RESULTS*****

* EMBEDMENT *

MINIMUM EMBEDMENT = 11.09, TOTAL MINIMUM PILE LENGTH = 40.79

* MOMENT IN PILE (per pile spacing)*

Pile Spacing: sheet piles are one foot or one meter; soldier piles are one pile.

No.	Depth	M @ Brace	Mmax in Span	Depth of Mmax
-----	-------	-----------	--------------	---------------

1	10.00	306.81	16.16	17.34
2	20.00	43.04	162.80	28.09

Overall Maximum Moment = 306.81 at 9.98

Maximum Shear = 88.76

Moment and Shear are per pile spacing: 6.0 foot or meter

-> Top Brace Increase 15%. (Horizontal) From 170.65 to 196.25

* BRACE: STRUT, TIEBACK, ANCHOR PLATE, DEADMAN, OR SHEET PILE AS ANCHOR*

The calculated brace force are per brace spacing.

No.	DEPTH	Tangle	SPACING	HORIZONTAL	VERTICAL	TOTAL LOAD
1	10.00	20.0	6.00	196.25	71.43	208.84
2	20.00	20.0	6.00	102.52	37.31	109.10

No.	DEPTH	Free length	Brace Type
1	10.00	16.53	Tieback, Bond length = 42.21
2	20.00	11.45	Tieback, Bond length = 22.05

* VERTICAL LOADING *

Vertical Loading from Braces = 108.74

Vertical Loading from External Load = 0.00

Total Vertical Loading = 108.74

*****SPECIFIED PILE *****

Overall Maximum Moment = 306.81 at 9.98

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

Request Min. Section Modulus = 73.63 in³/pile = 1206.64 cm³/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=1

HP14X89 has been found in Soldier Pile list!

(English Units):

Area= 26.1 in. Depth= 13.8 in. Width= 14.7 in. Height= 14 in.

Flange thickness= 0.615 in. Web thickness= 0.615 in.

Ix= 904 in⁴/pile Sx= 131 in³/pile Iy= 326 in⁴/pile Sy= 44.3 in³/pile

(Metric Units):

$I_x = 376.24 \times 100 \text{ cm}^4/\text{pile}$ $S_x = 2146.70 \text{ cm}^3/\text{pile}$ $I_y = 135.68 \times 100 \text{ cm}^4/\text{pile}$ $S_y = 725.94 \text{ cm}^3/\text{pile}$

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

HP14X89 is capable to support the shoring!

Top deflection = 0.647(in)

Max. deflection = 0.647(in)

***** LAGGING SIZE ESTIMATION *****

Max. Pressure above base = 2.02

Piles are more rigid than timber lagging, due to arching, only portion of pressures are acting to lagging, 30-50% loading is suggested.

If 50% loading is used for lagging design, Design Pressure = 1.01

Pile Spacing = 6.0, Max. Moment in lagging = 4.54

For 4"x12" Timber, Section Modules $S = 23.47 \text{ in}^3$. The request allowable bending strength, $fb = M/S = 2.32$

For 6"x12" Timber, Section Modules $S = 57.98 \text{ in}^3$. The request allowable bending strength, $fb = M/S = 0.94$

If 30% loading is used for lagging design, Design Pressure = 0.60

Pile Spacing = 6.0, Max. Moment in lagging = 2.72

For 4"x12" Timber, Section Modules $S = 23.47 \text{ in}^3$. The request allowable bending strength, $fb = M/S = 1.39$

For 6"x12" Timber, Section Modules $S = 57.98 \text{ in}^3$. The request allowable bending strength, $fb = M/S = 0.56$

Unit: Pressure: ksf, Spacing: ft, Moment: kip-ft, Bending Strength, fb: ksi

2 Tiebacks Culvert Span

Steel Beam and Cross-Section Properties

Assumed Pile Shape **HP 14x89**

Pile Availability

AISC Member Producers	3
Non-Member Producers	0

Shaft Geometry

Shaft Diameter	30	in
Longest Beam Dimension	20.162589	in
Clear Distance	4.9187054	in

Steel Beam Geometry

Beam Depth (D)	13.8	in
Web Thickness (t _w)	0.615	in
Flange Width (B _f)	14.7	in
Flange Thickness (t _f)	0.615	in
Area of Steel (A _s)	26.1	in ²

Steel Properties

Yield Strength of Steel	50	ksi
Moment of Inertia (I _{xx}) of Steel	904	in ⁴
Modulus of Elasticity of Steel (E)	29000	ksi
Modulus of Elasticity of Steel (E)	29000000	psi
EI (Steel Only)	2.622E+10	lb*in ²
Section Modulus (S _x)	131	in ³
Section Modulus (Z _x)	146	in ³
Shear-Buckling Coefficient (k)	5	
Ratio of Shear-Buckling Resistance (C)	1	
D/t _w	22.439024	
1.12VEk/F _{yw}	60.313846	
1.40VEk/F _{yw}	75.392307	

Determined by AASHTO LRFD Bridge Specifications
Eqn's 6.10.9.3.2-4, 6.10.9.3.2-5, and 6.10.9.3.2-6

Shear Capacity Calculation

$$V_u \leq \phi V_{cr}$$
$$\phi_b = \boxed{1} \text{ AASHTO LRFD Bridge Design Spec's 6.5.4.2}$$
$$V_u = \text{shear in web due to factored permanent and construction loads applied to noncompact section (kips)}$$
$$V_{cr} = \text{shear buckling resistance determined from Equation 6.10.9.3.3-1 (AASHTO LRFD Bridge Design Spec's)}$$
$$V_n = V_{cr} = C V_p$$
$$V_p = 0.58 F_{yw} D t_w$$
$$V_p = \text{plastic shear force (kips)}$$
$$C = \text{ratio of shear-buckling resistance to shear yield strength determined by AASHTO Eqn's 6.10.9.3.2-4, 6.10.9.3.2-5, 6.10.9.3.2-5, or 6.10.9.3.2-6}$$
$$V_p = 0.58 * 50 * 13.8 * 0.615$$
$$V_p = \boxed{246.1} \text{ kips}$$
$$\phi V_{cr} = \phi * C * V_p$$
$$\phi V_{cr} = 1 * 1 * 246.1$$
$$\phi V_{cr} = \boxed{246.1} \text{ kips}$$
$$V_u = \boxed{117.74} \text{ kips (from Shoring Suite)}$$
$$\boxed{} \text{ kips (from PYWALL)}$$
$$V_u < \phi V_{cr} \quad \text{OK}$$

Flexure Capacity Calculation

$$M_u \leq \phi M_n$$
$$\phi_b = \boxed{1} \text{ AASHTO LRFD Bridge Design Spec's 6.5.4.2}$$
$$M_u = \text{Moment due to the factored loads}$$
$$M_n = \text{Nominal flexural resistance of a section}$$
$$S_x = \text{Elastic section modulus about the x-axis}$$
$$\phi M_n = \phi * F_y * S_x$$
$$\phi M_n = 1 * 50 * 131$$
$$\phi M_n = \boxed{6550} \text{ in*kips}$$
$$M_u = \boxed{4952.3} \text{ in*kips (from Shoring Suite)}$$
$$M_u = \boxed{} \text{ in*kips (from PYWALL)}$$
$$M_u < \phi M_n \quad \text{OK}$$

Deflection Criteria

Pile Length Above Rock = 40.8	ft	Exposed Wall Height = 29.7	ft
Pile Length Above Rock = 40.8	in	Exposed Wall Height = 356.4	in

1.)

Per the ODOT GDM, pile-head deflection in the service limit state limited to 1% or less of the shaft length above bedrock, or 1% of total drilled shaft length if not embedded in bedrock.

2.)

Following industry acceptance criteria, limit wall deflection to 1% of exposed wall height where ODOT landslide criteria does not govern. Alternatively, limit wall deflection to 1.5% of the exposed wall height in accordance with NCDOT guidelines. Use 1.5% wall deflection for PYWALL software.

ODOT Landslide Criteria Governs

NO

OK

1% Wall Height OR 2 inches- LPILE

3.564 in

$\delta = \boxed{0.54}$ in (from Shoring Suite)

1.5% Wall Height - PYWALL

5.346 in

$\delta = \boxed{}$ in (from PYWALL)

Drilled Shafts Located Within 10 feet of Edge of Pavement

NO

Tieback Loading Computations

Design Tieback Load, TF1 = 196.3 kips / shaft
Design Tieback Load, TF2 = 102.8 kips / shaft

Horizontal values determined from Shoring Suite calculations.

1) Determine Tiebacks

Strands

0.6 GUTS per strand = 35.2 kips per strand (FHWA-NHI-07-071: Table 8-16)

(GUTS = guaranteed ultimate tensile strength)

Tieback	Inclin.	Required Anchor Load**	Strands	
No.	deg	kips	Required	Selected
1	20	208.9	5.9	6.0
2	20	109.4	3.1	4.0

**Required Anchor Load = (TF) / [Cos (Inclin. Angle)]

2) Check Pull-Out Capacity and Bond Length

Pullout Resistance Factor ϕ_{pr} = 0.7

Per AASHTO LRFD Table 11.5.7-1 for "Pullout resistance of anchors, cohesive soils"

Soil Friction Angle ϕ = 26

Table 8-16. Properties of 0.6 in. Diameter Prestressing Steel Strands (ASTM A416, Grade 270).

Number of 0.6 in. diameter strands	Cross section area	Ultimate strength (=GUTS)	Prestressing force		
			0.8 $f_{pu}A_{ps}$	0.7 $f_{pu}A_{ps}$	0.6 $f_{pu}A_{ps}$
	(in. ²)	(kips)	(kips)	(kips)	(kips)
1	0.217	58.6	46.9	41.0	35.2

Tieback	Height Above Bottom of Wall	Tieback Length to Active Wedge	Total Unbonded Length	Ultimate Bond Strength	Tieback Drill Hole Diameter	Surface Area per Foot of Tieback	Allowable Bond Strength per Foot of Tieback	Required Anchor Load	Required Bond Length	Total Tieback Length
No.	ft	ft	ft	ksf	in	in ² /ft	kips/ft	kips	ft	ft
1	20	10.7	21	3	9	339.3	4.95	208.9	43	64
2	10	5.3	16	3	9	339.3	4.95	109.4	23	39

Total unbonded length = Tieback length to active wedge + greater of 5 feet or H/3, with a 15 foot minimum, per AASHTO LRFD Figure 11.9.1-1

Ultimate bond strength per AASHTO LRFD Table C11.9.4.2-1. Tieback lengths assume entire bond length is in clay.

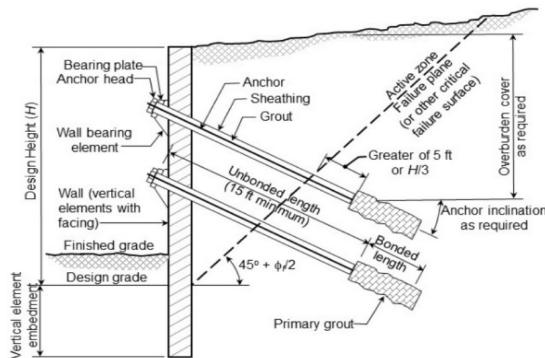


Figure 11.9.1-1—Anchored Wall Nomenclature and Anchor Embedment Guidelines

Table C11.9.4.2-1—Presumptive Ultimate Unit Bond Stress for Anchors in Cohesive Soils

Anchor/Soil Type (Grout Pressure)	Soil Stiffness or Unconfined Compressive Strength (tsf)	Presumptive Ultimate Unit Bond Stress, τ_u (ksf)
Gravity Grouted Anchors (<50 psi)		
Silt-Clay Mixtures	Stiff to Very Stiff 1.0-4.0	0.6 to 1.5
Pressure Grouted Anchors (50 psi-400 psi)		
High Plasticity Clay	Stiff 1.0-2.5 V. Stiff 2.5-4.0	0.6 to 2 1.5 to 3.6
Medium Plasticity Clay	Stiff 1.0-2.5 V. Stiff 2.5-4.0	2.0 to 5.2 2.9 to 7.3
Medium Plasticity Sandy Silt	V. Stiff 2.5-4.0	5.8 to 7.9



Service Limit Analysis (Soldier Pile and Lagging Wall with Tiebacks)

Date: 10/27/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 30' Wall Surcharge Service.lp8

Wall Height, H= 29.7 Load Depth, D= 0
Load Factor of Surcharge Loading = 1
Rigid Wall Condition -- No movement or deflection of the wall are allowed.
Max. Pressure = 0.140 at depth = 0.00

Infinite Surcharge, Q=.250 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

SURCHARGE LOADS CALCULATION SUMMARY
<Surcharge>
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Reference: Foundation Design, Wayne C. Teng, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1962

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Wall Surcharge Service.lp8

WAS-77-9.58
Traffic Loading

Height of Wall = 29.7
Depth of Load = 0
Load Factor of Surcharge Loading = 1

Wall Condition:
Rigid Wall Condition -- No movement or deflection of the wall are allowed.

*****Loading*****

INFINITE SURCHARGE LOADING: Q=.250
Active Wedge Approach * (recommend)

*****Total Pressure Distribution*****

Max. Pressure =0.140 at depth =0.00

Depth	Pressure
0.00	0.140
1.49	0.140
2.97	0.140
4.45	0.140
5.94	0.140
7.43	0.140
8.91	0.140
10.39	0.140
11.88	0.140
13.36	0.140
14.85	0.140
16.33	0.140
17.82	0.140
19.31	0.140
20.79	0.140
22.28	0.140
23.76	0.140

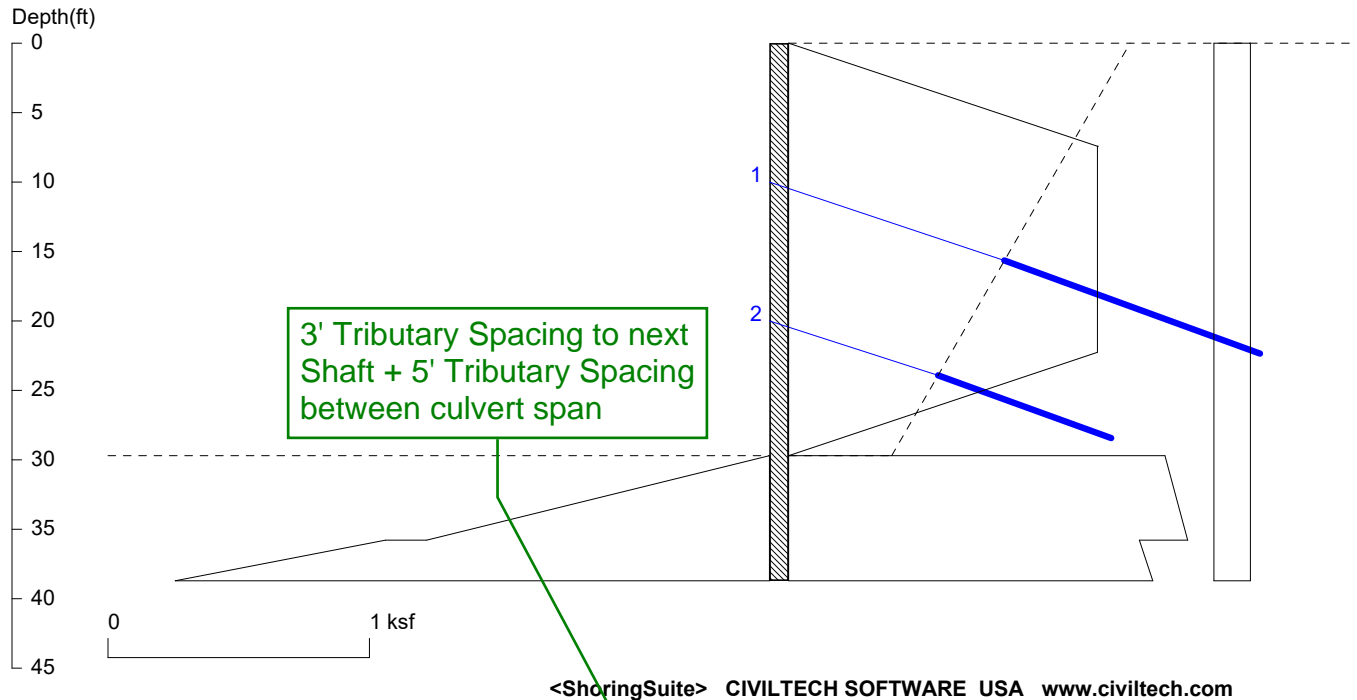
25.25	0.140
26.73	0.140
28.22	0.140
29.70	0.140
32.67	0.140
35.64	0.140
38.61	0.140
41.58	0.140
44.55	0.140
47.52	0.140
50.49	0.140
53.46	0.140
56.43	0.140
59.40	0.140
65.34	0.140
71.28	0.140
77.22	0.140
83.16	0.140
89.10	0.140
95.04	0.140
100.98	0.140
106.92	0.140
112.86	0.140
118.80	0.000

Surcharge loading cut off at top of rock (40.8 feet) in shoring module.

Depth Is Measured From Top of the Wall

LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

WAS-77-9.58



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Date: 11/3/2023

File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 30' Culvert Span Tieback Service.sh8

Wall Height=29.7

Pile Diameter=2.5

Pile Spacing=8.0

Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=9.02 Min. Pile Length=38.72

MOMENT IN PILE: Max. Moment=263.77 per Pile Spacing=8.0 at Depth=9.99

PILE SELECTION:

Request Min. Section Modulus = 63.3 in³/pile=1037.39 cm³/pile, F_y= 50 ksi = 345 MPa, F_b/F_y=1

HP14X89 has Section Modulus = 131.0 in³/pile=2146.70 cm³/pile. It is greater than Min. Requirements!

Top Deflection = 0.54(in) based on E (ksi)=29000.00 and I (in⁴)/pile=904.0

BRACE FORCE: Strut, Tieback, Plate Anchor, Deadman, Sheet Pile as Anchor

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	L _{free}	Fixed Length
1. Tieback	10.0	20.0	6.0	137.5*	129.2	47.0	16.5	27.8
2. Tieback	20.0	20.0	6.0	65.6	61.6	22.4	11.5	13.3

* Top Brace increased by 15% (DM7.2-103)

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	7.425	1.180	0.158920
7.425	1.180	22.27	1.180	0.000000
22.27	1.180	29.70	0.000	-0.15892
*	Below	Base		
29.70	1.439	35.80	1.525	0.014108
35.80	1.340	40.80	1.430	0.017999
*	Sur-	charg		
0.000	0.140	1.485	0.140	0.000000
1.485	0.140	2.970	0.140	0.000000
2.970	0.140	4.455	0.140	0.000000

4.455	0.140	5.940	0.140	0.000000
5.940	0.140	7.425	0.140	0.000000
7.425	0.140	8.910	0.140	0.000000
8.910	0.140	10.39	0.140	0.000000
10.39	0.140	11.88	0.140	0.000000
11.88	0.140	13.36	0.140	0.000000
13.36	0.140	14.85	0.140	0.000000
14.85	0.140	16.33	0.140	0.000000
16.33	0.140	17.82	0.140	0.000000
17.82	0.140	19.30	0.140	0.000000
19.30	0.140	20.79	0.140	0.000000
20.79	0.140	22.27	0.140	0.000000
22.27	0.140	23.76	0.140	0.000000
23.76	0.140	25.24	0.140	0.000000
25.24	0.140	26.73	0.140	0.000000
26.73	0.140	28.21	0.140	0.000000
28.21	0.140	29.70	0.140	0.000000
29.70	0.140	32.67	0.140	0.000000
32.67	0.140	35.64	0.140	0.000000
35.64	0.140	38.61	0.140	0.000000
38.61	0.140	41.58	0.140	0.000000

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
29.70	0.000	35.80	1.311	0.214939
35.80	1.469	40.80	2.846	0.275337

ACTIVE SPACING:

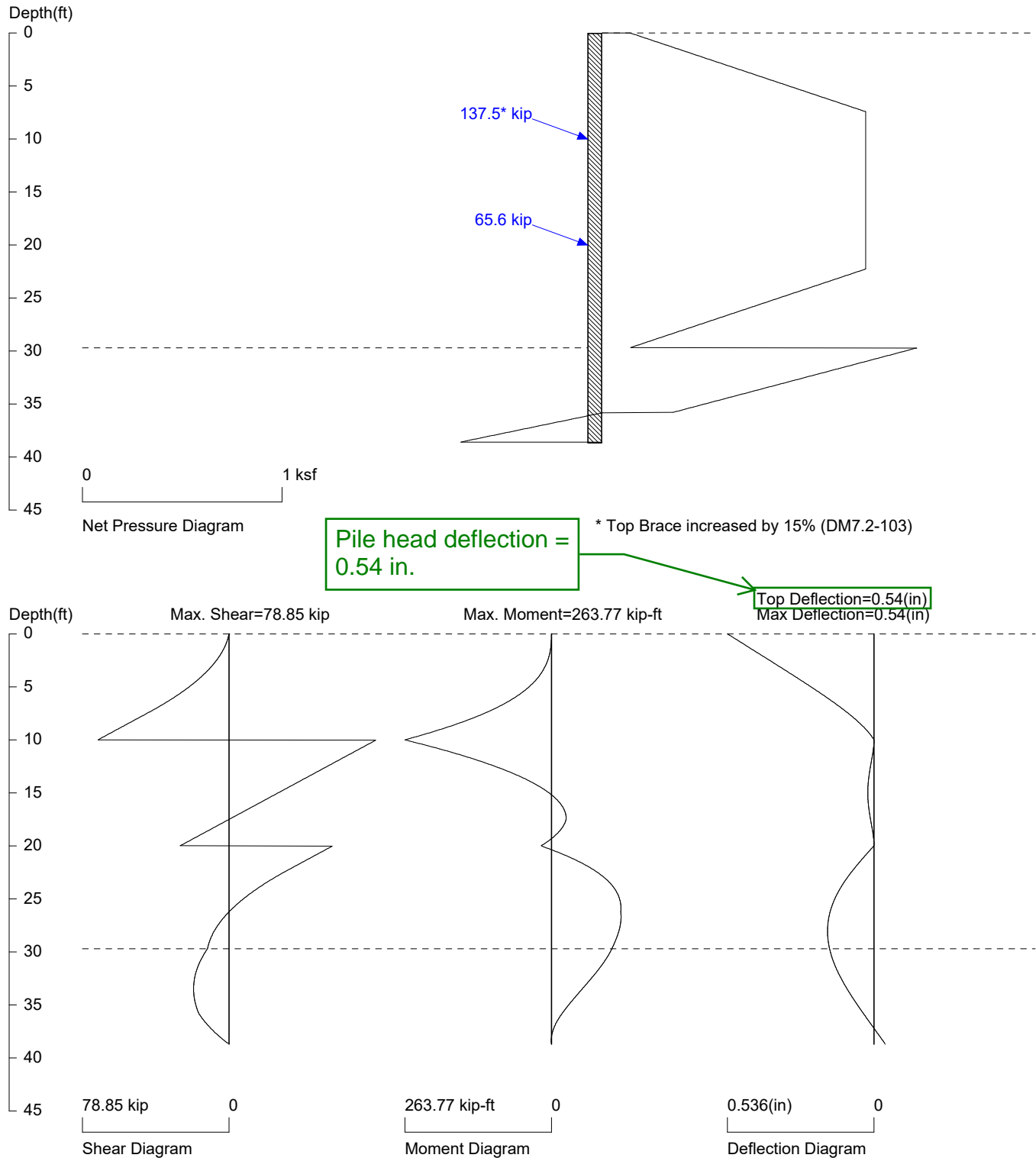
No.	Z depth	Spacing
1	0.00	8.00
2	29.70	2.50

PASSIVE SPACING:

No.	Z depth	Spacing
1	29.70	5.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft³; Deflection - in

WAS-77-9.58



PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 8.0 foot or meter

User Input Pile, HP14X89: E (ksi)=29000.0, I (in4)/pile=904.0

File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 30' Culvert Span Tieback Service.sh8

SHORING WALL CALCULATION SUMMARY
The leading shoring design and calculation software
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ShoringSuite Software is developed by CivilTech Software, Bellevue, WA, USA.

The calculation method is based on the following references:

1. FHWA 98-011, FHWA-RD-97-130, FHWA SA 96-069, FHWA-IF-99-015
2. STEEL SHEET PILING DESIGN MANUAL by Pile Buck Inc., 1987
3. DESIGN MANUAL DM-7 (NAVFAC), Department of the Navy, May 1982
4. TRENCHING AND SHORING MANUAL Revision 12, California Department of Transportation, January 2000
6. EARTH SUPPORT SYSTEM & RETAINING STRUCTURES, Pile Buck Inc. 2002
5. DESIGN OF SHEET PILE WALLS, EM 1110-2-2504, U.S. Army Corps of Engineers, 31 March 1994
7. EARTH RETENTION SYSTEMS HANDBOOK, Alan Macnab, McGraw-Hill. 2002
8. Temporary Structures in Construction, Robert T. Ratay (Co-author of Chapter 7: John J. Peirce), McGraw-Hill. 2012
9. AASHTO HB-17, American Association of State and Highway Transportation Officials, 2 September 2002

UNITS: Width/Spacing/Diameter/Length/Depth - ft, Force - kip, Moment - kip-ft, Friction/Bearing/Pressure - ksf, Pres.
Slope - kip/ft³, Deflection - in

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Date: 11/3/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 30' Culvert Span Tieback Service.sh8

Title: WAS-77-9.58

Subtitle:

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

Wall Type: 2. Soldier Pile, Drilled

Wall Height: 29.70

Pile Diameter: 2.50

Pile Spacing: 8.00

Factor of Safety (F.S.): 1.00

As Continuous Span Beam

Lateral Support Type (Braces): 3. Tieback

Top Brace Increase (Multi-Bracing): Add 15%*

No-Load Zone:

Vertical Depth for No-Load Zone: 29.70

H-Distance (Input H/V ratio) for No-Load Zone: 0.25

Angle from H. Line for No-Load Zone: 60.00
 Embedment Option: 1. Yes
 Friction at Pile Tip: No
 Pile Properties:
 Steel Strength, Fy: 50 ksi = 345 MPa
 Allowable Fb/Fy: 1
 Elastic Module, E: 29000.00
 Moment of Inertia, I: 904.00
 User Input Pile: HP14X89

* DRIVING PRESSURE (ACTIVE, WATER, & SURCHARGE) *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Above	Base		
2	0.000	0.000	7.425	1.180	0.158920
3	7.425	1.180	22.27	1.180	0.000000
4	22.27	1.180	29.70	0.000	-0.15892
5	*	Below	Base		
6	29.70	1.439	35.80	1.525	0.014108
7	35.80	1.340	40.80	1.430	0.017999
8	40.80	0.622	207.9	3.455	0.016954
9	*	Sur-	charg		
10	0.000	0.140	1.485	0.140	0.000000
11	1.485	0.140	2.970	0.140	0.000000
12	2.970	0.140	4.455	0.140	0.000000
13	4.455	0.140	5.940	0.140	0.000000
14	5.940	0.140	7.425	0.140	0.000000
15	7.425	0.140	8.910	0.140	0.000000
16	8.910	0.140	10.39	0.140	0.000000
17	10.39	0.140	11.88	0.140	0.000000
18	11.88	0.140	13.36	0.140	0.000000
19	13.36	0.140	14.85	0.140	0.000000
20	14.85	0.140	16.33	0.140	0.000000
21	16.33	0.140	17.82	0.140	0.000000
22	17.82	0.140	19.30	0.140	0.000000
23	19.30	0.140	20.79	0.140	0.000000
24	20.79	0.140	22.27	0.140	0.000000
25	22.27	0.140	23.76	0.140	0.000000
26	23.76	0.140	25.24	0.140	0.000000
27	25.24	0.140	26.73	0.140	0.000000
28	26.73	0.140	28.21	0.140	0.000000
29	28.21	0.140	29.70	0.140	0.000000

30	29.70	0.140	32.67	0.140	0.000000
31	32.67	0.140	35.64	0.140	0.000000
32	35.64	0.140	38.61	0.140	0.000000
33	38.61	0.140	40.8	0.140	0.000000

* PASSIVE PRESSURE *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Below	Base		
2	29.70	0.000	35.80	1.311	0.214939
3	35.80	1.469	40.80	2.846	0.275337
4	40.80	47	207.9	47	0.0000

Surcharge loading terminated at top of rock (40.8 feet).

* ACTIVE SPACE *

No.	Z depth	Spacing
1	0.00	8.00
2	29.70	2.50

Passive pressure for bedrock adjusted to 47 ksf based on an unconfined strength of 330 psi.

* PASSIVE SPACE *

No.	Z depth	Spacing
1	29.70	5.00

Hole diameter in feet (9 inches).

Allowable bond strength = resistance factor * ultimate bond strength = 0.7*3 ksf

* BRACE: STRUT, TIEBACK, ANCHOR PLATE, DEADMAN, OR SHEET PILE AS ANCHOR*

No.	Z brace	Angle	Spacing	Input1*	Input2*	Type
1	10.00	20.0	6.00	0.75	2.10	Tieback
2	20.00	20.0	6.00	0.75	2.10	Tieback

*For Tieback: Input1 = Diameter; Input2 = Bond Strength

*For Plate: Input1 = Diameter; Input2 = Allowable Pressure

*For Deadman: Input1 = Horz. Width; Input2 = Passive Pressure;

*For Sheet Pile Anchor: Input1 = Horz. Width; Input2 = Passive Slope;

*****CALCULATION*****

The calculated moment and shear are per pile spacing. Sheet piles are per one foot or meter; Soldier piles are per pile.

Top Pressures start at depth = 0.00

* CALCULATE REQUEST EMBEDMENT *

```
|<-- D1=20.00
|
==|== D2=29.70
|
| D3=38.72
```

D1 - TOP DEPTH R1 - TOP REACTION
D2 - EXCAVATION BASE
D3 - PILE TIP

TOTAL REACTION: R1 = 55.78

TOTAL PRESSURES ACTING ON WALL = 55.78

Total Reactions = Total Pressures, OK!

The Calculated Embedment, Yend = 9.02

-----MULTIPLE BRACE / TIEBACK CASE-----

** Use the calculated embedment, Yend = 9.02 for graphics and analysis.

NUMBER OF BRACE LEVEL= 2

* CANTILEVER SPAN, N0.0 *

```
| D1=0.00
|
|
|<-- D2=10.00                      R2=70.55, with Cantilever Moment=264.28
```

D1 - TOP DEPTH
D2 - BOTTOM DEPTH R2 - BOTTOM REACTION

TOTAL REACTION: R2 = 70.55

TOTAL PRESSURES ACTING ON WALL = 70.55

Total Reactions = Total Pressures, OK!

BRACE NO.1 AT DEPTH = 10.00
 R2 of Span No.0
 R1 of Last Span } Sum of Reaction = Brace Load = 149.78

* LAST SPAN *

```

| <-- D1=10.00      R1=79.23
|
| <-- D2=20.00      R2=82.15
|
|      D3=38.72

```

D1 - TOP DEPTH R1 - TOP REACTION
 D2 - LAST BRACE DEPTH R2 - LAST BRACE REACTION
 D3 - BOTTOM DEPTH

TOTAL REACTION: R1+R2 = 161.38
 TOTAL PRESSURES ACTING ON WALL = 161.38
 Total Reactions >= Total Pressures, OK!

BRACE NO.2 AT DEPTH = 20.00
 R2 of Last Span = Brace Load = 82.15

*****RESULTS*****

* EMBEDMENT *

MINIMUM EMBEDMENT = 9.02, TOTAL MINIMUM PILE LENGTH = 38.72

* MOMENT IN PILE (per pile spacing)*

Pile Spacing: sheet piles are one foot or one meter; soldier piles are one pile.

No.	Depth	M @ Brace	Mmax in Span	Depth of Mmax
1	10.00	263.77	26.36	17.40

2	20.00	18.50	125.14	26.71
---	-------	-------	--------	-------

Overall Maximum Moment = 263.77 at 9.99

Maximum Shear = 78.85

Moment and Shear are per pile spacing: 8.0 foot or meter

-> Top Brace Increase 15%. (Horizontal) From 149.78 to 172.25

* BRACE: STRUT, TIEBACK, ANCHOR PLATE, DEADMAN, OR SHEET PILE AS ANCHOR*

The calculated brace force are per brace spacing.

No.	DEPTH	Tangle	SPACING	HORIZONTAL	VERTICAL	TOTAL LOAD
1	10.00	20.0	6.00	129.19	47.02	137.48
2	20.00	20.0	6.00	61.61	22.43	65.57

No.	DEPTH	Free length	Brace Type
1	10.00	16.53	Tieback, Bond length = 27.78
2	20.00	11.45	Tieback, Bond length = 13.25

* VERTICAL LOADING *

Vertical Loading from Braces = 92.59

Vertical Loading from External Load = 0.00

Total Vertical Loading = 92.59

*****SPECIFIED PILE *****

Overall Maximum Moment = 263.77 at 9.99

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

Request Min. Section Modulus = 63.31 in³/pile = 1037.39 cm³/pile, Fy = 50 ksi = 345 MPa, Fb/Fy=1

HP14X89 has been found in Soldier Pile list!

(English Units):

Area= 26.1 in. Depth= 13.8 in. Width= 14.7 in. Height= 14 in.

Flange thickness= 0.615 in. Web thickness= 0.615 in.

Ix= 904 in⁴/pile Sx= 131 in³/pile Iy= 326 in⁴/pile Sy= 44.3 in³/pile

(Metric Units):

Ix= 376.24 x100cm⁴/pile Sx= 2146.70 cm³/pile Iy= 135.68 x100cm⁴/pile Sy= 725.94 cm³/pile

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

HP14X89 is capable to support the shoring!

Top deflection = 0.536(in)

Max. deflection = 0.536(in)

***** LAGGING SIZE ESTIMATION *****

Max. Pressure above base = 1.32

Piles are more rigid than timber lagging, due to arching, only portion of pressures are acting to lagging, 30-50% loading is suggested.

If 50% loading is used for lagging design, Design Pressure = 0.66

Pile Spacing = 8.0, Max. Moment in lagging = 5.28

For 4"x12" Timber, Section Modules $S=23.47 \text{ in}^3$. The request allowable bending strength, $fb=M/S=2.70$

For 6"x12" Timber, Section Modules $S=57.98 \text{ in}^3$. The request allowable bending strength, $fb=M/S=1.09$

If 30% loading is used for lagging design, Design Pressure = 0.40

Pile Spacing = 8.0, Max. Moment in lagging = 3.17

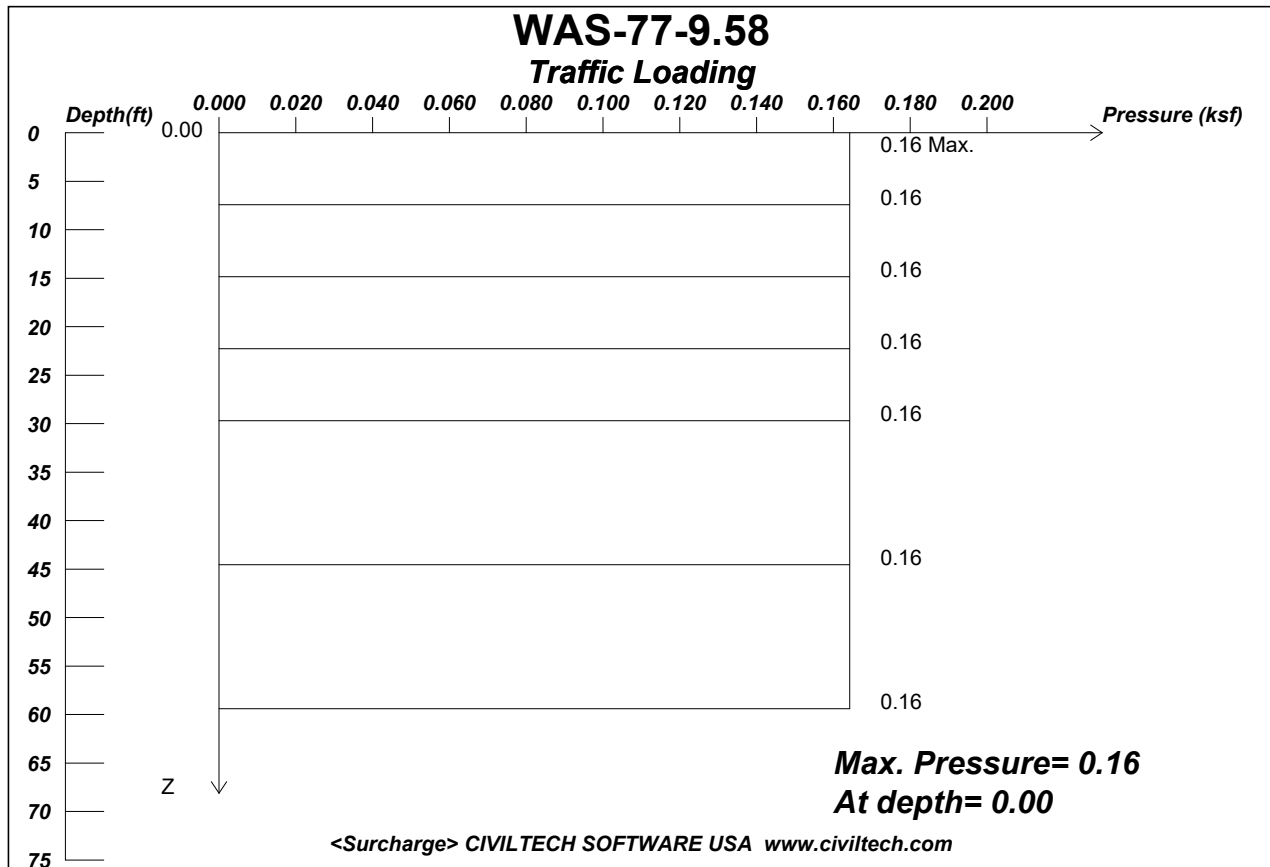
For 4"x12" Timber, Section Modules $S=23.47 \text{ in}^3$. The request allowable bending strength, $fb=M/S=1.62$

For 6"x12" Timber, Section Modules $S=57.98 \text{ in}^3$. The request allowable bending strength, $fb=M/S=0.66$

Unit: Pressure: ksf, Spacing: ft, Moment: kip-ft, Bending Strength, fb: ksi



Strength Limit Analysis (Soldier Pile and Lagging Wall with Tiebacks)



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Date: 10/27/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 30' Wall Surcharge Strength.lp8

Wall Height, H= 29.7

Load Depth, D= 0

Load Factor of Surcharge Loading = 1.17

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

Max. Pressure = 0.164 at depth = 0.00

A load factor of 1.5 is applied to all active loading in the wall analysis. As traffic loading uses 1.75, an extra factor has been applied here ($1.75/1.5 = 1.17$).

Infinite Surcharge, Q=.250

Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

SURCHARGE LOADS CALCULATION SUMMARY
<Surcharge>
Software Copyright by CivilTech Software
www.civiltech.com

Reference: Foundation Design, Wayne C. Teng, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1962

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Date: 10/27/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 30'
Wall Surcharge Strength.lp8

WAS-77-9.58
Traffic Loading

Height of Wall = 29.7
Depth of Load = 0
Load Factor of Surcharge Loading = 1.17

Wall Condition:
Rigid Wall Condition -- No movement or deflection of the wall are allowed.

*****Loading*****

INFINITE SURCHARGE LOADING: Q=.250
Active Wedge Approach * (recommend)

*****Total Pressure Distribution*****

Max. Pressure =0.164 at depth =0.00

Depth	Pressure
0.00	0.164
1.49	0.164
2.97	0.164
4.45	0.164
5.94	0.164
7.43	0.164
8.91	0.164
10.39	0.164
11.88	0.164
13.36	0.164
14.85	0.164
16.33	0.164
17.82	0.164
19.31	0.164
20.79	0.164
22.28	0.164
23.76	0.164

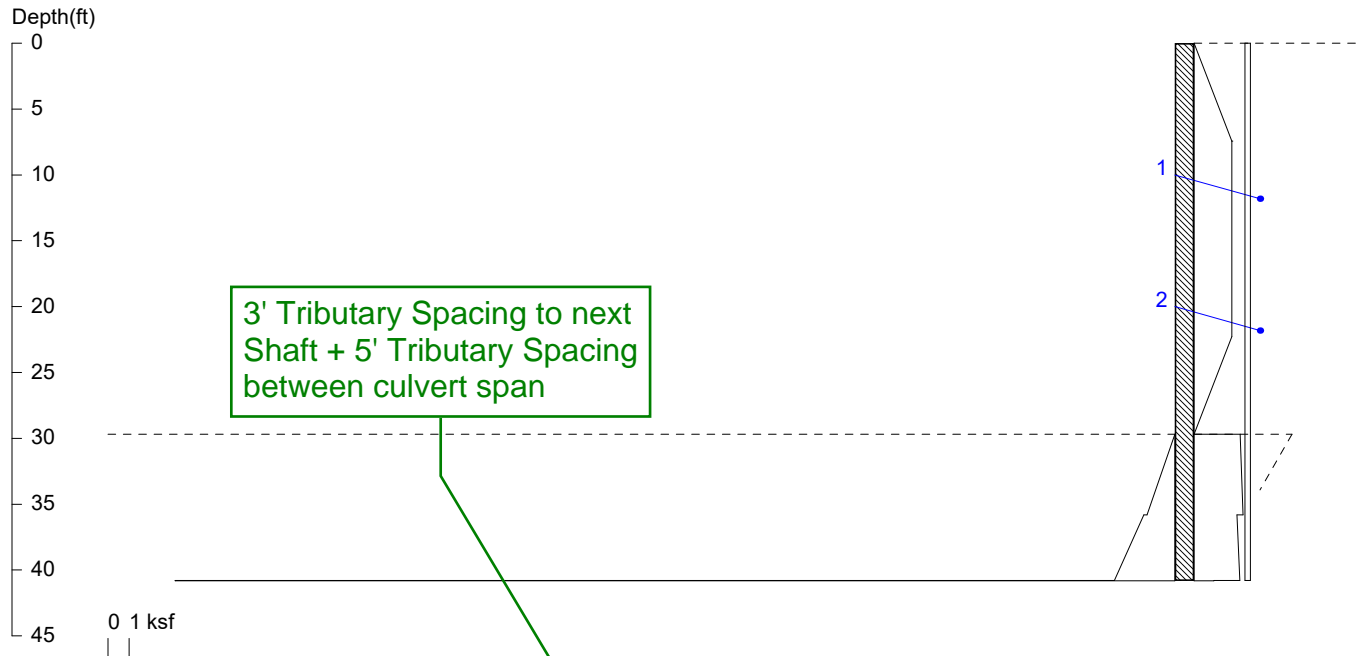
25.25	0.164
26.73	0.164
28.22	0.164
29.70	0.164
32.67	0.164
35.64	0.164
38.61	0.164
41.58	0.164
44.55	0.164
47.52	0.164
50.49	0.164
53.46	0.164
56.43	0.164
59.40	0.164
65.34	0.164
71.28	0.164
77.22	0.164
83.16	0.164
89.10	0.164
95.04	0.164
100.98	0.164
106.92	0.164
112.86	0.164
118.80	0.000

Surcharge loading cut off at top of rock (40.8 feet) in shoring module.

Depth Is Measured From Top of the Wall

LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

WAS-77-9.58



<ShoringSuite> CIVILTECH SOFTWARE USA www.civiltech.com

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Date: 11/3/2023

File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 30' Culvert Span Tieback Strength.sh8

Wall Height=29.7

Pile Diameter=2.5

Pile Spacing=8.0

Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=11.12 Min. Pile Length=40.82

MOMENT IN PILE: Max. Moment=412.69 per Pile Spacing=8.0 at Depth=9.99

Anchor loads and lengths

PILE SELECTION:

Request Min. Section Modulus = 99.0 in³/pile=1623.08 cm³/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=1

HP14X89 has Section Modulus = 131.0 in³/pile=2146.70 cm³/pile. It is greater than Min. Requirements!

Top Deflection = 0.88(in) based on E (ksi)=29000.00 and I (in⁴)/pile=904.0

BRACE FORCE: Strut, Tieback, Plate Anchor, Deadman, Sheet Pile as Anchor

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	Unbonded Length	Bonded Length
1. Tieback	10.0	20.0	6.0	208.9*	196.3	71.5	16.5	42.2
2. Tieback	20.0	20.0	6.0	109.4	102.8	37.4	11.5	22.1

* Top Brace increased by 15% (DM7.2-103)

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE): Pressures below will be multiplied by a Factor =1.5

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	7.425	1.180	0.158920
7.425	1.180	22.27	1.180	0.000000
22.27	1.180	29.70	0.000	-0.15892
*	Below	Base		
29.70	1.439	35.80	1.525	0.014108
35.80	1.340	40.80	1.430	0.017999
40.80	0.622	207.9	3.455	0.016954
*	Sur-	charg		
0.000	0.169	1.075	0.169	0.000000
1.075	0.169	2.150	0.169	0.000000

Applied 1.5 load factor for active earth pressures.

2.150	0.169	3.225	0.169	0.000000
3.225	0.169	4.300	0.169	0.000000
4.300	0.169	5.375	0.169	0.000000
5.375	0.169	6.450	0.169	0.000000
6.450	0.169	7.525	0.169	0.000000
7.525	0.169	8.600	0.169	0.000000
8.600	0.169	9.675	0.169	0.000000
9.675	0.169	10.75	0.169	0.000000
10.75	0.169	11.82	0.169	0.000000
11.82	0.169	12.90	0.169	0.000000
12.90	0.169	13.97	0.169	0.000000
13.97	0.169	15.05	0.169	0.000000
15.05	0.169	16.12	0.169	0.000000
16.12	0.169	17.20	0.169	0.000000
17.20	0.169	18.27	0.169	0.000000
18.27	0.169	19.35	0.169	0.000000
19.35	0.169	20.42	0.169	0.000000
20.42	0.169	21.50	0.169	0.000000
21.50	0.169	23.65	0.169	0.000000
23.65	0.169	25.80	0.169	0.000000
25.80	0.169	27.95	0.169	0.000000
27.95	0.169	30.10	0.169	0.000000
30.10	0.169	32.25	0.169	0.000000
32.25	0.169	34.40	0.169	0.000000
34.40	0.169	36.55	0.169	0.000000
36.55	0.169	38.70	0.169	0.000000
38.70	0.169	40.8	0.169	0.000000

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
29.70	0.000	35.80	1.311	0.214939
35.80	1.469	40.80	2.846	0.275337
40.80	47	207.9	47	0.0000

ACTIVE SPACING:

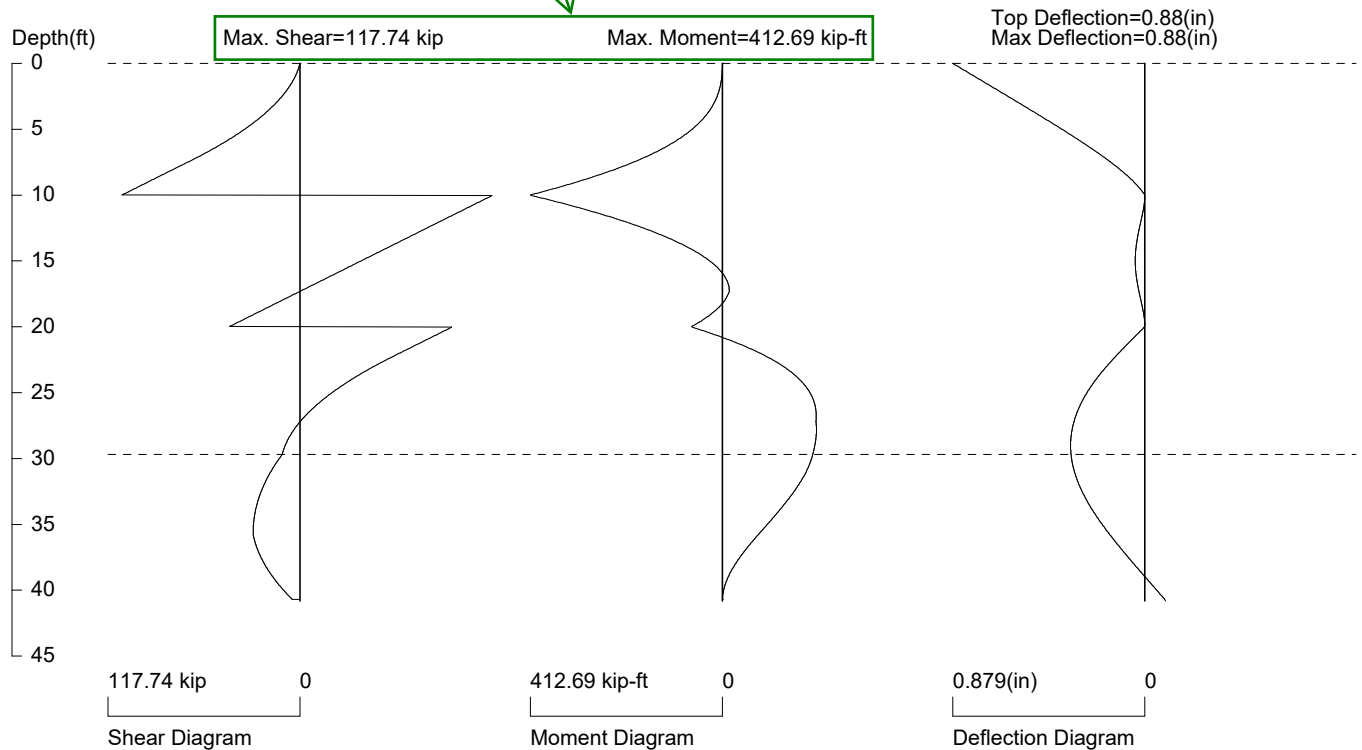
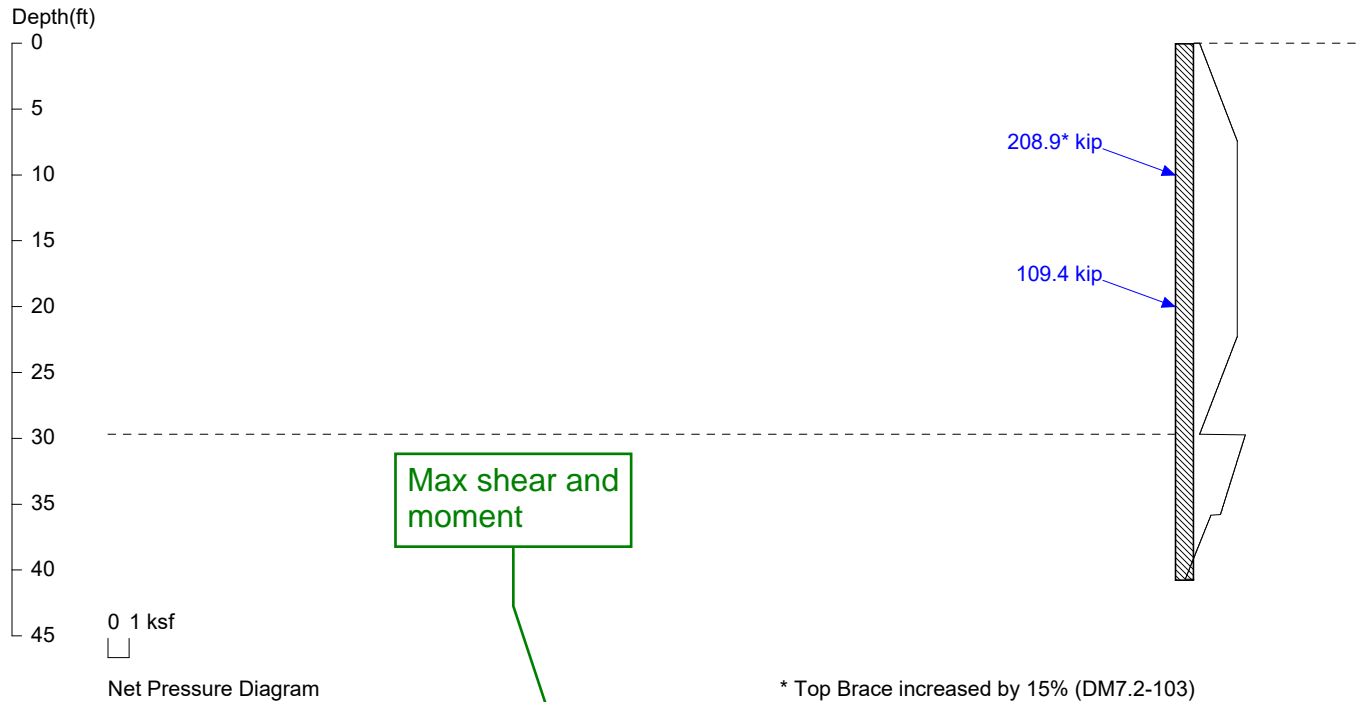
No.	Z depth	Spacing
1	0.00	8.00
2	29.70	2.50

PASSIVE SPACING:

No.	Z depth	Spacing
1	29.70	5.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft³; Deflection - in

WAS-77-9.58



PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 8.0 foot or meter

User Input Pile, HP14X89: E (ksi)=29000.0, I (in4)/pile=904.0

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SHORING WALL CALCULATION SUMMARY
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ShoringSuite Software is developed by CivilTech Software, Bellevue, WA, USA.

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3. DESIGN MANUAL DM-7 (NAVFAC), Department of the Navy, May 1982
4. TRENCHING AND SHORING MANUAL Revision 12, California Department of Transportation, January 2000
6. EARTH SUPPORT SYSTEM & RETAINING STRUCTURES, Pile Buck Inc. 2002
5. DESIGN OF SHEET PILE WALLS, EM 1110-2-2504, U.S. Army Corps of Engineers, 31 March 1994
7. EARTH RETENTION SYSTEMS HANDBOOK, Alan Macnab, McGraw-Hill. 2002
8. Temporary Structures in Construction, Robert T. Ratay (Co-author of Chapter 7: John J. Peirce), McGraw-Hill. 2012
9. AASHTO HB-17, American Association of State and Highway Transportation Officials, 2 September 2002

UNITS: Width/Spacing/Diameter/Length/Depth - ft, Force - kip, Moment - kip-ft, Friction/Bearing/Pressure - ksf, Pres.
Slope - kip/ft³, Deflection - in

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Date: 11/3/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 30' Culvert Span Tieback Strength.sh8

Title: WAS-77-9.58

Subtitle:

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

Wall Type: 2. Soldier Pile, Drilled

Wall Height: 29.70

Pile Diameter: 2.50

Pile Spacing: 8.00

Factor of Safety (F.S.): 1.00

As Continuous Span Beam

Lateral Support Type (Braces): 3. Tieback

Top Brace Increase (Multi-Bracing): Add 15%*

No-Load Zone:

Vertical Depth for No-Load Zone: 29.70

H-Distance (Input H/V ratio) for No-Load Zone: 0.25

Angle from H. Line for No-Load Zone: 60.00
 Embedment Option: 1. Yes
 Friction at Pile Tip: No
 Pile Properties:
 Steel Strength, Fy: 50 ksi = 345 MPa
 Allowable Fb/Fy: 1
 Elastic Module, E: 29000.00
 Moment of Inertia, I: 904.00
 User Input Pile: HP14X89

* DRIVING PRESSURE (ACTIVE, WATER, & SURCHARGE) *

The pressures below will be multiplied by a Factor =1.5

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Above	Base		
2	0.000	0.000	7.425	1.180	0.158920
3	7.425	1.180	22.27	1.180	0.000000
4	22.27	1.180	29.70	0.000	-0.15892
5	*	Below	Base		
6	29.70	1.439	35.80	1.525	0.014108
7	35.80	1.340	40.80	1.430	0.017999
8	40.80	0.622	207.9	3.455	0.016954
9	*	Sur-	charg		
10	0.000	0.169	1.075	0.169	0.000000
11	1.075	0.169	2.150	0.169	0.000000
12	2.150	0.169	3.225	0.169	0.000000
13	3.225	0.169	4.300	0.169	0.000000
14	4.300	0.169	5.375	0.169	0.000000
15	5.375	0.169	6.450	0.169	0.000000
16	6.450	0.169	7.525	0.169	0.000000
17	7.525	0.169	8.600	0.169	0.000000
18	8.600	0.169	9.675	0.169	0.000000
19	9.675	0.169	10.75	0.169	0.000000
20	10.75	0.169	11.82	0.169	0.000000
21	11.82	0.169	12.90	0.169	0.000000
22	12.90	0.169	13.97	0.169	0.000000
23	13.97	0.169	15.05	0.169	0.000000
24	15.05	0.169	16.12	0.169	0.000000
25	16.12	0.169	17.20	0.169	0.000000
26	17.20	0.169	18.27	0.169	0.000000
27	18.27	0.169	19.35	0.169	0.000000
28	19.35	0.169	20.42	0.169	0.000000

29	20.42	0.169	21.50	0.169	0.000000
30	21.50	0.169	23.65	0.169	0.000000
31	23.65	0.169	25.80	0.169	0.000000
32	25.80	0.169	27.95	0.169	0.000000
33	27.95	0.169	30.10	0.169	0.000000
34	30.10	0.169	32.25	0.169	0.000000
35	32.25	0.169	34.40	0.169	0.000000
36	34.40	0.169	36.55	0.169	0.000000
37	36.55	0.169	38.70	0.169	0.000000
38	38.70	0.169	40.8	0.169	0.000000

* PASSIVE PRESSURE *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Below	Base		
2	29.70	0.000	35.80	1.311	0.214939
3	35.80	1.469	40.80	2.846	0.275337
4	40.80	47	207.9	47	0.0000

Surcharge loading terminated at top of rock (40.8 feet).

* ACTIVE SPACE *

No.	Z depth	Spacing
1	0.00	8.00
2	29.70	2.50

Passive pressure for bedrock adjusted to 47 ksf based on an unconfined strength of 330 psi.

* PASSIVE SPACE *

No.	Z depth	Spacing
1	29.70	5.00

Hole diameter in feet (9 inches).

Allowable bond strength = resistance factor * ultimate bond strength = 0.7×3 ksf

* BRACE: STRUT, TIEBACK, ANCHOR PLATE, DEADMAN, OR SHEET PILE AS ANCHOR*

No.	Z brace	Angle	Spacing	Input1*	Input2*	Type
1	10.00	20.0	6.00	0.75	2.10	Tieback
2	20.00	20.0	6.00	0.75	2.10	Tieback

*For Tieback: Input1 = Diameter; Input2 = Bond Strength

*For Plate: Input1 = Diameter; Input2 = Allowable Pressure

*For Deadman: Input1 = Horz. Width; Input2 = Passive Pressure;
*For Sheet Pile Anchor: Input1 = Horz. Width; Input2 = Passive Slope;

*****CALCULATION*****

The calculated moment and shear are per pile spacing. Sheet piles are per one foot or meter; Soldier piles are per pile.

Top Pressures start at depth = 0.00

* CALCULATE REQUEST EMBEDMENT *

```
|<-- D1=20.00
|
==|== D2=29.70
|
|      D3=40.82
```

D1 - TOP DEPTH R1 - TOP REACTION
D2 - EXCAVATION BASE
D3 - PILE TIP

TOTAL REACTION: R1 = 91.55

TOTAL PRESSURES ACTING ON WALL = 91.55

Total Reactions = Total Pressures, OK!

The Calculated Embedment, Yend = 11.12

-----MULTIPLE BRACE / TIEBACK CASE-----

** Use the calculated embedment, Yend = 11.12 for graphics and analysis.

NUMBER OF BRACE LEVEL= 2

* CANTILEVER SPAN, N0.0 *

```
|      D1=0.00
|
|<-- D2=10.00                      R2=109.31, with Cantilever Moment=413.81
```

D1 - TOP DEPTH

D2 - BOTTOM DEPTH

R2 - BOTTOM REACTION

TOTAL REACTION: $R2 = 109.31$

TOTAL PRESSURES ACTING ON WALL = 109.31

Total Reactions = Total Pressures, OK!

BRACE NO.1 AT DEPTH = 10.00

R2 of Span No.0

} Sum of Reaction = Brace Load = 227.62

R1 of Last Span

* LAST SPAN *

| <-- D1=10.00 R1=118.31

| <-- D2=20.00 R2=137.04

| D3=40.82

D1 - TOP DEPTH R1 - TOP REACTION

D2 - LAST BRACE DEPTH R2 - LAST BRACE REACTION

D3 - BOTTOM DEPTH

TOTAL REACTION: $R1+R2 = 255.35$

TOTAL PRESSURES ACTING ON WALL = 255.35

Total Reactions \geq Total Pressures, OK!

BRACE NO.2 AT DEPTH = 20.00

R2 of Last Span = Brace Load = 137.04

*****RESULTS*****

* EMBEDMENT *

MINIMUM EMBEDMENT = 11.12, TOTAL MINIMUM PILE LENGTH = 40.82

* MOMENT IN PILE (per pile spacing)*

Pile Spacing: sheet piles are one foot or one meter; soldier piles are one pile.

No.	Depth	M @ Brace	Mmax in Span	Depth of Mmax
1	10.00	412.69	14.80	17.26
2	20.00	66.24	202.16	27.79

Overall Maximum Moment = 412.69 at 9.99

Maximum Shear = 117.74

Moment and Shear are per pile spacing: 8.0 foot or meter

-> Top Brace Increase 15%. (Horizontal) From 227.62 to 261.76

* BRACE: STRUT, TIEBACK, ANCHOR PLATE, DEADMAN, OR SHEET PILE AS ANCHOR*

The calculated brace force are per brace spacing.

No.	DEPTH	Tangle	SPACING	HORIZONTAL	VERTICAL	TOTAL LOAD
1	10.00	20.0	6.00	196.32	71.45	208.92
2	20.00	20.0	6.00	102.78	37.41	109.37

No.	DEPTH	Free length	Brace Type
1	10.00	16.53	Tieback, Bond length = 42.22
2	20.00	11.45	Tieback, Bond length = 22.10

* VERTICAL LOADING *

Vertical Loading from Braces = 145.15

Vertical Loading from External Load = 0.00

Total Vertical Loading = 145.15

*****SPECIFIED PILE *****

Overall Maximum Moment = 412.69 at 9.99

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

Request Min. Section Modulus = 99.05 in³/pile = 1623.08 cm³/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=1

HP14X89 has been found in Soldier Pile list!

(English Units):

Area= 26.1 in. Depth= 13.8 in. Width= 14.7 in. Height= 14 in.

Flange thickness= 0.615 in. Web thickness= 0.615 in.

$I_x = 904 \text{ in}^4/\text{pile}$ $S_x = 131 \text{ in}^3/\text{pile}$ $I_y = 326 \text{ in}^4/\text{pile}$ $S_y = 44.3 \text{ in}^3/\text{pile}$

(Metric Units):

$I_x = 376.24 \times 100 \text{ cm}^4/\text{pile}$ $S_x = 2146.70 \text{ cm}^3/\text{pile}$ $I_y = 135.68 \times 100 \text{ cm}^4/\text{pile}$ $S_y = 725.94 \text{ cm}^3/\text{pile}$

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

HP14X89 is capable to support the shoring!

Top deflection = 0.879(in)

Max. deflection = 0.879(in)

***** LAGGING SIZE ESTIMATION *****

Max. Pressure above base = 2.02

Piles are more rigid than timber lagging, due to arching, only portion of pressures are acting to lagging, 30-50% loading is suggested.

If 50% loading is used for lagging design, Design Pressure = 1.01

Pile Spacing = 8.0, Max. Moment in lagging = 8.09

For 4"x12" Timber, Section Modules $S = 23.47 \text{ in}^3$. The request allowable bending strength, $fb = M/S = 4.14$

For 6"x12" Timber, Section Modules $S = 57.98 \text{ in}^3$. The request allowable bending strength, $fb = M/S = 1.68$

If 30% loading is used for lagging design, Design Pressure = 0.61

Pile Spacing = 8.0, Max. Moment in lagging = 4.86

For 4"x12" Timber, Section Modules $S = 23.47 \text{ in}^3$. The request allowable bending strength, $fb = M/S = 2.48$

For 6"x12" Timber, Section Modules $S = 57.98 \text{ in}^3$. The request allowable bending strength, $fb = M/S = 1.01$

Unit: Pressure: ksf, Spacing: ft, Moment: kip-ft, Bending Strength, fb: ksi

1 Tieback



Earth Pressure Determination

Geometry

Elevation (ft)			Horiz. Distance from C/L (ft)		
Top of Backfill =	860.0	at Bottom of Embankment	Start of Wall Backfill =	50.0	at Bottom of Embankment
Top of Wall =	851.0	at C/L of Wall	Wall =	0.0	at C/L of Wall
Existing Ground Surface =	851.4	at C/L of Wall			
Bottom of Wall =	829.5	at C/L of Wall	Backfill Slope Angle =	5.6	H:1V
Groundwater =	848.5	at C/L of Wall		10.2	degrees

Wall Loading Profile (B-005-0-23)

	Top Elev.	Thickness (ft)	Cohesion (psf)	Phi (deg)	Unit Wt (pcf)
Layer 2 Medium Stiff to Stiff Cohesive	851.0	0.8	115	23	140
Layer 1 Soft to Medium Stiff Cohesive	850.2	5.0	65	21	115
Layer 2 Medium Stiff to Stiff Cohesive	845.2	10.0	115	23	140
Layer 3 Stiff to Very Stiff Cohesive	835.2	5.7	175	25	135
Bottom of Wall/Maintenance Bench	829.5				
Weighted Value		21.5	120	23	135

Earth Pressure Coefficients

	Deg	
Shear Resistance, Φ =	25	
Wall Friction, δ^A =	0.0	
Wall Slope, θ =	90	
Backfill Slope, β =	10.20	
Revised Backfill Slope, β =	10.20	
Backfill Condition	INFINITE	
Horz. Backslope Dist.	50.0	feet (C/L of Wall - Edge of Shoulder)
Wall Height (H)	21.5	feet (Top of Wall - Maintenance Bench)
Slope Height (h)	9.0	feet (Top of Backfill - Top of Wall)
I =	11.82	degrees

Notes:

- Wall friction neglected
- Figure and Equation for Active Earth Pressure from AASHTO 3.11.5.3 (LRFD Design Manual).
- The wall retained soil will consist of existing cohesive overburden. Using the soil layer thicknesses and respective soil parameters, a weighted average was determined and assumed for the entire profile ($c' = 120$ psf and $\phi' = 23^\circ$). The parameters were converted to equivalent soil strength parameters $c' = 0$ psf and $\phi' = 25^\circ$ for checking tieback lengths based on a 1 degree increase in friction angle for every 50 psf decrease in cohesion up to 150 psf (Ref: Hall's Thesis).

Shoring Suite Design Profile

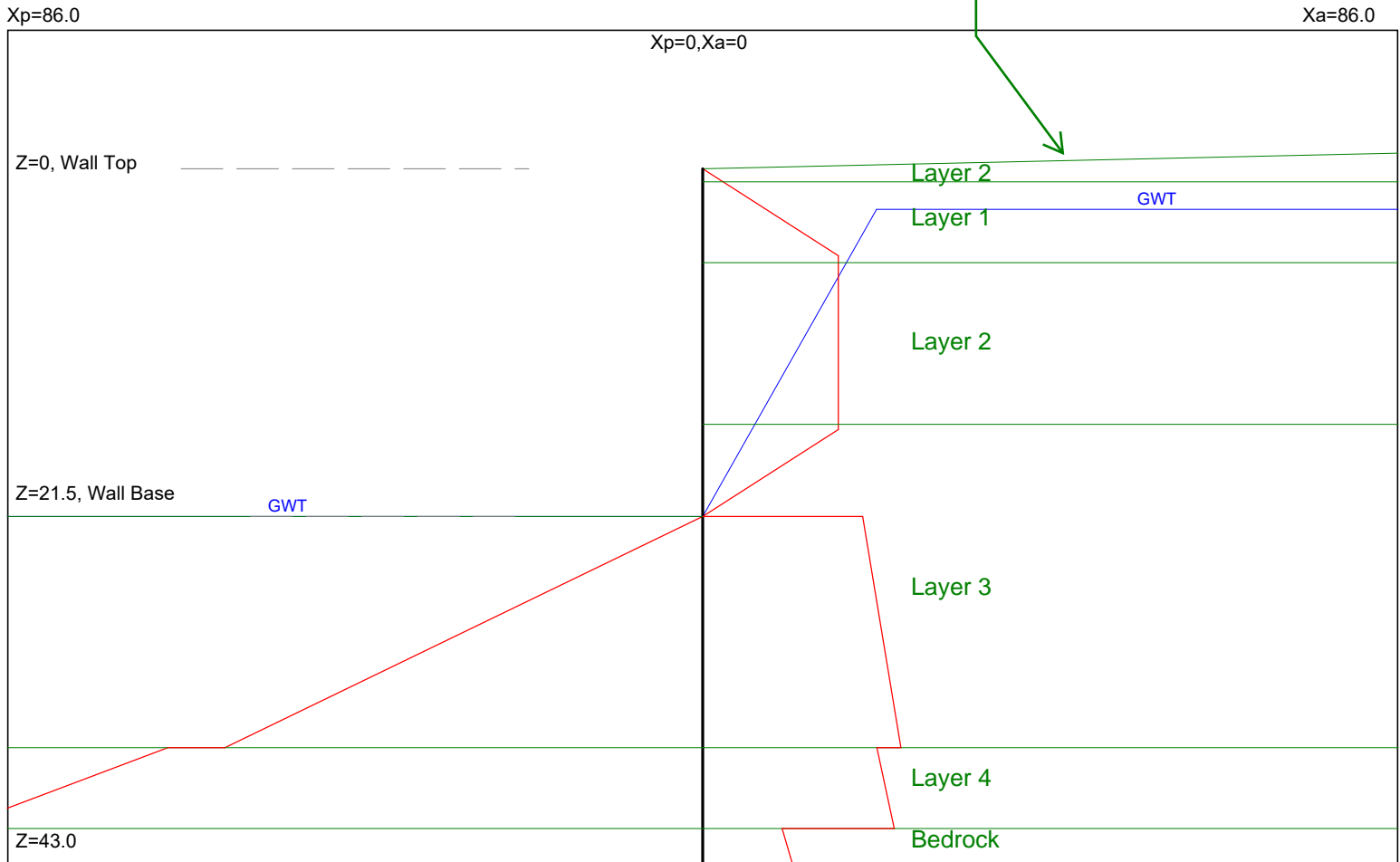
	Top Elev	Depth (ft)	Cohesion (psf)	Phi (deg)	Unit Wt (pcf)
Layer 2 Medium Stiff to Stiff Cohesive	851.0	0.0	0	25	140
Layer 1 Soft to Medium Stiff Cohesive	850.2	0.8	0	22	115
Layer 2 Medium Stiff to Stiff Cohesive	845.2	5.8	0	25	140
Layer 3 Stiff to Very Stiff Cohesive	835.2	15.8	0	28	135
Layer 4 Hard Cohesive	815.2	35.8	0	31	145
Bedrock	810.2	40.8	0	45	150

Depths referenced below the top of wall. Friction angles reflect adjustments made per Hall's Thesis. Bedrock modeled as very dense gravel.

Earth pressures generated using service loading.

WAS-77-9.58

5.6H:1V Backslope



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 UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf
 Date: 10/17/2023 File: C:\Users\abaratta\Desktop\WAS-77-9.58 21.5' Main Wall Tieback.ep8

* INPUT DATA *

Wall Height=21.5 Total Soil Types= 5

Soil No.	Weight	Saturate	Phi	Cohesion	Nspt	Type	Description
1	115.0	120.0	22	0	5	1	1. Soft to M
2	140.0	145.0	25	0.0	11	1	2. Medium St
3	135.0	140.0	28	0.0	24	1	3. Stiff to
4	145.0	150.0	31	0.0	65	1	4. Hard Cohe
5	150.0	155.0	45	0.0	100	5	Bedrock

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.	Description
1	0.0	0.0	-9.0	800.0	2	2. Medium St
2	0.8	0.0	0.8	800.0	1	1. Soft to M
3	5.8	0.0	5.8	800.0	2	2. Medium St
4	15.8	0.0	15.8	800.0	3	3. Stiff to
5	35.8	0.0	35.8	800.0	4	4. Hard Cohe
6	40.8	0.0	40.8	800.0	5	Bedrock

Water Table at Active Side:

Point	Z-water	X-water
1	21.5	0.0
2	2.5	21.5
3	2.5	800.0

Bedrock modeled as dense gravel to generate active pressures.

Ground Surface at Passive Side:

Line	Z1	Xp1	Z2	Xp2	Soil No.	Description
1	21.5	0.0	21.5	800.0	3	3. Stiff to
2	35.8	0.0	35.8	800.0	4	4. Hard Cohe
3	40.8	0.0	40.8	800.0	5	Bedrock

Water Table at Passive Side:

Point	Z-water	X-water
1	21.5	0.0
2	21.5	800.0

Wall Friction Options: 1.* No wall friction

Wall Batter Angle = 0

Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*

Water Density = 62.4

Water Pressure: 1.* No seepage at wall tip

* OUTPUT RESULTS *

Total Force above Base= 11.73 per one linear foot (or meter) width along wall height

Total Static Force above Base= 11.73. Distributed in Apparent Envelope along wall height. Ignore soil layers and water line

Driving Pressure above Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Coef.
0.00	0.00	5.38	0.87	0.1624	1.1603
5.38	0.87	16.13	0.87	0.0000	0.0000
16.13	0.87	21.50	0.00	-0.1624	-1.2033

Driving Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Ka or Ko
21.50	1.03	35.80	1.28	0.0172	0.2222
35.80	1.12	40.80	1.23	0.0224	0.2552
40.80	0.51	43.00	0.58	0.0307	0.3320

Passive Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pp1	Z2	Pp2	Slope	Kp
21.50	0.00	35.80	3.07	0.215	2.7698
35.80	3.44	40.80	4.82	0.276	3.1538
40.80	7.43	43.00	8.95	0.690	7.4523

Passive pressures below 45.8 feet manually adjusted in shoring module to reflect claystone strength.

UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

Date: 10/17/2023 File Name: C:\Users\labaratta\Desktop\WAS-77-9.58 21.5' Main Wall Tieback.ep8

EARTH PRESSURE ANALYSIS SUMMARY

<EarthPres>

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Date: 10/17/2023 File: C:\Users\abaratta\Desktop\WAS-77-9.58 21.5' Main Wall Tieback.ep8

Title 1: WAS-77-9.58

Title 2:

Input data: *****

Wall Height = 21.50

Depth of Ground at Active Side = 0.00

Depth of Ground at Passive Side = 21.50

Apparent Pressure Envelope: 4. 2-Trapezoid Envelope (Braced, Stiff Clay)

Pressure Type: 1.* Active, Ka

Earthquake Loading Apply to: 1. No Earthq. Loads

Earthquake Horizontal Acceleration, Kh = 0

Earthquake Vertical Acceleration, Kv = 0

Calculation Methods: 1.* Numerical Solution (Wedge Analysis)

Wall Friction Options: 1.* No wall friction

Wall Batter Angle = 0

Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*

Water Density = 62.4

Water Pressure: 1.* No seepage at wall tip

User's Settings

Ignore Passive from Depth = 0

Multiplier of Active Pressure = 1

Multiplier of Passive Pressure = 1

Multiplier of Water Pressure = 1

Multiplier of Earthq. Pressure = 1

Estimated Embedment: Very Shallow: 2H

Program's Settings

Max. Height, Hmax = 215.00

Analysis Segment, dz = 0.54

No. of Active Segment at H, nz0 = 4

No. of Active Segment at Hmax, nz = 7

No. of Passive Segment, nzp = 3

Active Depth at H, Zh = 21.50

Active Depth at Hmax, Z = 215.00

Passive Depth at Hmax, Zp = 215.00

Max. Pressure = 103.18

Total Soil Types= 5

Soil	Weight	W(S)	Phi	Cohesion	Nspt	Type	Description
1	115.0	120.0	22	0	5	1	1. Soft to M
>	115.0	120.0	22.0	0.0	5	1	Converted
2	140.0	145.0	25	0.0	11	1	2. Medium St
>	140.0	145.0	25.0	0.0	11	1	Converted
3	135.0	140.0	28	0.0	24	1	3. Stiff to

>	135.0	140.0	28.0	0.0	24	1	Converted
4	145.0	150.0	31	0.0	65	1	4. Hard Cohe
>	145.0	150.0	31.0	0.0	65	1	Converted
5	150.0	155.0	45	0.0	100	5	Bedrock

Soil Type: 1 Equivalent Clay; 2 Clay; 3 Silt; 4 Sand; 5 Gravel

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.
1	0.0	0.0	-9.0	800.0	2
2	0.8	0.0	0.8	800.0	1
3	5.8	0.0	5.8	800.0	2
4	15.8	0.0	15.8	800.0	3
5	35.8	0.0	35.8	800.0	4
6	40.8	0.0	40.8	800.0	5

Water Table at Active Side:

Point	Z-water	X-water
1	21.5	0.0
2	2.5	21.5
3	2.5	800.0

Ground Surface at Passive Side:

Line	Z1	Xp1	Z2	Xp2	Soil No.
1	21.5	0.0	21.5	800.0	3
2	35.8	0.0	35.8	800.0	4
3	40.8	0.0	40.8	800.0	5

Water Table at Passive Side:

Point	Z-water	X-water
1	21.5	0.0
2	21.5	800.0

Output data: *****

Total Force above Base= 11.73 per one linear foot (or meter) width along wall height
 Static Force above Base= 11.73. Distributed in Apparent Envelope along wall height.
 Ignore soil layers and water line

Apparent Pressure above Base - Output to Shoring

Active/At-Rest Force above Base, Ea = 11.73

No	Z1	P1	Z2	P2	Slope	Coef.
0	0.0	0.00	5.4	0.87	0.1624	1.1603
1	5.4	0.87	16.1	0.87	0.0000	0.0000
2	16.1	0.87	21.5	0.00	-0.1624	-1.2033

Driving Pressure below Base - Output to Shoring

No	Z1	P1	Z2	P2	Slope	Ka or Ko
0	21.5	1.03	35.8	1.28	0.0172	0.2222
1	35.8	1.12	40.8	1.23	0.0224	0.2552
2	40.8	0.60	215.0	3.51	0.0167	0.1806

Passive Pressure below Base - Output to Shoring

No	Z1	P1	Z2	P2	Slope	Kp
----	----	----	----	----	-------	----

0	21.5	0.00	35.8	3.07	0.2149	2.7698
1	35.8	3.44	40.8	4.82	0.2763	3.1538
2	40.8	8.71	215.0	103.18	0.5423	5.8560

Passive pressures below 45.8 feet manually adjusted in shoring module to reflect claystone strength.

DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

Z, Xa, Xp - Coordinates of ground lines

Z- Depth measured from wall top

Xa - Distance measure from wall to active side.

Xp - Distance measure from wall to passive side

Z1, P1, Z2, P2 - Four values to define a pressure diagram

Z1- Top depth of the diagram

P1- Top pressure of the diagram

Z2- Bottom depth of the diagram

P2- Bottom pressure of the diagram

Slope - $(P2-P1)/(Z2-Z1)$, Slope of the diagram. It also called Equivalent fluid density.

Coef. - Pressure Coefficient = Slope/Unit Weight

Ka - Active Earth Pressure Coefficient

Ko - At-Rest Earth Pressure Coefficient

Kp - Passive Earth Pressure Coefficient

Steel Beam and Cross-Section Properties

Assumed Pile Shape **HP 14x89**

Pile Availability

AISC Member Producers	3
Non-Member Producers	0

Shaft Geometry

Shaft Diameter	30	in
Longest Beam Dimension	20.162589	in
Clear Distance	4.9187054	in

Steel Beam Geometry

Beam Depth (D)	13.8	in
Web Thickness (t _w)	0.615	in
Flange Width (B _f)	14.7	in
Flange Thickness (t _f)	0.615	in
Area of Steel (A _s)	26.1	in ²

Steel Properties

Yield Strength of Steel	50	ksi
Moment of Inertia (I _{xx}) of Steel	904	in ⁴
Modulus of Elasticity of Steel (E)	29000	ksi
Modulus of Elasticity of Steel (E)	29000000	psi
EI (Steel Only)	2.622E+10	lb*in ²
Section Modulus (S _x)	131	in ³
Section Modulus (Z _x)	146	in ³
Shear-Buckling Coefficient (k)	5	
Ratio of Shear-Buckling Resistance (C)	1	
D/t _w	22.439024	
1.12VEk/F _{yw}	60.313846	
1.40VEk/F _{yw}	75.392307	

Determined by AASHTO LRFD Bridge Specifications
Eqn's 6.10.9.3.2-4, 6.10.9.3.2-5, and 6.10.9.3.2-6

Shear Capacity Calculation

$$V_u \leq \phi V_{cr}$$
$$\phi_b = \boxed{1} \text{ AASHTO LRFD Bridge Design Spec's 6.5.4.2}$$
$$V_u = \text{shear in web due to factored permanent and construction loads applied to noncompact section (kips)}$$
$$V_{cr} = \text{shear buckling resistance determined from Equation 6.10.9.3.3-1 (AASHTO LRFD Bridge Design Spec's)}$$
$$V_n = V_{cr} = C V_p$$
$$V_p = 0.58 F_{yw} D t_w$$
$$V_p = \text{plastic shear force (kips)}$$
$$C = \text{ratio of shear-buckling resistance to shear yield strength determined by AASHTO Eqn's 6.10.9.3.2-4, 6.10.9.3.2-5, 6.10.9.3.2-5, or 6.10.9.3.2-6}$$
$$V_p = 0.58 * 50 * 13.8 * 0.615$$
$$V_p = \boxed{246.1} \text{ kips}$$
$$\phi V_{cr} = \phi * C * V_p$$
$$\phi V_{cr} = 1 * 1 * 246.1$$
$$\phi V_{cr} = \boxed{246.1} \text{ kips}$$
$$V_u = \boxed{83.79} \text{ kips (from Shoring Suite)}$$
$$\boxed{} \text{ kips (from PYWALL)}$$
$$V_u < \phi V_{cr} \quad \text{OK}$$

Flexure Capacity Calculation

$$M_u \leq \phi M_n$$
$$\phi_b = \boxed{1} \text{ AASHTO LRFD Bridge Design Spec's 6.5.4.2}$$
$$M_u = \text{Moment due to the factored loads}$$
$$M_n = \text{Nominal flexural resistance of a section}$$
$$S_x = \text{Elastic section modulus about the x-axis}$$
$$\phi M_n = \phi * F_y * S_x$$
$$\phi M_n = 1 * 50 * 131$$
$$\phi M_n = \boxed{6550} \text{ in*kips}$$
$$M_u = \boxed{3546} \text{ in*kips (from Shoring Suite)}$$
$$M_u = \boxed{} \text{ in*kips (from PYWALL)}$$
$$M_u < \phi M_n \quad \text{OK}$$

Deflection Criteria

Pile Length Above Rock =	40.8	ft	Exposed Wall Height =	21.5	ft
Pile Length Above Rock =		in	Exposed Wall Height =	258	in

1.)

Per the ODOT GDM, pile-head deflection in the service limit state limited to 1% or less of the shaft length above bedrock, or 1% of total drilled shaft length if not embedded in bedrock.

2.)

Following industry acceptance criteria, limit wall deflection to 1% of exposed wall height where ODOT landslide criteria does not govern. Alternatively, limit wall deflection to 1.5% of the exposed wall height in accordance with NCDOT guidelines. Use 1.5% wall deflection for PYWALL software.

ODOT Landslide Criteria Governs

NO

OK

1% Wall Height OR 2 inches- LPILE

2.58

in

$\delta =$

0.44

in (from Shoring Suite)

1.5% Wall Height - PYWALL

3.87

in

$\delta =$

in (from PYWALL)

Drilled Shafts Located Within 10 feet of Edge of Pavement

NO

Tieback Loading Computations

Design Tieback Load, TF1 = 156.5 kips / shaft

Horizontal values determined from Shoring Suite calculations.

1) Determine Tiebacks

Strands

0.6 GUTS per strand = 35.2 kips per strand (FHWA-NHI-07-071: Table 8-16)

(GUTS = guaranteed ultimate tensile strength)

Tieback	Inclin.	Required Anchor Load**	Strands	
No.	deg	kips	Required	Selected
1	20	166.5	4.7	5.0

**Required Anchor Load = (TF) / [Cos (Inclin. Angle)]

Table 8-16. Properties of 0.6 in. Diameter Prestressing Steel Strands (ASTM A416, Grade 270).

Number of 0.6 in. diameter strands	Cross section area	Ultimate strength (=GUTS)	Prestressing force		
			0.8 $f_{pu}A_{ps}$	0.7 $f_{pu}A_{ps}$	0.6 $f_{pu}A_{ps}$
	(in. ²)	(kips)	(kips)	(kips)	(kips)
1	0.217	58.6	46.9	41.0	35.2

2) Check Pull-Out Capacity and Bond Length

Pullout Resistance Factor ϕ_{pr} = 0.7

Per AASHTO LRFD Table 11.5.7-1 for "Pullout resistance of anchors, cohesive soils"

Soil Friction Angle ϕ = 25

Tieback	Height Above Bottom of Wall	Tieback Length to Active Wedge	Total Unbonded Length	Ultimate Bond Strength	Tieback Drill Hole Diameter	Surface Area per Foot of Tieback	Allowable Bond Strength per Foot of Tieback	Required Anchor Load	Required Bond Length	Total Tieback Length
No.	ft	ft	ft	ksf	in	in ² /ft	kips/ft	kips	ft	ft
1	12	6.3	15	3	9	339.3	4.95	166.5	34	49

Total unbonded length = Tieback length to active wedge + greater of 5 feet or H/3, with a 15 foot minimum, per AASHTO LRFD Figure 11.9.1-1

Ultimate bond strength per AASHTO LRFD Table C11.9.4.2-1. Tieback lengths assume entire bond length is in clay.

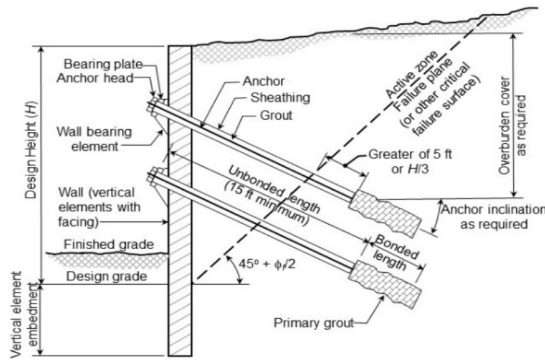


Figure 11.9.1-1—Anchored Wall Nomenclature and Anchor Embedment Guidelines

Table C11.9.4.2-1—Presumptive Ultimate Unit Bond Stress for Anchors in Cohesive Soils

Anchor/Soil Type (Grout Pressure)	Soil Stiffness or Unconfined Compressive Strength (tsf)	Presumptive Ultimate Unit Bond Stress, τ_u (ksf)
Gravity Grouted Anchors (<50 psi)		
Silt-Clay Mixtures	Stiff to Very Stiff 1.0–4.0	0.6 to 1.5
Pressure Grouted Anchors (50 psi–400 psi)		
High Plasticity Clay	Stiff 1.0–2.5 V. Stiff 2.5–4.0	0.6 to 2 1.5 to 3.6
Medium Plasticity Clay	Stiff 1.0–2.5 V. Stiff 2.5–4.0	2.0 to 5.2 2.9 to 7.3
Medium Plasticity Sandy Silt	V. Stiff 2.5–4.0	5.8 to 7.9



Service Limit Analysis (Soldier Pile and Lagging Wall with Tiebacks)

SURCHARGE LOADS CALCULATION SUMMARY
<Surcharge>
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Reference: Foundation Design, Wayne C. Teng, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1962

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Wall Surcharge Service.lp8

WAS-77-9.58
Traffic Loading

Height of Wall = 21.5
Depth of Load = 0
Load Factor of Surcharge Loading = 1

Wall Condition:
Rigid Wall Condition -- No movement or deflection of the wall are allowed.

*****Loading*****

INFINITE SURCHARGE LOADING: Q=.250
Active Wedge Approach * (recommend)

*****Total Pressure Distribution*****

Max. Pressure =0.144 at depth =0.00

Depth	Pressure
0.00	0.144
1.08	0.144
2.15	0.144
3.23	0.144
4.30	0.144
5.38	0.144
6.45	0.144
7.52	0.144
8.60	0.144
9.67	0.144
10.75	0.144
11.82	0.144
12.90	0.144
13.97	0.144
15.05	0.144
16.12	0.144
17.20	0.144

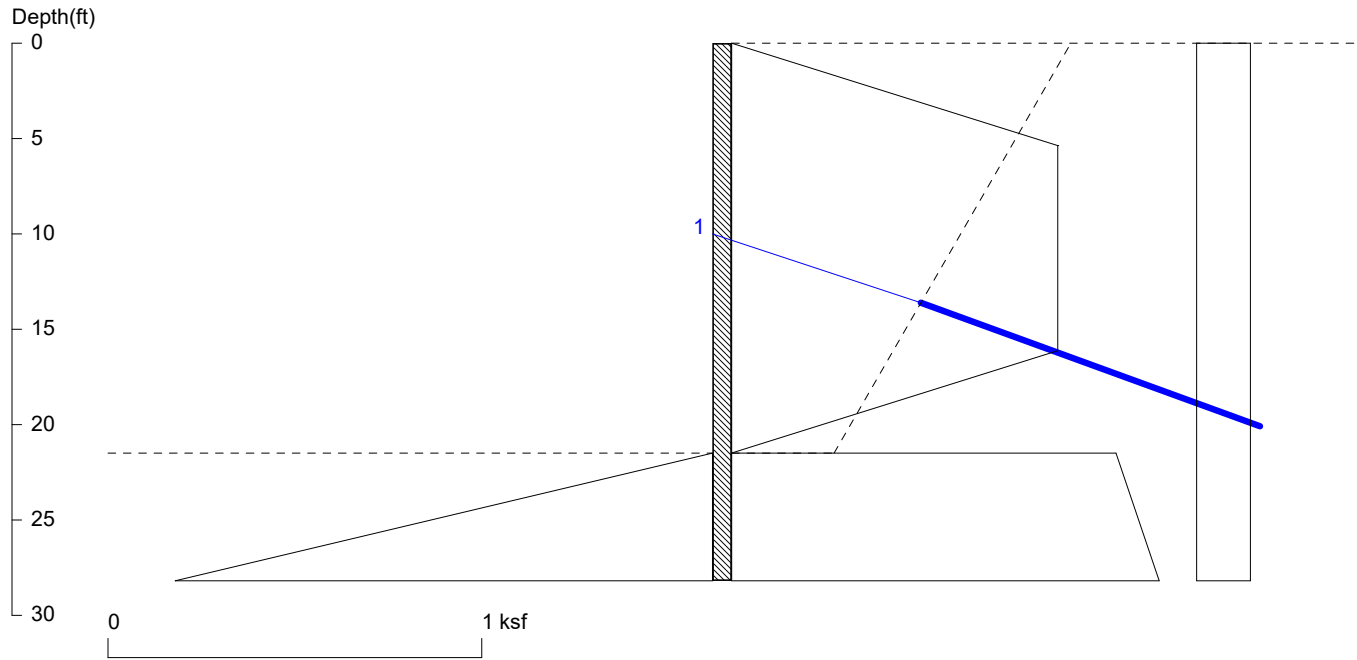
18.27	0.144
19.35	0.144
20.43	0.144
21.50	0.144
23.65	0.144
25.80	0.144
27.95	0.144
30.10	0.144
32.25	0.144
34.40	0.144
36.55	0.144
38.70	0.144
40.85	0.144
43.00	0.144
47.30	0.144
51.60	0.144
55.90	0.144
60.20	0.144
64.50	0.144
68.80	0.144
73.10	0.144
77.40	0.144
81.70	0.144
86.00	0.000

Surcharge loading cut off at top of rock (40.8 feet) in shoring module.

Depth Is Measured From Top of the Wall

LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

WAS-77-9.58



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File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 21.5' Main Wall Tieback Service.sh8

Wall Height=21.5

Pile Diameter=2.5

Pile Spacing=6.0

Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=6.69 Min. Pile Length=28.19

MOMENT IN PILE: Max. Moment=189.37 per Pile Spacing=6.0 at Depth=10.00

PILE SELECTION:

Request Min. Section Modulus = 45.4 in³/pile=744.77 cm³/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=1

HP14X89 has Section Modulus = 131.0 in³/pile=2146.70 cm³/pile. It is greater than Min. Requirements!

Top Deflection = 0.44(in) based on E (ksi)=29000.00 and I (in⁴)/pile=904.0

BRACE FORCE: Strut, Tieback, Plate Anchor, Deadman, Sheet Pile as Anchor

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	L_free	Fixed Length
1. Tieback	10.0	20.0	6.0	105.9	99.6	36.2	10.6	21.4

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	5.375	0.873	0.162445
5.375	0.873	16.12	0.873	0.000000
16.12	0.873	21.50	0.000	-0.16244
*	Below	Base		
21.50	1.029	35.80	1.276	0.017239
*	Sur-	charg		
0.000	0.144	1.075	0.144	0.000000
1.075	0.144	2.150	0.144	0.000000
2.150	0.144	3.225	0.144	0.000000
3.225	0.144	4.300	0.144	0.000000
4.300	0.144	5.375	0.144	0.000000
5.375	0.144	6.450	0.144	0.000000

6.450	0.144	7.525	0.144	0.000000
7.525	0.144	8.600	0.144	0.000000
8.600	0.144	9.675	0.144	0.000000
9.675	0.144	10.75	0.144	0.000000
10.75	0.144	11.82	0.144	0.000000
11.82	0.144	12.90	0.144	0.000000
12.90	0.144	13.97	0.144	0.000000
13.97	0.144	15.05	0.144	0.000000
15.05	0.144	16.12	0.144	0.000000
16.12	0.144	17.20	0.144	0.000000
17.20	0.144	18.27	0.144	0.000000
18.27	0.144	19.35	0.144	0.000000
19.35	0.144	20.42	0.144	0.000000
20.42	0.144	21.50	0.144	0.000000
21.50	0.144	23.65	0.144	0.000000
23.65	0.144	25.80	0.144	0.000000
25.80	0.144	27.95	0.144	0.000000
27.95	0.144	30.10	0.144	0.000000

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
21.50	0.000	35.80	3.074	0.214939

ACTIVE SPACING:

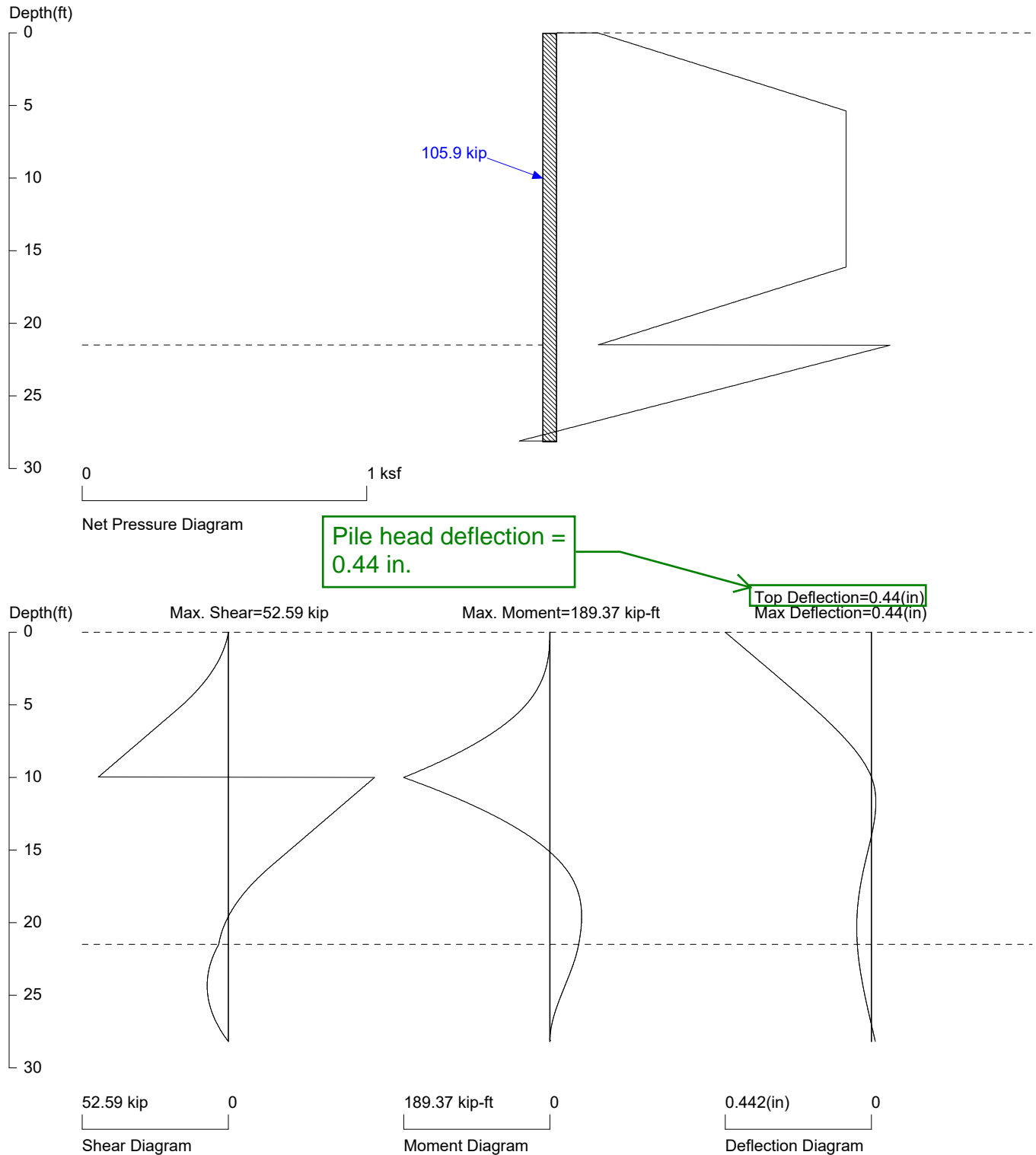
No.	Z depth	Spacing
1	0.00	6.00
2	21.50	2.50

PASSIVE SPACING:

No.	Z depth	Spacing
1	21.50	5.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft³; Deflection - in

WAS-77-9.58



PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 6.0 foot or meter

User Input Pile, HP14X89: E (ksi)=29000.0, I (in⁴)/pile=904.0

File: C:\Users\labaratta\Desktop\WAS-77\WAS-77-9.58 21.5' Main Wall Tieback Service.sh8

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SHORING WALL CALCULATION SUMMARY
The leading shoring design and calculation software
Software Copyright by CivilTech Software
www.civiltech.com

ShoringSuite Software is developed by CivilTech Software, Bellevue, WA, USA.

The calculation method is based on the following references:

1. FHWA 98-011, FHWA-RD-97-130, FHWA SA 96-069, FHWA-IF-99-015
2. STEEL SHEET PILING DESIGN MANUAL by Pile Buck Inc., 1987
3. DESIGN MANUAL DM-7 (NAVFAC), Department of the Navy, May 1982
4. TRENCHING AND SHORING MANUAL Revision 12, California Department of Transportation, January 2000
6. EARTH SUPPORT SYSTEM & RETAINING STRUCTURES, Pile Buck Inc. 2002
5. DESIGN OF SHEET PILE WALLS, EM 1110-2-2504, U.S. Army Corps of Engineers, 31 March 1994
7. EARTH RETENTION SYSTEMS HANDBOOK, Alan Macnab, McGraw-Hill. 2002
8. Temporary Structures in Construction, Robert T. Ratay (Co-author of Chapter 7: John J. Peirce), McGraw-Hill. 2012
9. AASHTO HB-17, American Association of State and Highway Transportation Officials, 2 September 2002

UNITS: Width/Spacing/Diameter/Length/Depth - ft, Force - kip, Moment - kip-ft, Friction/Bearing/Pressure - ksf, Pres.
Slope - kip/ft³, Deflection - in

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Date: 11/3/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 21.5' Main Wall Tieback Service.sh8

Title: WAS-77-9.58

Subtitle:

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

Wall Type: 2. Soldier Pile, Drilled

Wall Height: 21.50

Pile Diameter: 2.50

Pile Spacing: 6.00

Factor of Safety (F.S.): 1.00

Lateral Support Type (Braces): 3. Tieback

Top Brace Increase (Multi-Bracing): Add 15%*

Brace Position (One Brace Case): Normal Brace*

No-Load Zone:

Vertical Depth for No-Load Zone: 21.50

H-Distance (Input H/V ratio) for No-Load Zone: 0.25

Angle from H. Line for No-Load Zone: 60.00
 Embedment Option: 1. Yes
 Friction at Pile Tip: No
 Pile Properties:
 Steel Strength, Fy: 50 ksi = 345 MPa
 Allowable Fb/Fy: 1
 Elastic Module, E: 29000.00
 Moment of Inertia, I: 904.00
 User Input Pile: HP14X89

* DRIVING PRESSURE (ACTIVE, WATER, & SURCHARGE) *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Above	Base		
2	0.000	0.000	5.375	0.873	0.162445
3	5.375	0.873	16.12	0.873	0.000000
4	16.12	0.873	21.50	0.000	-0.16244
5	*	Below	Base		
6	21.50	1.029	35.80	1.276	0.017239
7	35.80	1.121	40.80	1.233	0.022352
8	40.80	0.565	172.0	2.833	0.017285
9	*	Sur-	charg		
10	0.000	0.144	1.075	0.144	0.000000
11	1.075	0.144	2.150	0.144	0.000000
12	2.150	0.144	3.225	0.144	0.000000
13	3.225	0.144	4.300	0.144	0.000000
14	4.300	0.144	5.375	0.144	0.000000
15	5.375	0.144	6.450	0.144	0.000000
16	6.450	0.144	7.525	0.144	0.000000
17	7.525	0.144	8.600	0.144	0.000000
18	8.600	0.144	9.675	0.144	0.000000
19	9.675	0.144	10.75	0.144	0.000000
20	10.75	0.144	11.82	0.144	0.000000
21	11.82	0.144	12.90	0.144	0.000000
22	12.90	0.144	13.97	0.144	0.000000
23	13.97	0.144	15.05	0.144	0.000000
24	15.05	0.144	16.12	0.144	0.000000
25	16.12	0.144	17.20	0.144	0.000000
26	17.20	0.144	18.27	0.144	0.000000
27	18.27	0.144	19.35	0.144	0.000000
28	19.35	0.144	20.42	0.144	0.000000
29	20.42	0.144	21.50	0.144	0.000000

30	21.50	0.144	23.65	0.144	0.000000
31	23.65	0.144	25.80	0.144	0.000000
32	25.80	0.144	27.95	0.144	0.000000
33	27.95	0.144	30.10	0.144	0.000000
34	30.10	0.144	32.25	0.144	0.000000
35	32.25	0.144	34.40	0.144	0.000000
36	34.40	0.144	36.55	0.144	0.000000
37	36.55	0.144	38.70	0.144	0.000000
38	38.70	0.144	40.8	0.144	0.000000

* PASSIVE PRESSURE *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Below	Base		
2	21.50	0.000	35.80	3.074	0.214939
3	35.80	3.442	40.80	4.823	0.276272
4	40.80	47	172.0	47	0.0000

Surcharge loading terminated at top of rock (40.8 feet).

* ACTIVE SPACE *

No.	Z depth	Spacing
1	0.00	6.00
2	21.50	2.50

Passive pressure for bedrock adjusted to 47 ksf based on an unconfined strength of 330 psi.

* PASSIVE SPACE *

No.	Z depth	Spacing
1	21.50	5.00

Hole diameter in feet (9 inches).

Allowable bond strength = resistance factor * ultimate bond strength = 0.7×3 ksf

* BRACE: STRUT, TIEBACK, ANCHOR PLATE, DEADMAN, OR SHEET PILE AS ANCHOR*

No.	Z brace	Angle	Spacing	Input1*	Input2*	Type
1	10.00	20.0	6.00	0.75	2.10	Tieback

*For Tieback: Input1 = Diameter; Input2 = Bond Strength

*For Plate: Input1 = Diameter; Input2 = Allowable Pressure

*For Deadman: Input1 = Horz. Width; Input2 = Passive Pressure;

*For Sheet Pile Anchor: Input1 = Horz. Width; Input2 = Passive Slope;

*****CALCULATION*****

The calculated moment and shear are per pile spacing. Sheet piles are per one foot or meter; Soldier piles are per pile.

Top Pressures start at depth = 0.00

NUMBER OF BRACE LEVEL = 1

	D1=0.00	
<--	D2=10.00	R1=99.56
== ==	D3=21.50	
	D4=28.19	

D1 - TOP DEPTH
D2 - BRACE DEPTH R1 - REACTION
D3 - EXCAVATION BASE
D4 - PILE TIP

TOTAL REACTION: R1 = 99.56
TOTAL PRESSURES ACTING ON WALL = 99.56
Total Reactions = Total Pressures, OK!

BRACE NO.1 AT DEPTH = 10.00
R1 = Brace Load = 99.56

*****RESULTS*****

* EMBEDMENT *
MINIMUM EMBEDMENT = 6.69, TOTAL MINIMUM PILE LENGTH = 28.19

* MOMENT IN PILE (per pile spacing)*

Pile Spacing: sheet piles are one foot or one meter; soldier piles are one pile.

No.	Depth	M @ Brace	Mmax in Span	Depth of Mmax
1	10.00	188.27	41.17	19.57

Overall Maximum Moment = 189.37 at 10.00

Maximum Shear = 52.59

Moment and Shear are per pile spacing: 6.0 foot or meter

* BRACE: STRUT, TIEBACK, ANCHOR PLATE, DEADMAN, OR SHEET PILE AS ANCHOR*

The calculated brace force are per brace spacing.

No.	DEPTH	Tangle	SPACING	HORIZONTAL	VERTICAL	TOTAL LOAD
1	10.00	20.0	6.00	99.56	36.24	105.95
No.	DEPTH	Free length	Brace Type			
1	10.00	10.57	Tieback, Bond length = 21.41			

* VERTICAL LOADING *

Vertical Loading from Braces = 36.24

Vertical Loading from External Load = 0.00

Total Vertical Loading = 36.24

*****SPECIFIED PILE *****

Overall Maximum Moment = 189.37 at 10.00

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

Request Min. Section Modulus = 45.45 in³/pile = 744.77 cm³/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=1

HP14X89 has been found in Soldier Pile list!

(English Units):

Area= 26.1 in. Depth= 13.8 in. Width= 14.7 in. Height= 14 in.

Flange thickness= 0.615 in. Web thickness= 0.615 in.

Ix= 904 in⁴/pile Sx= 131 in³/pile Iy= 326 in⁴/pile Sy= 44.3 in³/pile

(Metric Units):

Ix= 376.24 x100cm⁴/pile Sx= 2146.70 cm³/pile Iy= 135.68 x100cm⁴/pile Sy= 725.94 cm³/pile

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

HP14X89 is capable to support the shoring!

Top deflection = 0.442(in)

Max. deflection = 0.442(in)

***** LAGGING SIZE ESTIMATION *****

Max. Pressure above base = 1.02

Piles are more rigid than timber lagging, due to arching, only portion of pressures are acting to lagging, 30-50% loading is suggested.

If 50% loading is used for lagging design, Design Pressure = 0.51

Pile Spacing = 6.0, Max. Moment in lagging = 2.29

For 4"x12" Timber, Section Modules $S=23.47 \text{ in}^3$. The request allowable bending strength, $fb=M/S=1.17$

For 6"x12" Timber, Section Modules $S=57.98 \text{ in}^3$. The request allowable bending strength, $fb=M/S=0.47$

If 30% loading is used for lagging design, Design Pressure = 0.31

Pile Spacing = 6.0, Max. Moment in lagging = 1.37

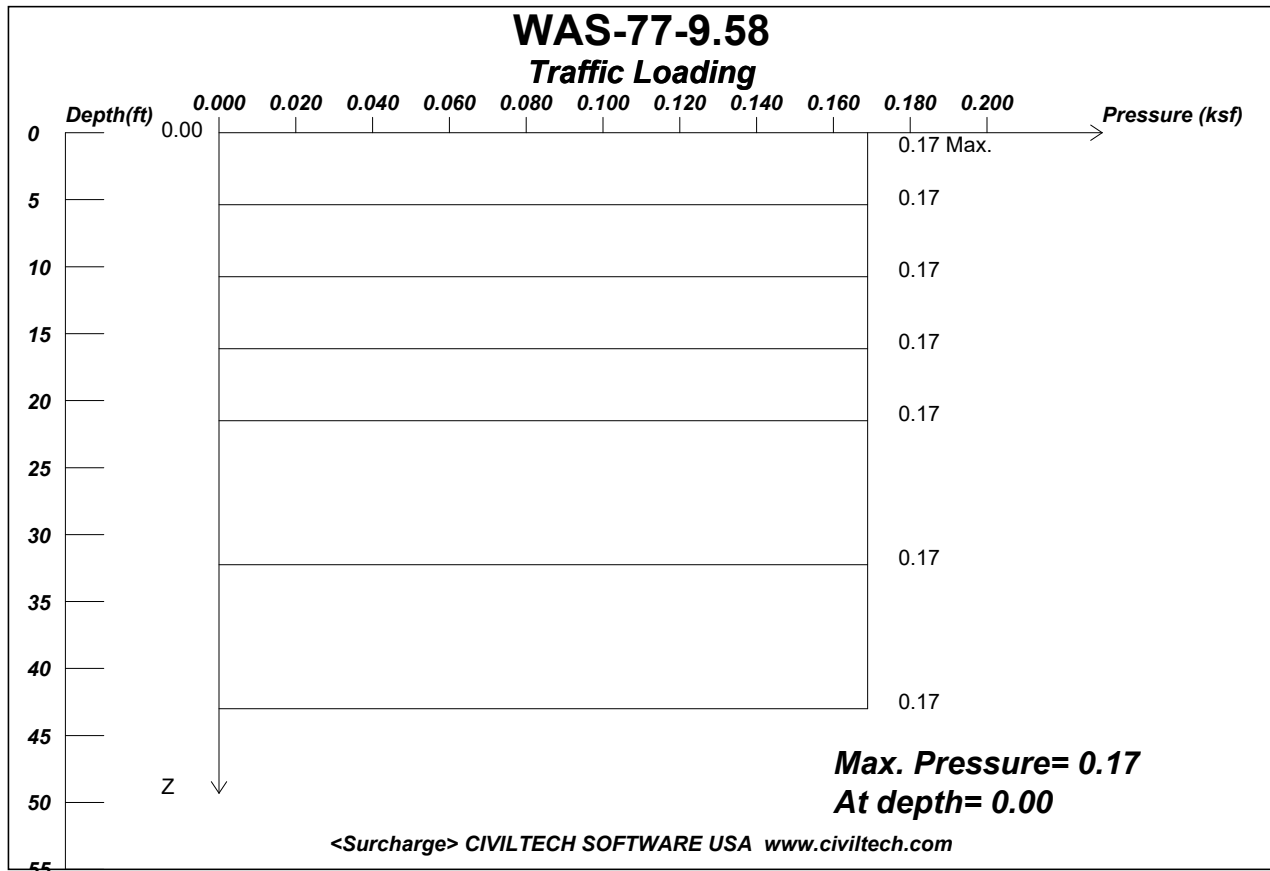
For 4"x12" Timber, Section Modules $S=23.47 \text{ in}^3$. The request allowable bending strength, $fb=M/S=0.70$

For 6"x12" Timber, Section Modules $S=57.98 \text{ in}^3$. The request allowable bending strength, $fb=M/S=0.28$

Unit: Pressure: ksf, Spacing: ft, Moment: kip-ft, Bending Strength, fb: ksi



Strength Limit Analysis (Soldier Pile and Lagging Wall with Tiebacks)



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Wall Height, H= 21.5

Load Depth, D= 0

Load Factor of Surcharge Loading = 1.17

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

Max. Pressure = 0.169 at depth = 0.00

A load factor of 1.5 is applied to all active loading in the wall analysis. As traffic loading uses 1.75, an extra factor has been applied here ($1.75/1.5 = 1.17$).

Infinite Surcharge, Q=.250

Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

SURCHARGE LOADS CALCULATION SUMMARY
<Surcharge>
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Date: 10/30/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 21.5'
Wall Surcharge Strength.lp8

WAS-77-9.58
Traffic Loading

Height of Wall = 21.5
Depth of Load = 0
Load Factor of Surcharge Loading = 1.17

Wall Condition:
Rigid Wall Condition -- No movement or deflection of the wall are allowed.

*****Loading*****

INFINITE SURCHARGE LOADING: Q=.250
Active Wedge Approach * (recommend)

*****Total Pressure Distribution*****

Max. Pressure =0.169 at depth =0.00

Depth	Pressure
0.00	0.169
1.08	0.169
2.15	0.169
3.23	0.169
4.30	0.169
5.38	0.169
6.45	0.169
7.52	0.169
8.60	0.169
9.67	0.169
10.75	0.169
11.82	0.169
12.90	0.169
13.97	0.169
15.05	0.169
16.12	0.169
17.20	0.169

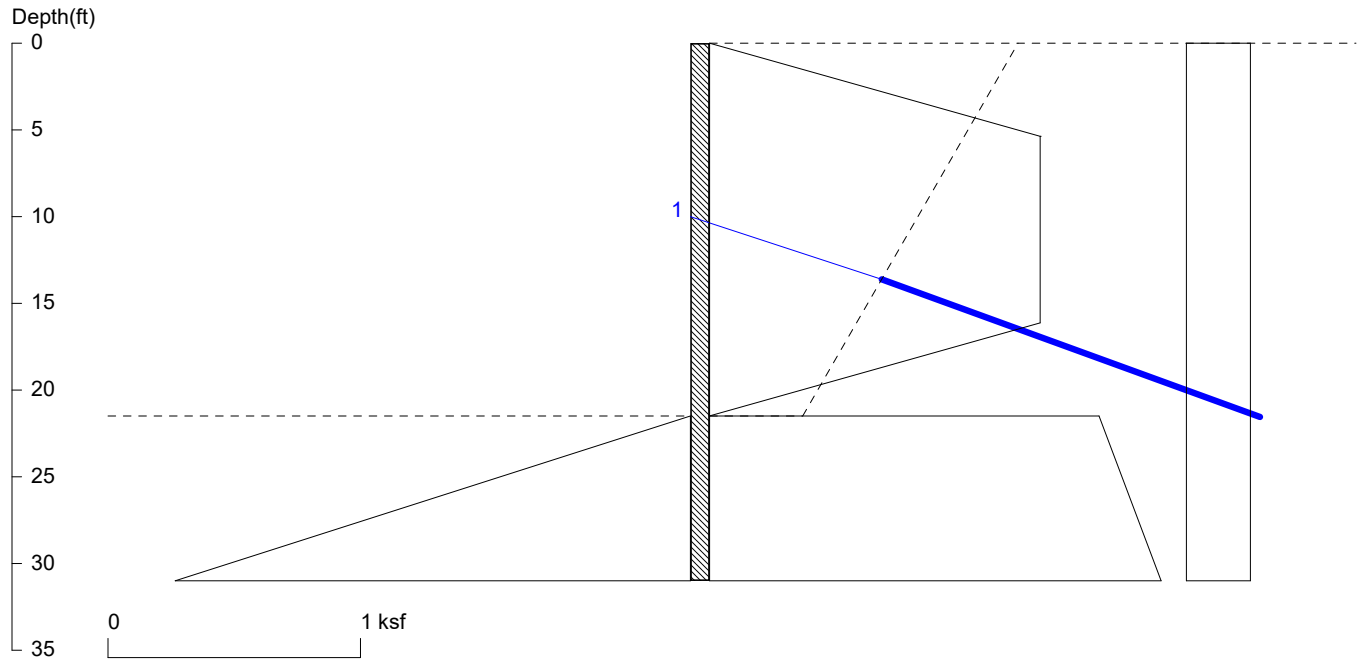
18.27	0.169
19.35	0.169
20.43	0.169
21.50	0.169
23.65	0.169
25.80	0.169
27.95	0.169
30.10	0.169
32.25	0.169
34.40	0.169
36.55	0.169
38.70	0.169
40.85	0.169
43.00	0.169
47.30	0.169
51.60	0.169
55.90	0.169
60.20	0.169
64.50	0.169
68.80	0.169
73.10	0.169
77.40	0.169
81.70	0.169
86.00	0.000

Surcharge loading cut off at top of rock (40.8 feet) in shoring module.

Depth Is Measured From Top of the Wall

LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

WAS-77-9.58



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Date: 10/30/2023

File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 21.5' Main Wall Tieback Strength.sh8

Wall Height=21.5

Pile Diameter=2.5

Pile Spacing=6.0

Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=9.50 Min. Pile Length=31.00

MOMENT IN PILE: Max. Moment=295.50 per Pile Spacing=6.0 at Depth=10.00

PILE SELECTION:

Request Min. Section Modulus = 70.9 in³/pile=1162.17 cm³/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=1

HP14X89 has Section Modulus = 131.0 in³/pile=2146.70 cm³/pile. It is greater than Min. Requirements!

Top Deflection = 0.58(in) based on E (ksi)=29000.00 and I (in⁴)/pile=904.0

BRACE FORCE: Strut, Tieback, Plate Anchor, Deadman, Sheet Pile as Anchor

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	L_free	Fixed Length
1. Tieback	10.0	20.0	6.0	166.5	156.5	56.9	10.6	33.7

UNITS: Width,Diameter,Spacing,Length,Depth,and Height - ft; Force - kip; Bond Strength and Pressure - ksf

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE): Pressures below will be multiplied by a Factor =1.5

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	5.375	0.873	0.162445
5.375	0.873	16.12	0.873	0.000000
16.12	0.873	21.50	0.000	-0.16244
*	Below	Base		
21.50	1.029	35.80	1.276	0.017239
*	Sur-	charg		
0.000	0.169	1.075	0.169	0.000000
1.075	0.169	2.150	0.169	0.000000
2.150	0.169	3.225	0.169	0.000000
3.225	0.169	4.300	0.169	0.000000
4.300	0.169	5.375	0.169	0.000000
5.375	0.169	6.450	0.169	0.000000

Anchor loads and lengths

Unbonded Length Bonded Length

Applied 1.5 load factor for active earth pressures.

6.450	0.169	7.525	0.169	0.000000
7.525	0.169	8.600	0.169	0.000000
8.600	0.169	9.675	0.169	0.000000
9.675	0.169	10.75	0.169	0.000000
10.75	0.169	11.82	0.169	0.000000
11.82	0.169	12.90	0.169	0.000000
12.90	0.169	13.97	0.169	0.000000
13.97	0.169	15.05	0.169	0.000000
15.05	0.169	16.12	0.169	0.000000
16.12	0.169	17.20	0.169	0.000000
17.20	0.169	18.27	0.169	0.000000
18.27	0.169	19.35	0.169	0.000000
19.35	0.169	20.42	0.169	0.000000
20.42	0.169	21.50	0.169	0.000000
21.50	0.169	23.65	0.169	0.000000
23.65	0.169	25.80	0.169	0.000000
25.80	0.169	27.95	0.169	0.000000
27.95	0.169	30.10	0.169	0.000000
30.10	0.169	32.25	0.169	0.000000

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
21.50	0.000	35.80	3.074	0.214939

ACTIVE SPACING:

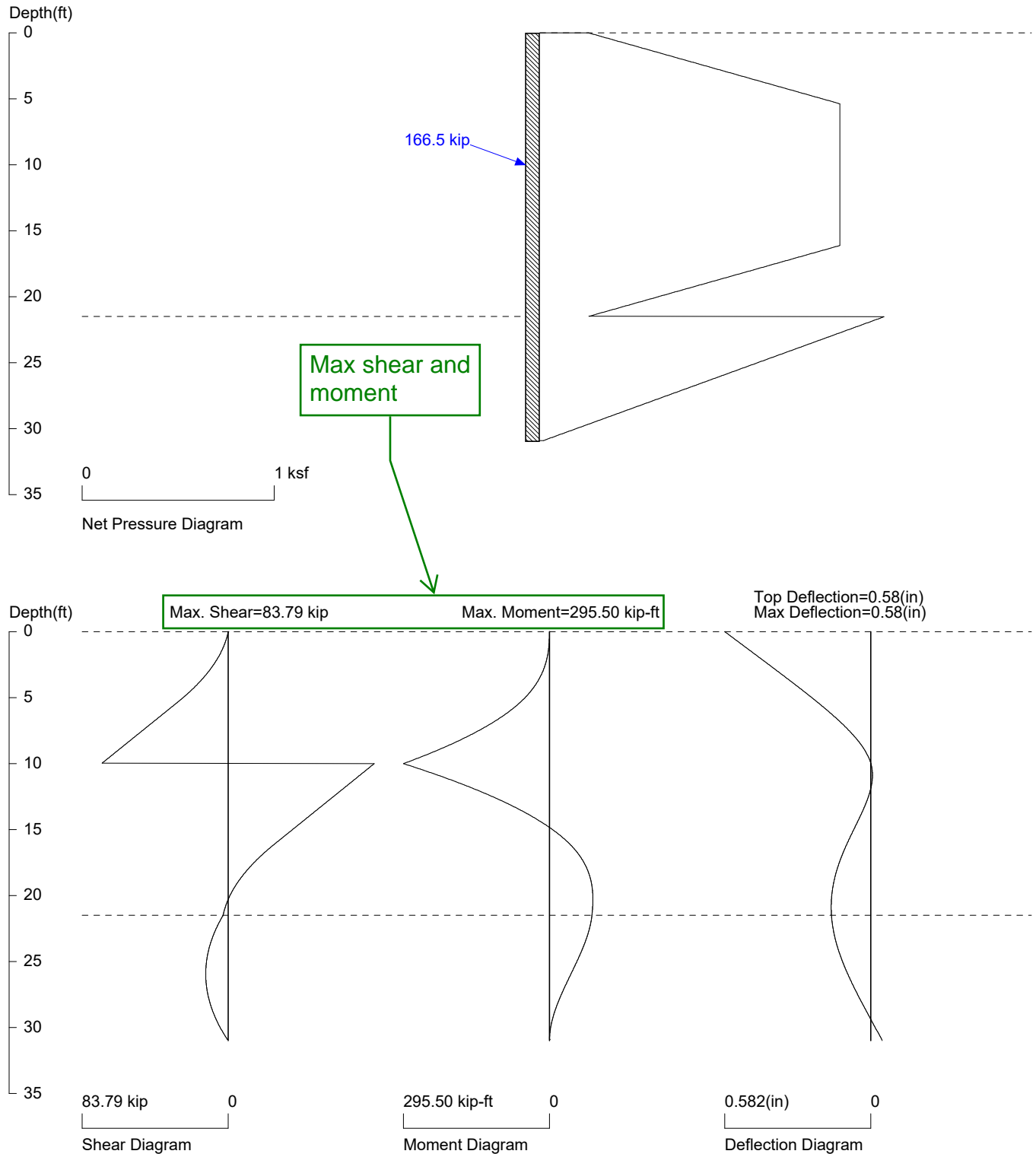
No.	Z depth	Spacing
1	0.00	6.00
2	21.50	2.50

PASSIVE SPACING:

No.	Z depth	Spacing
1	21.50	5.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft³; Deflection - in

WAS-77-9.58



PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 6.0 foot or meter

User Input Pile, HP14X89: E (ksi)=29000.0, I (in⁴)/pile=904.0

File: C:\Users\labaratta\Desktop\WAS-77\WAS-77-9.58 21.5' Main Wall Tieback Strength.sh8

SHORING WALL CALCULATION SUMMARY
The leading shoring design and calculation software
Software Copyright by CivilTech Software
www.civiltech.com

ShoringSuite Software is developed by CivilTech Software, Bellevue, WA, USA.

The calculation method is based on the following references:

1. FHWA 98-011, FHWA-RD-97-130, FHWA SA 96-069, FHWA-IF-99-015
2. STEEL SHEET PILING DESIGN MANUAL by Pile Buck Inc., 1987
3. DESIGN MANUAL DM-7 (NAVFAC), Department of the Navy, May 1982
4. TRENCHING AND SHORING MANUAL Revision 12, California Department of Transportation, January 2000
6. EARTH SUPPORT SYSTEM & RETAINING STRUCTURES, Pile Buck Inc. 2002
5. DESIGN OF SHEET PILE WALLS, EM 1110-2-2504, U.S. Army Corps of Engineers, 31 March 1994
7. EARTH RETENTION SYSTEMS HANDBOOK, Alan Macnab, McGraw-Hill. 2002
8. Temporary Structures in Construction, Robert T. Ratay (Co-author of Chapter 7: John J. Peirce), McGraw-Hill. 2012
9. AASHTO HB-17, American Association of State and Highway Transportation Officials, 2 September 2002

UNITS: Width/Spacing/Diameter/Length/Depth - ft, Force - kip, Moment - kip-ft, Friction/Bearing/Pressure - ksf, Pres.
Slope - kip/ft³, Deflection - in

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Date: 11/3/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 21.5' Main Wall Tieback Strength.sh8

Title: WAS-77-9.58

Subtitle:

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

Wall Type: 2. Soldier Pile, Drilled

Wall Height: 21.50

Pile Diameter: 2.50

Pile Spacing: 6.00

Factor of Safety (F.S.): 1.00

Lateral Support Type (Braces): 3. Tieback

Top Brace Increase (Multi-Bracing): Add 15%*

Brace Position (One Brace Case): Normal Brace*

No-Load Zone:

Vertical Depth for No-Load Zone: 21.50

H-Distance (Input H/V ratio) for No-Load Zone: 0.25

Angle from H. Line for No-Load Zone: 60.00
 Embedment Option: 1. Yes
 Friction at Pile Tip: No
 Pile Properties:
 Steel Strength, Fy: 50 ksi = 345 MPa
 Allowable Fb/Fy: 1
 Elastic Module, E: 29000.00
 Moment of Inertia, I: 904.00
 User Input Pile: HP14X89

* DRIVING PRESSURE (ACTIVE, WATER, & SURCHARGE) *
 The pressures below will be multiplied by a Factor =1.5

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Above	Base		
2	0.000	0.000	5.375	0.873	0.162445
3	5.375	0.873	16.12	0.873	0.000000
4	16.12	0.873	21.50	0.000	-0.16244
5	*	Below	Base		
6	21.50	1.029	35.80	1.276	0.017239
7	35.80	1.121	40.80	1.233	0.022352
8	40.80	0.565	172.0	2.833	0.017285
9	*	Sur-	charg		
10	0.000	0.169	1.075	0.169	0.000000
11	1.075	0.169	2.150	0.169	0.000000
12	2.150	0.169	3.225	0.169	0.000000
13	3.225	0.169	4.300	0.169	0.000000
14	4.300	0.169	5.375	0.169	0.000000
15	5.375	0.169	6.450	0.169	0.000000
16	6.450	0.169	7.525	0.169	0.000000
17	7.525	0.169	8.600	0.169	0.000000
18	8.600	0.169	9.675	0.169	0.000000
19	9.675	0.169	10.75	0.169	0.000000
20	10.75	0.169	11.82	0.169	0.000000
21	11.82	0.169	12.90	0.169	0.000000
22	12.90	0.169	13.97	0.169	0.000000
23	13.97	0.169	15.05	0.169	0.000000
24	15.05	0.169	16.12	0.169	0.000000
25	16.12	0.169	17.20	0.169	0.000000
26	17.20	0.169	18.27	0.169	0.000000
27	18.27	0.169	19.35	0.169	0.000000
28	19.35	0.169	20.42	0.169	0.000000

29	20.42	0.169	21.50	0.169	0.000000
30	21.50	0.169	23.65	0.169	0.000000
31	23.65	0.169	25.80	0.169	0.000000
32	25.80	0.169	27.95	0.169	0.000000
33	27.95	0.169	30.10	0.169	0.000000
34	30.10	0.169	32.25	0.169	0.000000
35	32.25	0.169	34.40	0.169	0.000000
36	34.40	0.169	36.55	0.169	0.000000
37	36.55	0.169	38.70	0.169	0.000000
38	38.70	0.169	40.8	0.169	0.000000

* PASSIVE PRESSURE *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Below	Base		
2	21.50	0.000	35.80	3.074	0.214939
3	35.80	3.442	40.80	4.823	0.276272
4	40.80	47	172.0	47	0.0000

Surcharge loading terminated at top of rock (40.8 feet).

* ACTIVE SPACE *

No.	Z depth	Spacing
1	0.00	6.00
2	21.50	2.50

Passive pressure for bedrock adjusted to 47 ksf based on an unconfined strength of 330 psi.

* PASSIVE SPACE *

No.	Z depth	Spacing
1	21.50	5.00

Hole diameter in feet (9 inches).

Allowable bond strength = resistance factor * ultimate bond strength = 0.7×3 ksf

* BRACE: STRUT, TIEBACK, ANCHOR PLATE, DEADMAN, OR SHEET PILE AS ANCHOR*

No.	Z brace	Angle	Spacing	Input1*	Input2*	Type
1	10.00	20.0	6.00	0.75	2.10	Tieback

*For Tieback: Input1 = Diameter; Input2 = Bond Strength

*For Plate: Input1 = Diameter; Input2 = Allowable Pressure

*For Deadman: Input1 = Horz. Width; Input2 = Passive Pressure;

*For Sheet Pile Anchor: Input1 = Horz. Width; Input2 = Passive Slope;

*****CALCULATION*****

The calculated moment and shear are per pile spacing. Sheet piles are per one foot or meter; Soldier piles are per pile.

Top Pressures start at depth = 0.00

NUMBER OF BRACE LEVEL = 1

	D1=0.00	
<--	D2=10.00	R1=156.46
== ==	D3=21.50	
	D4=31.00	

D1 - TOP DEPTH
D2 - BRACE DEPTH R1 - REACTION
D3 - EXCAVATION BASE
D4 - PILE TIP

TOTAL REACTION: R1 = 156.46
TOTAL PRESSURES ACTING ON WALL = 156.46
Total Reactions = Total Pressures, OK!

BRACE NO.1 AT DEPTH = 10.00
R1 = Brace Load = 156.46

*****RESULTS*****

* EMBEDMENT *

MINIMUM EMBEDMENT = 9.50, TOTAL MINIMUM PILE LENGTH = 31.00

* MOMENT IN PILE (per pile spacing)*

Pile Spacing: sheet piles are one foot or one meter; soldier piles are one pile.

No.	Depth	M @ Brace	Mmax in Span	Depth of Mmax
1	10.00	293.18	87.84	20.28

Overall Maximum Moment = 295.50 at 10.00

Maximum Shear = 83.79

Moment and Shear are per pile spacing: 6.0 foot or meter

* BRACE: STRUT, TIEBACK, ANCHOR PLATE, DEADMAN, OR SHEET PILE AS ANCHOR*

The calculated brace force are per brace spacing.

No.	DEPTH	Tangle	SPACING	HORIZONTAL	VERTICAL	TOTAL LOAD
1	10.00	20.0	6.00	156.46	56.95	166.51
No.	DEPTH	Free length	Brace Type			
1	10.00	10.57	Tieback, Bond length = 33.65			

* VERTICAL LOADING *

Vertical Loading from Braces = 56.95

Vertical Loading from External Load = 0.00

Total Vertical Loading = 56.95

*****SPECIFIED PILE *****

Overall Maximum Moment = 295.50 at 10.00

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

Request Min. Section Modulus = 70.92 in³/pile = 1162.17 cm³/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=1

HP14X89 has been found in Soldier Pile list!

(English Units):

Area= 26.1 in. Depth= 13.8 in. Width= 14.7 in. Height= 14 in.

Flange thickness= 0.615 in. Web thickness= 0.615 in.

Ix= 904 in⁴/pile Sx= 131 in³/pile Iy= 326 in⁴/pile Sy= 44.3 in³/pile

(Metric Units):

$I_x = 376.24 \times 100 \text{ cm}^4/\text{pile}$ $S_x = 2146.70 \text{ cm}^3/\text{pile}$ $I_y = 135.68 \times 100 \text{ cm}^4/\text{pile}$ $S_y = 725.94 \text{ cm}^3/\text{pile}$

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

HP14X89 is capable to support the shoring!

Top deflection = 0.582(in)

Max. deflection = 0.582(in)

***** LAGGING SIZE ESTIMATION *****

Max. Pressure above base = 1.56

Piles are more rigid than timber lagging, due to arching, only portion of pressures are acting to lagging, 30-50% loading is suggested.

If 50% loading is used for lagging design, Design Pressure = 0.78

Pile Spacing = 6.0, Max. Moment in lagging = 3.52

For 4"x12" Timber, Section Modules $S = 23.47 \text{ in}^3$. The request allowable bending strength, $fb = M/S = 1.80$

For 6"x12" Timber, Section Modules $S = 57.98 \text{ in}^3$. The request allowable bending strength, $fb = M/S = 0.73$

If 30% loading is used for lagging design, Design Pressure = 0.47

Pile Spacing = 6.0, Max. Moment in lagging = 2.11

For 4"x12" Timber, Section Modules $S = 23.47 \text{ in}^3$. The request allowable bending strength, $fb = M/S = 1.08$

For 6"x12" Timber, Section Modules $S = 57.98 \text{ in}^3$. The request allowable bending strength, $fb = M/S = 0.44$

Unit: Pressure: ksf, Spacing: ft, Moment: kip-ft, Bending Strength, fb: ksi

No Tiebacks
(Shoring Suite)



Earth Pressure Determination

Geometry

Elevation (ft)			Horiz. Distance from C/L (ft)		
Top of Backfill =	860.0	at Bottom of Embankment	Start of Wall Backfill =	50.0	at Bottom of Embankment
Top of Wall =	851.0	at C/L of Wall	Wall =	0.0	at C/L of Wall
Existing Ground Surface =	851.4	at C/L of Wall			
Bottom of Wall =	841.0	at C/L of Wall	Backfill Slope Angle =	5.6	H:1V
Groundwater =	848.5	at C/L of Wall		10.2	degrees

Wall Loading Profile (B-005-0-23)

	Top Elev.	Thickness (ft)	Cohesion (psf)	Phi (deg)	Unit Wt (pcf)
Layer 2 Medium Stiff to Stiff Cohesive	851.0	0.8	115	23	140
Layer 1 Soft to Medium Stiff Cohesive	850.2	5.0	65	21	115
Layer 2 Medium Stiff to Stiff Cohesive	845.2	4.2	115	23	140
Bottom of Wall/Maintenance Bench	841.0				
Weighted Value		10.0	90	22	130

Earth Pressure Coefficients

	Deg	
Shear Resistance, Φ =	23	
Wall Friction, δ^A =	0.0	
Wall Slope, θ =	90	
Backfill Slope, β =	10.20	
Revised Backfill Slope, β =	10.20	
Backfill Condition	INFINITE	
Horz. Backslope Dist.	50.0	feet (C/L of Wall - Edge of Shoulder)
Wall Height (H)	10.0	feet (Top of Wall - Maintenance Bench)
Slope Height (h)	9.0	feet (Top of Backfill - Top of Wall)
I =	24.23	degrees

Notes:

- Wall friction neglected
- Figure and Equation for Active Earth Pressure from AASHTO 3.11.5.3 (LRFD Design Manual).
- The wall retained soil will consist of existing cohesive overburden. Using the soil layer thicknesses and respective soil parameters, a weighted average was determined and assumed for the entire profile ($c' = 90$ psf and $\phi' = 22^\circ$). The parameters were converted to equivalent soil strength parameters $c' = 0$ psf and $\phi' = 23^\circ$ for checking tieback lengths based on a 1 degree increase in friction angle for every 50 psf decrease in cohesion up to 150 psf (Ref: Hall's Thesis).

Shoring Suite Design Profile

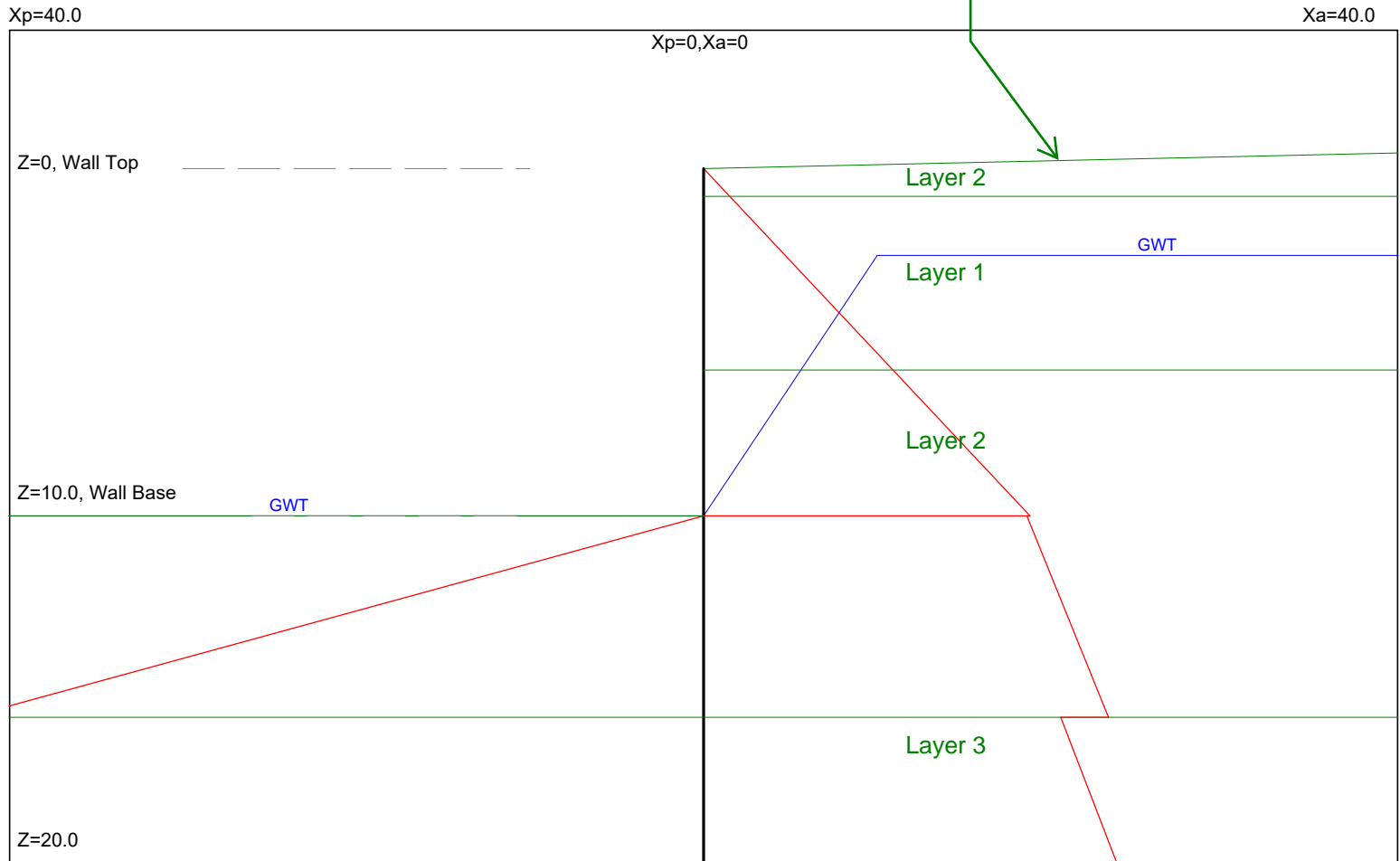
	Top Elev	Depth (ft)	Cohesion (psf)	Phi (deg)	Unit Wt (pcf)
Layer 2 Medium Stiff to Stiff Cohesive	851.0	0.0	0	25	140
Layer 1 Soft to Medium Stiff Cohesive	850.2	0.8	0	22	115
Layer 2 Medium Stiff to Stiff Cohesive	845.2	5.8	0	25	140
Layer 3 Stiff to Very Stiff Cohesive	835.2	15.8	0	28	135
Layer 4 Hard Cohesive	815.2	35.8	0	31	145
Bedrock	810.2	40.8	0	45	150

Depths referenced below the top of wall. Friction angles reflect adjustments made per Hall's Thesis. Bedrock modeled as very dense gravel.

Earth pressures generated using
service loading.

WAS-77-9.58

5.6H:1V Backslope



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UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf
Date: 10/30/2023 File: C:\Users\labaratta\Desktop\WAS-77\WAS-77-9.58 10' Wall Tieback.ep8

* INPUT DATA *

Wall Height=10.0 Total Soil Types= 5

Soil No.	Weight	Saturate	Phi	Cohesion	Nspt	Type	Description
1	115.0	120.0	22	0	5	1	1. Soft to M
2	140.0	145.0	25	0.0	11	1	2. Medium St
3	135.0	140.0	28	0.0	24	1	3. Stiff to
4	145.0	150.0	31	0.0	65	1	4. Hard Cohe
5	150.0	155.0	45	0.0	100	5	Bedrock

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.	Description
1	0.0	0.0	-9.0	800.0	2	2. Medium St
2	0.8	0.0	0.8	800.0	1	1. Soft to M
3	5.8	0.0	5.8	800.0	2	2. Medium St
4	15.8	0.0	15.8	800.0	3	3. Stiff to
5	35.8	0.0	35.8	800.0	4	4. Hard Cohe
6	40.8	0.0	40.8	800.0	5	Bedrock

Water Table at Active Side:

Point	Z-water	X-water
1	10.0	0.0
2	2.5	10.0
3	2.5	800.0

Bedrock modeled as
dense gravel to generate
active pressures.

Ground Surface at Passive Side:

Soil Layers in Front of Wall

Line	Z1	Xp1	Z2	Xp2	Soil No.	Description
1	10.0	0.0	10.0	800.0	2	2. Medium St
2	15.8	0.0	15.8	800.0	3	3. Stiff to
3	35.8	0.0	35.8	800.0	4	4. Hard Cohe
4	40.8	0.0	40.8	800.0	5	Bedrock

Water Table at Passive Side:

Water Depth in Front of Wall

Point	Z-water	X-water
1	10.0	0.0
2	10.0	800.0

Wall Friction Options: 1.* No wall friction

Wall Batter Angle = 0

Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*

Water Density = 62.4

Water Pressure: 1.* No seepage at wall tip

* OUTPUT RESULTS *

Total Force above Base= 2.62 per one linear foot (or meter) width along wall height

Total Static Force above Base= 2.62. Distributed in Triangular Envelope along wall height. Ignore soil layers and water line

Driving Pressure above Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Coef.
0.00	0.00	10.00	0.52	0.0524	0.3744

Driving Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Ka or Ko
10.00	0.52	15.80	0.65	0.0226	0.2733
15.80	0.57	20.00	0.66	0.0215	0.2765

Passive Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pp1	Z2	Pp2	Slope	Kp
10.00	0.00	15.80	1.18	0.204	2.4643
15.80	1.32	20.00	2.23	0.217	2.7995

UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

Date: 10/30/2023 File Name: C:\Users\labaratta\Desktop\WAS-77\WAS-77-9.58 10' Wall Tieback.ep8

EARTH PRESSURE ANALYSIS SUMMARY

<EarthPres>

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Date: 10/30/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 10' Wall Tieback.ep8

Title 1: WAS-77-9.58

Title 2:

Input data: *****

Wall Height = 10.00

Depth of Ground at Active Side = 0.00

Depth of Ground at Passive Side = 10.00

Apparent Pressure Envelope: 2. Triangular Envelope (No-braced, all soils)

Pressure Type: 1.* Active, Ka

Earthquake Loading Apply to: 1. No Earthq. Loads

Earthquake Horizontal Acceleration, Kh = 0

Earthquake Vertical Acceleration, Kv = 0

Calculation Methods: 1.* Numerical Solution (Wedge Analysis)

Wall Friction Options: 1.* No wall friction

Wall Batter Angle = 0

Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*

Water Density = 62.4

Water Pressure: 1.* No seepage at wall tip

User's Settings

Ignore Passive from Depth = 0

Multiplier of Active Pressure = 1

Multiplier of Passive Pressure = 1

Multiplier of Water Pressure = 1

Multiplier of Earthq. Pressure = 1

Estimated Embedment: Very Shallow: 2H

Program's Settings

Max. Height, Hmax = 100.00

Analysis Segment, dz = 0.25

No. of Active Segment at H, nz0 = 3

No. of Active Segment at Hmax, nz = 7

No. of Passive Segment, nzp = 4

Active Depth at H, Zh = 10.00

Active Depth at Hmax, Z = 100.00

Passive Depth at Hmax, Zp = 100.00

Max. Pressure = 46.58

Total Soil Types= 5

Soil	Weight	W(S)	Phi	Cohesion	Nspt	Type	Description
1	115.0	120.0	22	0	5	1	1. Soft to M
>	115.0	120.0	22.0	0.0	5	1	Converted
2	140.0	145.0	25	0.0	11	1	2. Medium St
>	140.0	145.0	25.0	0.0	11	1	Converted
3	135.0	140.0	28	0.0	24	1	3. Stiff to

>	135.0	140.0	28.0	0.0	24	1	Converted
4	145.0	150.0	31	0.0	65	1	4. Hard Cohe
>	145.0	150.0	31.0	0.0	65	1	Converted
5	150.0	155.0	45	0.0	100	5	Bedrock

Soil Type: 1 Equivalent Clay; 2 Clay; 3 Silt; 4 Sand; 5 Gravel

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.
1	0.0	0.0	-9.0	800.0	2
2	0.8	0.0	0.8	800.0	1
3	5.8	0.0	5.8	800.0	2
4	15.8	0.0	15.8	800.0	3
5	35.8	0.0	35.8	800.0	4
6	40.8	0.0	40.8	800.0	5

Water Table at Active Side:

Point	Z-water	X-water
1	10.0	0.0
2	2.5	10.0
3	2.5	800.0

Ground Surface at Passive Side:

Line	Z1	Xp1	Z2	Xp2	Soil No.
1	10.0	0.0	10.0	800.0	2
2	15.8	0.0	15.8	800.0	3
3	35.8	0.0	35.8	800.0	4
4	40.8	0.0	40.8	800.0	5

Water Table at Passive Side:

Point	Z-water	X-water
1	10.0	0.0
2	10.0	800.0

Output data: *****

Total Force above Base= 2.62 per one linear foot (or meter) width along wall height
 Static Force above Base= 2.62. Distributed in Triangular Envelope along wall height.
 Ignore soil layers and water line

Apparent Pressure above Base - Output to Shoring

Active/At-Rest Force above Base, Ea = 2.62

No	Z1	P1	Z2	P2	Slope	Coef.
0	0.0	0.00	10.0	0.52	0.0524	0.3744

Driving Pressure below Base - Output to Shoring

No	Z1	P1	Z2	P2	Slope	Ka or Ko
0	10.0	0.52	15.8	0.65	0.0226	0.2733
1	15.8	0.55	35.8	1.11	0.0278	0.3581
2	35.8	0.97	40.8	1.12	0.0287	0.3275
3	40.8	0.51	100.0	1.60	0.0184	0.1990

Passive Pressure below Base - Output to Shoring

No	Z1	P1	Z2	P2	Slope	Kp
----	----	----	----	----	-------	----

0	10.0	0.00	15.8	1.18	0.2036	2.4643
1	15.8	1.32	35.8	5.63	0.2152	2.7730
2	35.8	6.29	40.8	7.68	0.2794	3.1899
3	40.8	12.71	100.0	46.58	0.5722	6.1796

Passive pressures below 40.8 feet manually adjusted in shoring module to reflect claystone strength.

DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

Z, Xa, Xp - Coordinates of ground lines

Z- Depth measured from wall top

Xa - Distance measure from wall to active side.

Xp - Distance measure from wall to passive side

Z1, P1, Z2, P2 - Four values to define a pressure diagram

Z1- Top depth of the diagram

P1- Top pressure of the diagram

Z2- Bottom depth of the diagram

P2- Bottom pressure of the diagram

Slope - $(P2-P1)/(Z2-Z1)$, Slope of the diagram. It also called Equivalent fluid density.

Coef. - Pressure Coefficient = Slope/Unit Weight

Ka - Active Earth Pressure Coefficient

Ko - At-Rest Earth Pressure Coefficient

Kp - Passive Earth Pressure Coefficient

Steel Beam and Cross-Section Properties

Assumed Pile Shape **HP 14x89**

Pile Availability

AISC Member Producers	3
Non-Member Producers	0

Shaft Geometry

Shaft Diameter	30 in
Longest Beam Dimension	20.162589 in
Clear Distance	4.9187054 in

Steel Beam Geometry

Beam Depth (D)	13.8 in
Web Thickness (t_w)	0.615 in
Flange Width (B_f)	14.7 in
Flange Thickness (t_f)	0.615 in
Area of Steel (A_s)	26.1 in ²

Steel Properties

Yield Strength of Steel	50 ksi
Moment of Inertia (I_{xx}) of Steel	904 in ⁴
Modulus of Elasticity of Steel (E)	29000 ksi
Modulus of Elasticity of Steel (E)	29000000 psi
EI (Steel Only)	2.622E+10 lb*in ²
Section Modulus (S_x)	131 in ³
Section Modulus (Z_x)	146 in ³
Shear-Buckling Coefficient (k)	5
Ratio of Shear-Buckling Resistance (C)	1
D/ t_w	22.439024
1.12VEk/ F_{yw}	60.313846
1.40VEk/ F_{yw}	75.392307

Determined by AASHTO LRFD Bridge Specifications
Eqn's 6.10.9.3.2-4, 6.10.9.3.2-5, and 6.10.9.3.2-6

Shear Capacity Calculation

$$V_u \leq \phi V_{cr}$$

$$\phi_b = \frac{1}{1} \text{ AASHTO LRFD Bridge Design Spec's 6.5.4.2}$$

$$V_u = \text{shear in web due to factored permanent and construction loads applied to noncompact section (kips)}$$

$$V_{cr} = \text{shear buckling resistance determined from Equation 6.10.9.3.3-1 (AASHTO LRFD Bridge Design Spec's)}$$

$$V_n = V_{cr} = C V_p$$

$$V_p = 0.58 F_{yw} D t_w$$

$$V_p = \text{plastic shear force (kips)}$$

$$C = \text{ratio of shear-buckling resistance to shear yield strength determined by AASHTO Eqn's 6.10.9.3.2-4, 6.10.9.3.2-5, 6.10.9.3.2-5, or 6.10.9.3.2-6}$$

$$V_p = 0.58 * 50 * 13.8 * 0.615$$

$$V_p = 246.1 \text{ kips}$$

$$\phi V_{cr} = \phi * C * V_p$$

$$\phi V_{cr} = 1 * 1 * 246.1$$

$$\phi V_{cr} = 246.1 \text{ kips}$$

$$V_u = 128.63 \text{ kips (from Shoring Suite)}$$

$$V_u = \text{ kips (from PYWALL)}$$

$$V_u < \phi V_{cr} \text{ OK}$$

Flexure Capacity Calculation

$$M_u \leq \phi M_n$$

$$\phi_b = \frac{1}{1} \text{ AASHTO LRFD Bridge Design Spec's 6.5.4.2}$$

$$M_u = \text{Moment due to the factored loads}$$

$$M_n = \text{Nominal flexural resistance of a section}$$

$$S_x = \text{Elastic section modulus about the x-axis}$$

$$\phi M_n = \phi * F_y * S_x$$

$$\phi M_n = 1 * 50 * 131$$

$$\phi M_n = 6550 \text{ in*kips}$$

$$M_u = 6380.5 \text{ in*kips (from Shoring Suite)}$$

$$M_u = \text{ in*kips (from PYWALL)}$$

$$M_u < \phi M_n \text{ OK}$$

Deflection Criteria

Pile Length Above Rock = 40.8 ft	Exposed Wall Height = 10 ft
Pile Length Above Rock = in	Exposed Wall Height = 120 in

- 1.) Per the ODOT GDM, pile-head deflection in the service limit state limited to 1% or less of the shaft length above bedrock, or 1% of total drilled shaft length if not embedded in bedrock.
- 2.) Following industry acceptance criteria, limit wall deflection to 1% of exposed wall height where ODOT landslide criteria does not govern. Alternatively, limit wall deflection to 1.5% of the exposed wall height in accordance with NCDOT guidelines. Use 1.5% wall deflection for PYWALL software.

ODOT Landslide Criteria Governs

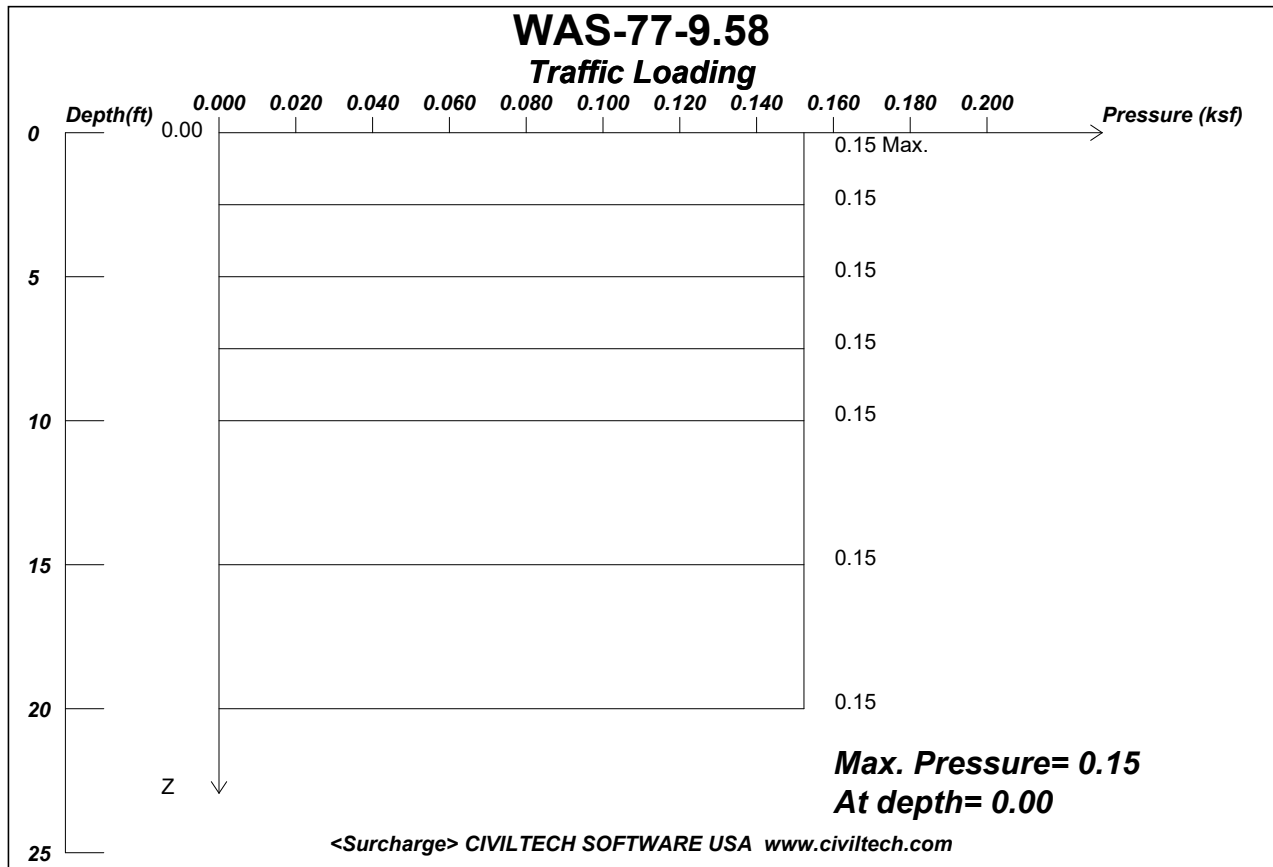
1% Wall Height OR 2 inches- LPILE	2	in	$\delta = 2.06$	in (from Shoring Suite)
1.5% Wall Height - PYWALL	1.8	in	$\delta =$	in (from PYWALL)

Drilled Shafts Located Within 10 feet of Edge of Pavement **NO**

Approx. 2",
considered ok



Service Limit Analysis (Soldier Pile and Lagging Wall without Tiebacks)



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Date: 10/30/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 10' Wall Surcharge Service.lp8

Wall Height, H= 10

Load Depth, D= 0

Load Factor of Surcharge Loading = 1

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

Max. Pressure = 0.152 at depth = 0.00

Infinite Surcharge, Q=.250

Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

SURCHARGE LOADS CALCULATION SUMMARY
<Surcharge>
Software Copyright by CivilTech Software
www.civiltech.com

Reference: Foundation Design, Wayne C. Teng, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1962

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Date: 10/30/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 10'
Wall Surcharge Service.lp8

WAS-77-9.58
Traffic Loading

Height of Wall = 10
Depth of Load = 0
Load Factor of Surcharge Loading = 1

Wall Condition:
Rigid Wall Condition -- No movement or deflection of the wall are allowed.

*****Loading*****

INFINITE SURCHARGE LOADING: Q=.250
Active Wedge Approach * (recommend)

*****Total Pressure Distribution*****

Max. Pressure =0.152 at depth =0.00

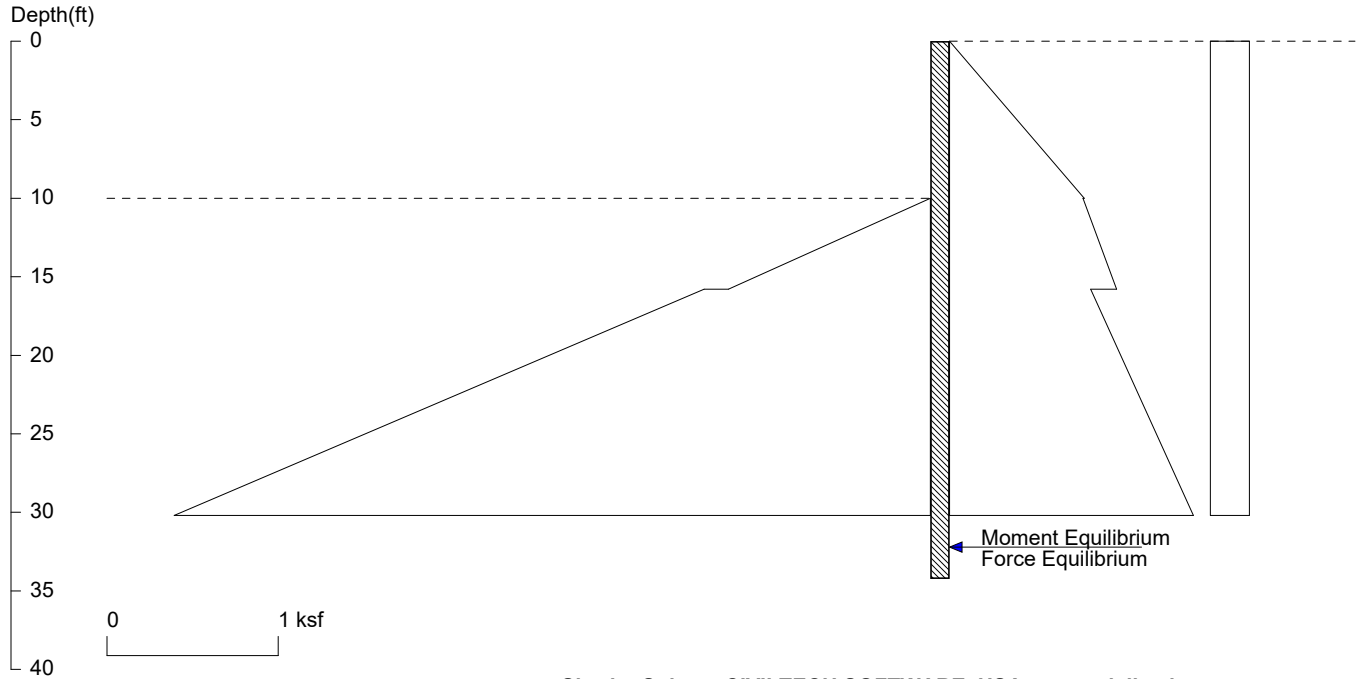
Depth	Pressure
0.00	0.152
0.50	0.152
1.00	0.152
1.50	0.152
2.00	0.152
2.50	0.152
3.00	0.152
3.50	0.152
4.00	0.152
4.50	0.152
5.00	0.152
5.50	0.152
6.00	0.152
6.50	0.152
7.00	0.152
7.50	0.152
8.00	0.152

8.50	0.152
9.00	0.152
9.50	0.152
10.00	0.152
11.00	0.152
12.00	0.152
13.00	0.152
14.00	0.152
15.00	0.152
16.00	0.152
17.00	0.152
18.00	0.152
19.00	0.152
20.00	0.152
22.00	0.152
24.00	0.152
26.00	0.152
28.00	0.152
30.00	0.152
32.00	0.152
34.00	0.152
36.00	0.152
38.00	0.152
40.00	0.000

Depth Is Measured From Top of the Wall

LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

WAS-77-9.58



<ShoringSuite> CIVILTECH SOFTWARE USA www.civiltech.com

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Date: 10/30/2023

File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 10' Main Wall Tieback Service.sh8

Wall Height=10.0 Pile Diameter=2.5 Pile Spacing=6.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=24.23 Min. Pile Length=34.23

MOMENT IN PILE: Max. Moment=486.87 per Pile Spacing=6.0 at Depth=21.26

PILE SELECTION:

Request Min. Section Modulus = $116.8 \text{ in}^3/\text{pile} = 1914.81 \text{ cm}^3/\text{pile}$, $F_y = 50 \text{ ksi} = 345 \text{ MPa}$, $F_b/F_y = 1$

HP14X89 has Section Modulus = 131.0 in³/pile=2146.70 cm³/pile. It is greater than Min. Requirements!

Top Deflection = 2.06(in) based on E (ksi)=29000.00 and I (in⁴)/pile=904.0

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE): Pressures below will be multiplied by a Factor = 1.5

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	10.00	0.524	0.052420
*	Below	Base		
10.00	0.519	15.80	0.650	0.022578
15.80	0.549	35.80	1.105	0.027790
*	Sur-	charg		
0.000	0.152	0.500	0.152	0.000000
0.500	0.152	1.000	0.152	0.000000
1.000	0.152	1.500	0.152	0.000000
1.500	0.152	2.000	0.152	0.000000
2.000	0.152	2.500	0.152	0.000000
2.500	0.152	3.000	0.152	0.000000
3.000	0.152	3.500	0.152	0.000000
3.500	0.152	4.000	0.152	0.000000
4.000	0.152	4.500	0.152	0.000000
4.500	0.152	5.000	0.152	0.000000
5.000	0.152	5.500	0.152	0.000000
5.500	0.152	6.000	0.152	0.000000

6.000	0.152	6.500	0.152	0.000000
6.500	0.152	7.000	0.152	0.000000
7.000	0.152	7.500	0.152	0.000000
7.500	0.152	8.000	0.152	0.000000
8.000	0.152	8.500	0.152	0.000000
8.500	0.152	9.000	0.152	0.000000
9.000	0.152	9.500	0.152	0.000000
9.500	0.152	10.00	0.152	0.000000
10.00	0.152	11.00	0.152	0.000000
11.00	0.152	12.00	0.152	0.000000
12.00	0.152	13.00	0.152	0.000000
13.00	0.152	14.00	0.152	0.000000
14.00	0.152	15.00	0.152	0.000000
15.00	0.152	16.00	0.152	0.000000
16.00	0.152	17.00	0.152	0.000000
17.00	0.152	18.00	0.152	0.000000
18.00	0.152	19.00	0.152	0.000000
19.00	0.152	20.00	0.152	0.000000
20.00	0.152	22.00	0.152	0.000000
22.00	0.152	24.00	0.152	0.000000
24.00	0.152	26.00	0.152	0.000000
26.00	0.152	28.00	0.152	0.000000
28.00	0.152	30.00	0.152	0.000000
30.00	0.152	32.00	0.152	0.000000
32.00	0.152	34.00	0.152	0.000000
34.00	0.152	36.00	0.152	0.000000

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
10.00	0.000	15.80	1.181	0.203551
15.80	1.323	35.80	5.627	0.215183

ACTIVE SPACING:

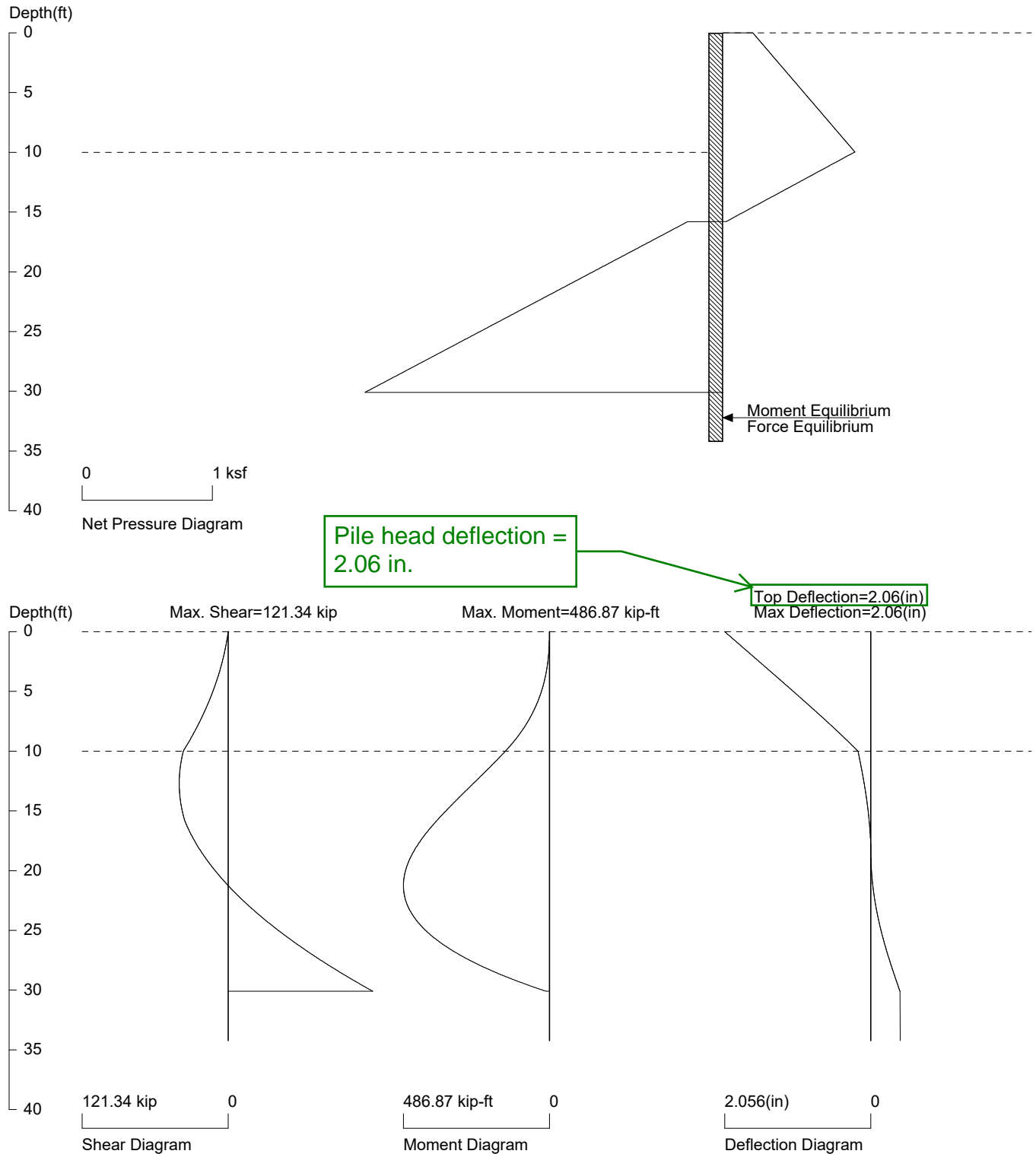
No.	Z depth	Spacing
1	0.00	6.00
2	10.00	2.50

PASSIVE SPACING:

No.	Z depth	Spacing
1	10.00	5.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft³; Deflection - in

WAS-77-9.58



PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 6.0 foot or meter

User Input Pile, HP14X89: E (ksi)=29000.0, I (in4)/pile=904.0

File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 10' Main Wall Tieback Service.sh8

SHORING WALL CALCULATION SUMMARY
The leading shoring design and calculation software
Software Copyright by CivilTech Software
www.civiltech.com

ShoringSuite Software is developed by CivilTech Software, Bellevue, WA, USA.

The calculation method is based on the following references:

1. FHWA 98-011, FHWA-RD-97-130, FHWA SA 96-069, FHWA-IF-99-015
2. STEEL SHEET PILING DESIGN MANUAL by Pile Buck Inc., 1987
3. DESIGN MANUAL DM-7 (NAVFAC), Department of the Navy, May 1982
4. TRENCHING AND SHORING MANUAL Revision 12, California Department of Transportation, January 2000
6. EARTH SUPPORT SYSTEM & RETAINING STRUCTURES, Pile Buck Inc. 2002
5. DESIGN OF SHEET PILE WALLS, EM 1110-2-2504, U.S. Army Corps of Engineers, 31 March 1994
7. EARTH RETENTION SYSTEMS HANDBOOK, Alan Macnab, McGraw-Hill. 2002
8. Temporary Structures in Construction, Robert T. Ratay (Co-author of Chapter 7: John J. Peirce), McGraw-Hill. 2012
9. AASHTO HB-17, American Association of State and Highway Transportation Officials, 2 September 2002

UNITS: Width/Spacing/Diameter/Length/Depth - ft, Force - kip, Moment - kip-ft, Friction/Bearing/Pressure - ksf, Pres.
Slope - kip/ft³, Deflection - in

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Date: 10/30/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 10' Main Wall Tieback Service.sh8

Title: WAS-77-9.58

Subtitle:

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

Wall Type: 2. Soldier Pile, Drilled

Wall Height: 10.00

Pile Diameter: 2.50

Pile Spacing: 6.00

Factor of Safety (F.S.): 1.00

Lateral Support Type (Braces): 1. No

Top Brace Increase (Multi-Bracing): Add 15%*

Embedment Option: 1. Yes

Friction at Pile Tip: No

Pile Properties:

Steel Strength, Fy: 50 ksi = 345 MPa

Allowable Fb/Fy: 1
Elastic Module, E: 29000.00
Moment of Inertia, I: 904.00
User Input File: HP14X89

* DRIVING PRESSURE (ACTIVE, WATER, & SURCHARGE) *

The pressures below will be multiplied by a Factor =1.5

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope

1	*	Above	Base		
2	0.000	0.000	10.00	0.524	0.052420
3	*	Below	Base		
4	10.00	0.519	15.80	0.650	0.022578
5	15.80	0.549	35.80	1.105	0.027790
6	35.80	0.972	40.80	1.115	0.028685
7	40.80	0.489	90.00	1.443	0.019381
8	*	Sur-	charg		
9	0.000	0.152	0.500	0.152	0.000000
10	0.500	0.152	1.000	0.152	0.000000
11	1.000	0.152	1.500	0.152	0.000000
12	1.500	0.152	2.000	0.152	0.000000
13	2.000	0.152	2.500	0.152	0.000000
14	2.500	0.152	3.000	0.152	0.000000
15	3.000	0.152	3.500	0.152	0.000000
16	3.500	0.152	4.000	0.152	0.000000
17	4.000	0.152	4.500	0.152	0.000000
18	4.500	0.152	5.000	0.152	0.000000
19	5.000	0.152	5.500	0.152	0.000000
20	5.500	0.152	6.000	0.152	0.000000
21	6.000	0.152	6.500	0.152	0.000000
22	6.500	0.152	7.000	0.152	0.000000
23	7.000	0.152	7.500	0.152	0.000000
24	7.500	0.152	8.000	0.152	0.000000
25	8.000	0.152	8.500	0.152	0.000000
26	8.500	0.152	9.000	0.152	0.000000
27	9.000	0.152	9.500	0.152	0.000000
28	9.500	0.152	10.00	0.152	0.000000
29	10.00	0.152	11.00	0.152	0.000000
30	11.00	0.152	12.00	0.152	0.000000
31	12.00	0.152	13.00	0.152	0.000000
32	13.00	0.152	14.00	0.152	0.000000
33	14.00	0.152	15.00	0.152	0.000000

34	15.00	0.152	16.00	0.152	0.000000
35	16.00	0.152	17.00	0.152	0.000000
36	17.00	0.152	18.00	0.152	0.000000
37	18.00	0.152	19.00	0.152	0.000000
38	19.00	0.152	20.00	0.152	0.000000
39	20.00	0.152	22.00	0.152	0.000000
40	22.00	0.152	24.00	0.152	0.000000
41	24.00	0.152	26.00	0.152	0.000000
42	26.00	0.152	28.00	0.152	0.000000
43	28.00	0.152	30.00	0.152	0.000000
44	30.00	0.152	32.00	0.152	0.000000
45	32.00	0.152	34.00	0.152	0.000000
46	34.00	0.152	36.00	0.152	0.000000
47	36.00	0.152	38.00	0.152	0.000000
48	38.00	0.152	40.00	0.000	-0.07615

* PASSIVE PRESSURE *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Below	Base		
2	10.00	0.000	15.80	1.181	0.203551
3	15.80	1.323	35.80	5.627	0.215183
4	35.80	6.287	40.80	7.684	0.279431
5	40.80	47	90.00	47	0.0000

* ACTIVE SPACE *

No.	Z depth	Spacing
1	0.00	6.00
2	10.00	2.50

* PASSIVE SPACE *

No.	Z depth	Spacing
1	10.00	5.00

*For Tieback: Input1 = Diameter; Input2 = Bond Strength

*For Plate: Input1 = Diameter; Input2 = Allowable Pressure

*For Deadman: Input1 = Horz. Width; Input2 = Passive Pressure;

Passive pressure for bedrock
adjusted to 47 ksf based on an
unconfined strength of 330 psi.

*For Sheet Pile Anchor: Input1 = Horz. Width; Input2 = Passive Slope;

*****CALCULATION*****

The calculated moment and shear are per pile spacing. Sheet piles are per one foot or meter; Soldier piles are per pile.

Top Pressures start at depth = 0.00

	D1=0.00
== ==	D2=10.00
	D3=34.23

D1 - TOP DEPTH
D2 - EXCAVATION BASE
D3 - PILE TIP

MOMENT equilibrium AT DEPTH=30.19 WITH EMBEDMENT OF 20.19
FORCE equilibrium AT DEPTH=34.23 WITH EMBEDMENT OF 24.23

The program calculates an embedment for moment equilibrium, then increase the embedment by 1.2

*****RESULTS*****

* EMBEDMENT Notes *

Based on USS Design Manual, first calculate embedment for moment equilibrium, then increased the embedment to get the design depth.

The embedment for moment equilibrium is 20.19

The program calculates an embedment for moment equilibrium, then increase the embedment by 1.2

The total design embedment is 24.23

Embedment Information:

If 20% increased, the total design embedment is 24.23

If 30% increased, the total design embedment is 26.25

If 40% increased, the total design embedment is 28.27

If 50% increased, the total design embedment is 30.29

* MOMENT IN PILE (per pile spacing)*

Pile Spacing: sheet piles are one foot or one meter; soldier piles are one pile.

Overall Maximum Moment = 486.87 at 21.26

Maximum Shear = 121.34

Moment and Shear are per pile spacing: 6.0 foot or meter

* VERTICAL LOADING *

Vertical Loading from Braces = 0.00

Vertical Loading from External Load = 0.00

Total Vertical Loading = 0.00

*****SPECIFIED PILE *****

Overall Maximum Moment = 486.87 at 21.26

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

Request Min. Section Modulus = 116.85 in³/pile = 1914.81 cm³/pile, $F_y = 50 \text{ ksi} = 345 \text{ MPa}$, $F_b/F_y = 1$

HP14X89 has been found in Soldier Pile list!

(English Units):

Area= 26.1 in. Depth= 13.8 in. Width= 14.7 in. Height= 14 in.

Flange thickness= 0.615 in. Web thickness= 0.615 in.

$I_x = 904 \text{ in}^4/\text{pile}$ $S_x = 131 \text{ in}^3/\text{pile}$ $I_y = 326 \text{ in}^4/\text{pile}$ $S_y = 44.3 \text{ in}^3/\text{pile}$

(Metric Units):

$I_x = 376.24 \times 10^6 \text{ cm}^4/\text{pile}$ $S_x = 2146.70 \text{ cm}^3/\text{pile}$ $I_y = 135.68 \times 10^6 \text{ cm}^4/\text{pile}$ $S_y = 725.94 \text{ cm}^3/\text{pile}$

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

HP14X89 is capable to support the shoring!

Top deflection = 2.056(in)

Max. deflection = 2.056(in)

***** LAGGING SIZE ESTIMATION *****

Max. Pressure above base = 1.01

Piles are more rigid than timber lagging, due to arching, only portion of pressures are acting to lagging, 30-50%

loading is suggested.

If 50% loading is used for lagging design, Design Pressure = 0.51

Pile Spacing = 6.0, Max. Moment in lagging = 2.28

For 4"x12" Timber, Section Modules $S=23.47 \text{ in}^3$. The request allowable bending strength, $fb=M/S=1.16$

For 6"x12" Timber, Section Modules $S=57.98 \text{ in}^3$. The request allowable bending strength, $fb=M/S=0.47$

If 30% loading is used for lagging design, Design Pressure = 0.30

Pile Spacing = 6.0, Max. Moment in lagging = 1.37

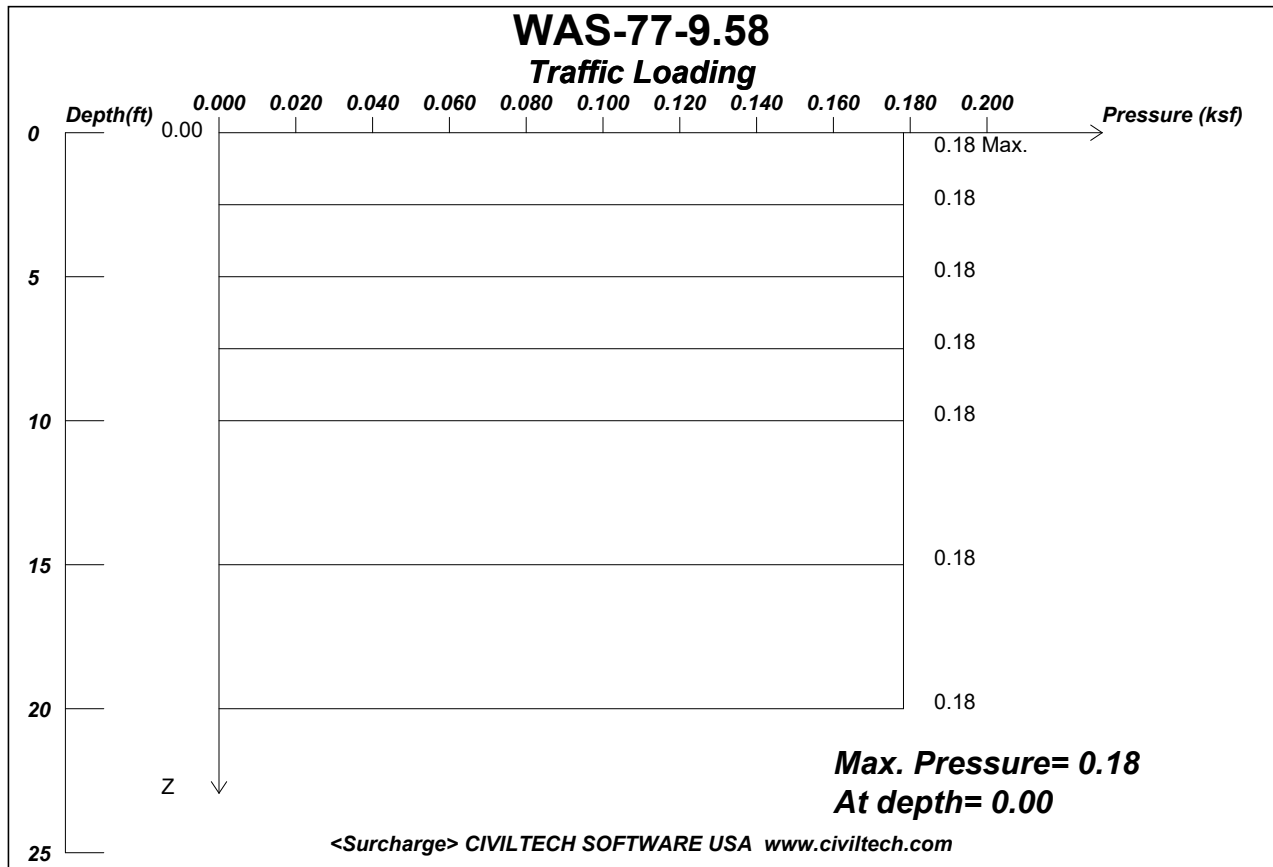
For 4"x12" Timber, Section Modules $S=23.47 \text{ in}^3$. The request allowable bending strength, $fb=M/S=0.70$

For 6"x12" Timber, Section Modules $S=57.98 \text{ in}^3$. The request allowable bending strength, $fb=M/S=0.28$

Unit: Pressure: ksf, Spacing: ft, Moment: kip-ft, Bending Strength, fb: ksi



Strength Limit Analysis (Soldier Pile and Lagging Wall without Tiebacks)



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Date: 10/30/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 10' Wall Surcharge Strength.lp8

Wall Height, H= 10

Load Depth, D= 0

Load Factor of Surcharge Loading = 1.17

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

Max. Pressure = 0.178 at depth = 0.00

A load factor of 1.5 is applied to all active loading in the wall analysis. As traffic loading uses 1.75, an extra factor has been applied here ($1.75/1.5 = 1.17$).

Infinite Surcharge, Q=.250

Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

SURCHARGE LOADS CALCULATION SUMMARY
<Surcharge>
Software Copyright by CivilTech Software
www.civiltech.com

Reference: Foundation Design, Wayne C. Teng, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1962

Licensed to A. Baratta HDR
Date: 10/30/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 10'
Wall Surcharge Strength.lp8

WAS-77-9.58
Traffic Loading

Height of Wall = 10
Depth of Load = 0
Load Factor of Surcharge Loading = 1.17

Wall Condition:
Rigid Wall Condition -- No movement or deflection of the wall are allowed.

*****Loading*****

INFINITE SURCHARGE LOADING: Q=.250
Active Wedge Approach * (recommend)

*****Total Pressure Distribution*****

Max. Pressure =0.178 at depth =0.00

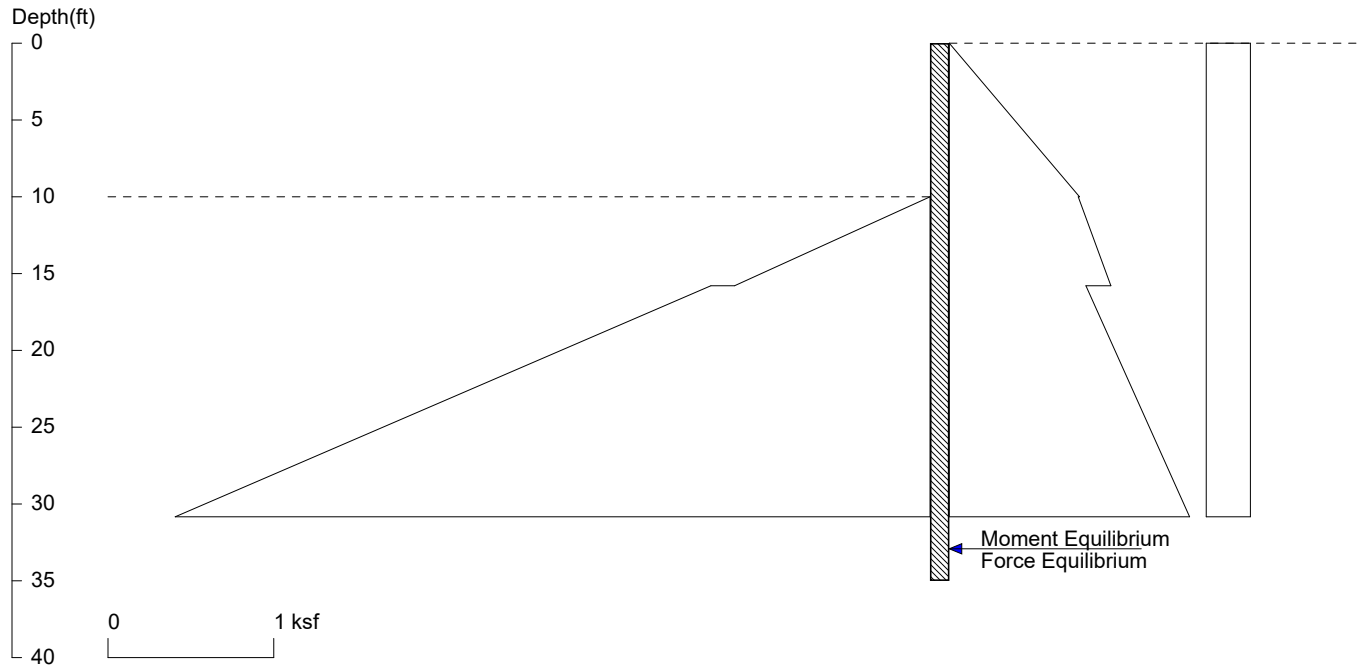
Depth	Pressure
0.00	0.178
0.50	0.178
1.00	0.178
1.50	0.178
2.00	0.178
2.50	0.178
3.00	0.178
3.50	0.178
4.00	0.178
4.50	0.178
5.00	0.178
5.50	0.178
6.00	0.178
6.50	0.178
7.00	0.178
7.50	0.178
8.00	0.178

8.50	0.178
9.00	0.178
9.50	0.178
10.00	0.178
11.00	0.178
12.00	0.178
13.00	0.178
14.00	0.178
15.00	0.178
16.00	0.178
17.00	0.178
18.00	0.178
19.00	0.178
20.00	0.178
22.00	0.178
24.00	0.178
26.00	0.178
28.00	0.178
30.00	0.178
32.00	0.178
34.00	0.178
36.00	0.178
38.00	0.178
40.00	0.000

Depth Is Measured From Top of the Wall

LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

WAS-77-9.58



<ShoringSuite> CIVILTECH SOFTWARE USA www.civiltech.com

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Date: 10/30/2023

File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 10' Main Wall Tieback Strength.sh8

Wall Height=10.0

Pile Diameter=2.5

Pile Spacing=6.0

Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=25.00 Min. Pile Length=35.00

MOMENT IN PILE: Max. Moment=531.71 per Pile Spacing=6.0 at Depth=21.61

PILE SELECTION:

Request Min. Section Modulus = 127.6 in³/pile=2091.14 cm³/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=1

HP14X89 has Section Modulus = 131.0 in³/pile=2146.70 cm³/pile. It is greater than Min. Requirements!

Top Deflection = 2.30(in) based on E (ksi)=29000.00 and I (in⁴)/pile=904.0

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE): Pressures below will be multiplied by a Factor =1.5

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	10.00	0.524	0.052420
*	Below	Base		
10.00	0.519	15.80	0.650	0.022578
15.80	0.549	35.80	1.105	0.027790
*	Sur-	charg		
0.000	0.178	0.500	0.178	0.000000
0.500	0.178	1.000	0.178	0.000000
1.000	0.178	1.500	0.178	0.000000
1.500	0.178	2.000	0.178	0.000000
2.000	0.178	2.500	0.178	0.000000
2.500	0.178	3.000	0.178	0.000000
3.000	0.178	3.500	0.178	0.000000
3.500	0.178	4.000	0.178	0.000000
4.000	0.178	4.500	0.178	0.000000
4.500	0.178	5.000	0.178	0.000000
5.000	0.178	5.500	0.178	0.000000
5.500	0.178	6.000	0.178	0.000000

Applied 1.5 load factor for active earth pressures.

6.000	0.178	6.500	0.178	0.000000
6.500	0.178	7.000	0.178	0.000000
7.000	0.178	7.500	0.178	0.000000
7.500	0.178	8.000	0.178	0.000000
8.000	0.178	8.500	0.178	0.000000
8.500	0.178	9.000	0.178	0.000000
9.000	0.178	9.500	0.178	0.000000
9.500	0.178	10.00	0.178	0.000000
10.00	0.178	11.00	0.178	0.000000
11.00	0.178	12.00	0.178	0.000000
12.00	0.178	13.00	0.178	0.000000
13.00	0.178	14.00	0.178	0.000000
14.00	0.178	15.00	0.178	0.000000
15.00	0.178	16.00	0.178	0.000000
16.00	0.178	17.00	0.178	0.000000
17.00	0.178	18.00	0.178	0.000000
18.00	0.178	19.00	0.178	0.000000
19.00	0.178	20.00	0.178	0.000000
20.00	0.178	22.00	0.178	0.000000
22.00	0.178	24.00	0.178	0.000000
24.00	0.178	26.00	0.178	0.000000
26.00	0.178	28.00	0.178	0.000000
28.00	0.178	30.00	0.178	0.000000
30.00	0.178	32.00	0.178	0.000000
32.00	0.178	34.00	0.178	0.000000
34.00	0.178	36.00	0.178	0.000000

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
*	Below	Base		
10.00	0.000	15.80	1.181	0.203551
15.80	1.323	35.80	5.627	0.215183

ACTIVE SPACING:

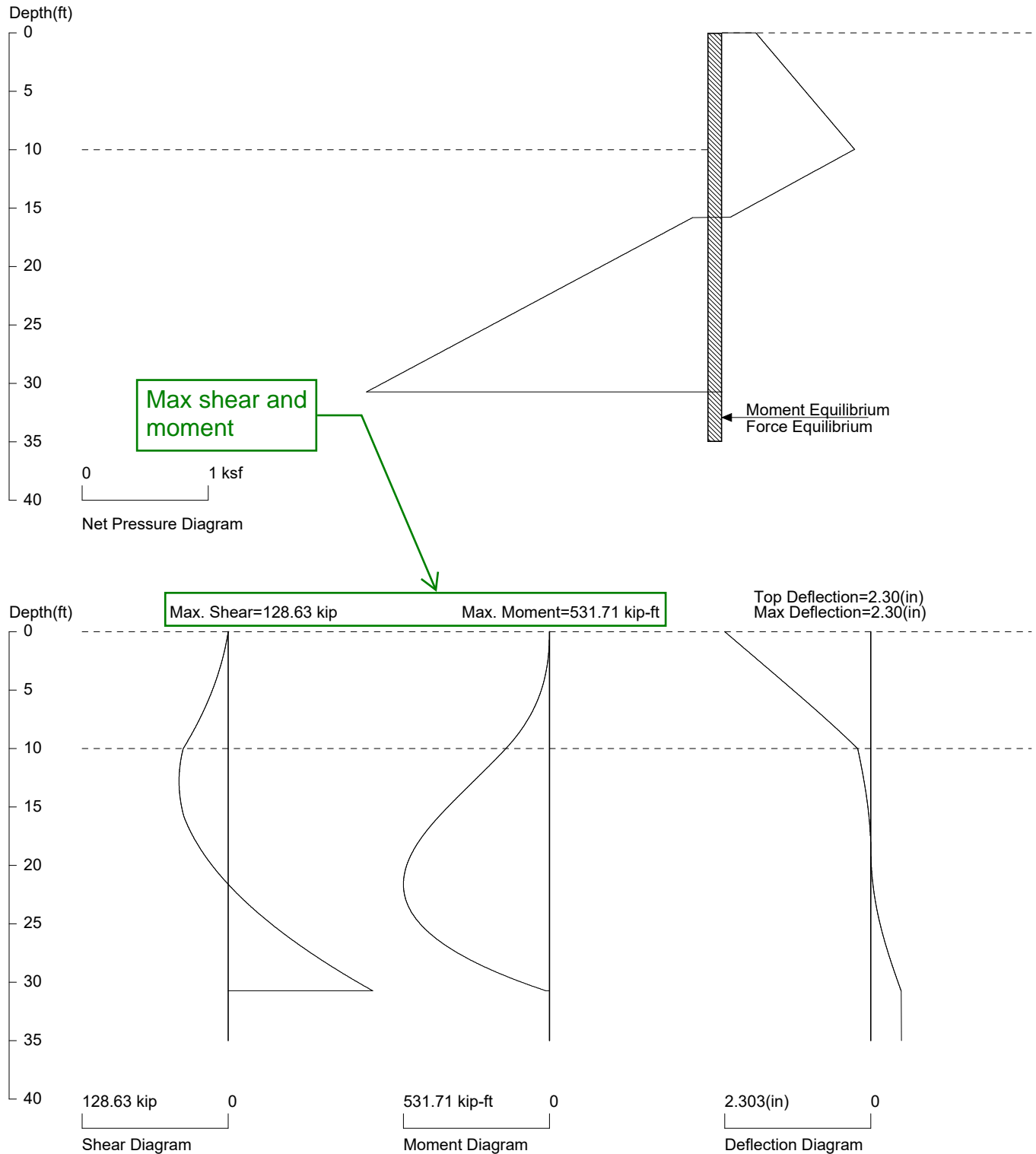
No.	Z depth	Spacing
1	0.00	6.00
2	10.00	2.50

PASSIVE SPACING:

No.	Z depth	Spacing
1	10.00	5.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft³; Deflection - in

WAS-77-9.58



PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 6.0 foot or meter

User Input Pile, HP14X89: E (ksi)=29000.0, I (in4)/pile=904.0

File: C:\Users\labaratta\Desktop\WAS-77\WAS-77-9.58 10' Main Wall Tieback Strength.sh8

SHORING WALL CALCULATION SUMMARY
The leading shoring design and calculation software
Software Copyright by CivilTech Software
www.civiltech.com

ShoringSuite Software is developed by CivilTech Software, Bellevue, WA, USA.

The calculation method is based on the following references:

1. FHWA 98-011, FHWA-RD-97-130, FHWA SA 96-069, FHWA-IF-99-015
2. STEEL SHEET PILING DESIGN MANUAL by Pile Buck Inc., 1987
3. DESIGN MANUAL DM-7 (NAVFAC), Department of the Navy, May 1982
4. TRENCHING AND SHORING MANUAL Revision 12, California Department of Transportation, January 2000
6. EARTH SUPPORT SYSTEM & RETAINING STRUCTURES, Pile Buck Inc. 2002
5. DESIGN OF SHEET PILE WALLS, EM 1110-2-2504, U.S. Army Corps of Engineers, 31 March 1994
7. EARTH RETENTION SYSTEMS HANDBOOK, Alan Macnab, McGraw-Hill. 2002
8. Temporary Structures in Construction, Robert T. Ratay (Co-author of Chapter 7: John J. Peirce), McGraw-Hill. 2012
9. AASHTO HB-17, American Association of State and Highway Transportation Officials, 2 September 2002

UNITS: Width/Spacing/Diameter/Length/Depth - ft, Force - kip, Moment - kip-ft, Friction/Bearing/Pressure - ksf, Pres.
Slope - kip/ft³, Deflection - in

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Date: 10/30/2023 File: C:\Users\abaratta\Desktop\WAS-77\WAS-77-9.58 10' Main Wall Tieback Strength.sh8

Title: WAS-77-9.58

Subtitle:

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

Wall Type: 2. Soldier Pile, Drilled

Wall Height: 10.00

Pile Diameter: 2.50

Pile Spacing: 6.00

Factor of Safety (F.S.): 1.00

Lateral Support Type (Braces): 1. No

Top Brace Increase (Multi-Bracing): Add 15%*

Embedment Option: 1. Yes

Friction at Pile Tip: No

Pile Properties:

Steel Strength, Fy: 50 ksi = 345 MPa

Allowable Fb/Fy: 1
Elastic Module, E: 29000.00
Moment of Inertia, I: 904.00
User Input File: HP14X89

* DRIVING PRESSURE (ACTIVE, WATER, & SURCHARGE) *

The pressures below will be multiplied by a Factor =1.5

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Above	Base		
2	0.000	0.000	10.00	0.524	0.052420
3	*	Below	Base		
4	10.00	0.519	15.80	0.650	0.022578
5	15.80	0.549	35.80	1.105	0.027790
6	35.80	0.972	40.80	1.115	0.028685
7	40.80	0.489	90.00	1.443	0.019381
8	*	Sur-	charg		
9	0.000	0.178	0.500	0.178	0.000000
10	0.500	0.178	1.000	0.178	0.000000
11	1.000	0.178	1.500	0.178	0.000000
12	1.500	0.178	2.000	0.178	0.000000
13	2.000	0.178	2.500	0.178	0.000000
14	2.500	0.178	3.000	0.178	0.000000
15	3.000	0.178	3.500	0.178	0.000000
16	3.500	0.178	4.000	0.178	0.000000
17	4.000	0.178	4.500	0.178	0.000000
18	4.500	0.178	5.000	0.178	0.000000
19	5.000	0.178	5.500	0.178	0.000000
20	5.500	0.178	6.000	0.178	0.000000
21	6.000	0.178	6.500	0.178	0.000000
22	6.500	0.178	7.000	0.178	0.000000
23	7.000	0.178	7.500	0.178	0.000000
24	7.500	0.178	8.000	0.178	0.000000
25	8.000	0.178	8.500	0.178	0.000000
26	8.500	0.178	9.000	0.178	0.000000
27	9.000	0.178	9.500	0.178	0.000000
28	9.500	0.178	10.00	0.178	0.000000
29	10.00	0.178	11.00	0.178	0.000000
30	11.00	0.178	12.00	0.178	0.000000
31	12.00	0.178	13.00	0.178	0.000000
32	13.00	0.178	14.00	0.178	0.000000
33	14.00	0.178	15.00	0.178	0.000000

34	15.00	0.178	16.00	0.178	0.000000
35	16.00	0.178	17.00	0.178	0.000000
36	17.00	0.178	18.00	0.178	0.000000
37	18.00	0.178	19.00	0.178	0.000000
38	19.00	0.178	20.00	0.178	0.000000
39	20.00	0.178	22.00	0.178	0.000000
40	22.00	0.178	24.00	0.178	0.000000
41	24.00	0.178	26.00	0.178	0.000000
42	26.00	0.178	28.00	0.178	0.000000
43	28.00	0.178	30.00	0.178	0.000000
44	30.00	0.178	32.00	0.178	0.000000
45	32.00	0.178	34.00	0.178	0.000000
46	34.00	0.178	36.00	0.178	0.000000
47	36.00	0.178	38.00	0.178	0.000000
48	38.00	0.178	40.00	0.000	-0.08910

* PASSIVE PRESSURE *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	*	Below	Base		
2	10.00	0.000	15.80	1.181	0.203551
3	15.80	1.323	35.80	5.627	0.215183
4	35.80	6.287	40.80	7.684	0.279431
5	40.80	47	90.00	47	0.0000

* ACTIVE SPACE *

No.	Z depth	Spacing
1	0.00	6.00
2	10.00	2.50

* PASSIVE SPACE *

No.	Z depth	Spacing
1	10.00	5.00

*For Tieback: Input1 = Diameter; Input2 = Bond Strength

*For Plate: Input1 = Diameter; Input2 = Allowable Pressure

*For Deadman: Input1 = Horz. Width; Input2 = Passive Pressure;

Passive pressure for bedrock
adjusted to 47 ksf based on an
unconfined strength of 330 psi.

*For Sheet Pile Anchor: Input1 = Horz. Width; Input2 = Passive Slope;

*****CALCULATION*****

The calculated moment and shear are per pile spacing. Sheet piles are per one foot or meter; Soldier piles are per pile.

Top Pressures start at depth = 0.00

```

|      D1=0.00
|
|
==|= D2=10.00
|
|      D3=35.00
|
```

D1 - TOP DEPTH
D2 - EXCAVATION BASE
D3 - PILE TIP

MOMENT equilibrium AT DEPTH=30.83 WITH EMBEDMENT OF 20.83
FORCE equilibrium AT DEPTH=35.00 WITH EMBEDMENT OF 25.00

The program calculates an embedment for moment equilibrium, then increase the embedment by 1.2

*****RESULTS*****

* EMBEDMENT Notes *

Based on USS Design Manual, first calculate embedment for moment equilibrium, then increased the embedment to get the design depth.

The embedment for moment equilibrium is 20.83

The program calculates an embedment for moment equilibrium, then increase the embedment by 1.2

The total design embedment is 25.00

Embedment Information:

If 20% increased, the total design embedment is 25.00

If 30% increased, the total design embedment is 27.08

If 40% increased, the total design embedment is 29.16
If 50% increased, the total design embedment is 31.25

* MOMENT IN PILE (per pile spacing)*

Pile Spacing: sheet piles are one foot or one meter; soldier piles are one pile.

Overall Maximum Moment = 531.71 at 21.61

Maximum Shear = 128.63

Moment and Shear are per pile spacing: 6.0 foot or meter

* VERTICAL LOADING *

Vertical Loading from Braces = 0.00

Vertical Loading from External Load = 0.00

Total Vertical Loading = 0.00

*****SPECIFIED PILE *****

Overall Maximum Moment = 531.71 at 21.61

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

Request Min. Section Modulus = 127.61 in³/pile = 2091.14 cm³/pile, $F_y = 50 \text{ ksi} = 345 \text{ MPa}$, $F_b/F_y = 1$

HP14X89 has been found in Soldier Pile list!

(English Units):

Area= 26.1 in. Depth= 13.8 in. Width= 14.7 in. Height= 14 in.

Flange thickness= 0.615 in. Web thickness= 0.615 in.

$I_x = 904 \text{ in}^4/\text{pile}$ $S_x = 131 \text{ in}^3/\text{pile}$ $I_y = 326 \text{ in}^4/\text{pile}$ $S_y = 44.3 \text{ in}^3/\text{pile}$

(Metric Units):

$I_x = 376.24 \times 10^6 \text{ cm}^4/\text{pile}$ $S_x = 2146.70 \text{ cm}^3/\text{pile}$ $I_y = 135.68 \times 10^6 \text{ cm}^4/\text{pile}$ $S_y = 725.94 \text{ cm}^3/\text{pile}$

The pile selection is based on the magnitude of the moment only. Axial force is neglected.

HP14X89 is capable to support the shoring!

Top deflection = 2.303(in)

Max. deflection = 2.303(in)

***** LAGGING SIZE ESTIMATION *****

Max. Pressure above base = 1.05

Piles are more rigid than timber lagging, due to arching, only portion of pressures are acting to lagging, 30-50%

loading is suggested.

If 50% loading is used for lagging design, Design Pressure = 0.53

Pile Spacing = 6.0, Max. Moment in lagging = 2.37

For 4"x12" Timber, Section Modules $S=23.47 \text{ in}^3$. The request allowable bending strength, $fb=M/S=1.21$

For 6"x12" Timber, Section Modules $S=57.98 \text{ in}^3$. The request allowable bending strength, $fb=M/S=0.49$

If 30% loading is used for lagging design, Design Pressure = 0.32

Pile Spacing = 6.0, Max. Moment in lagging = 1.42

For 4"x12" Timber, Section Modules $S=23.47 \text{ in}^3$. The request allowable bending strength, $fb=M/S=0.73$

For 6"x12" Timber, Section Modules $S=57.98 \text{ in}^3$. The request allowable bending strength, $fb=M/S=0.29$

Unit: Pressure: ksf, Spacing: ft, Moment: kip-ft, Bending Strength, fb: ksi

No Tiebacks
(LPile)



Earth Pressure Determination

Geometry

Elevation (ft)			Horiz. Distance from C/L (ft)		
Top of Backfill =	860.0	at Bottom of Embankment	Start of Wall Backfill =	50.0	at Bottom of Embankment
Top of Wall =	851.0	at C/L of Wall	Wall =	0.0	at C/L of Wall
Existing Ground Surface =	851.4	at C/L of Wall			
Maintenance Bench =	841.0	at C/L of Wall	Backfill Slope Angle =	5.6	H:1V
Groundwater =	848.5	at C/L of Wall			

Wall Loading Profile

	Top Elev.	Thickness (ft)	Cohesion (psf)	Phi (deg)	Unit Wt (pcf)
Layer 2 Medium Stiff to Stiff Cohesive	851.0	0.8	115	23	140
Layer 1 Soft to Medium Stiff Cohesive	850.2	5.0	65	21	115
Layer 2 Medium Stiff to Stiff Cohesive	845.2	4.2	115	23	140
Bottom of Wall/Maintenance Bench	841.0				
Weighted Value		10.0	90	22	130

Earth Pressure Coefficients

	Deg	
Shear Resistance, Φ =	23	
Wall Friction, δ^A =	0.0	
Wall Slope, θ =	90	
Backfill Slope, β =	10.20	
Revised Backfill Slope, β =	10.20	
Backfill Condition	INFINITE	
Horz. Backslope Dist.	50.0	feet (C/L of Wall - Edge of Shoulder)
Wall Height (H)	10.0	feet (Top of Wall - Maintenance Bench)
Slope Height (h)	9.0	feet (Top of Backfill - Top of Wall)
I =	24.23	degrees

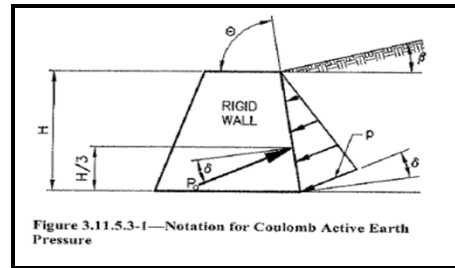


Figure 3.11.5.3-1—Notation for Coulomb Active Earth Pressure

Active Earth Coefficient

$$K_a = \frac{\sin^2(\theta + \Phi)}{(\sin^2(\theta) * \sin(\theta - \delta) * [1 + v(\sin(\Phi + \delta) * \sin(\Phi - \beta)) / (\sin(\theta - \delta) * \sin(\theta + \beta))]^2)}$$

$K_a = 0.504$

At-Rest Earth Coefficient

$$K_o = (1 - \sin(\phi)) * (1 + \sin(\beta))$$

$K_o = 0.717$

Notes:

- Wall friction neglected
- Figure and Equation for Active Earth Pressure from AASHTO 3.11.5.3 (LRFD Design Manual).
- The wall backfill will consist of proposed fill and cohesive overburden. Using the soil layer thicknesses and respective soil parameters as determined by backcalculation in SlopeW, a weighted average was determined and assumed for the entire backfill ($c' = 90$ psf and $\phi' = 22^\circ$, per backcalculated UA Slope Values). The parameters were converted to equivalent soil strength parameters $c' = 0$ psf and $\phi' = 23^\circ$ for computing earth pressures based on a 1 degree increase in friction angle for every 50 psf decrease in cohesion up to 150 psf (Ref: Hall's Thesis).

Soil Lateral Design Profile							
	Top Elev	Depth (ft)	Cohesion (psf)	Phi (deg)	Unit Wt (pcf)	ϵ_{50}	k
Layer 2 Medium Stiff to Stiff Cohesive	841.0	10.0	1500	0	77.6	0.007	N/A
Layer 3 Stiff to Very Stiff Cohesive	835.2	15.8	3000	0	72.6	0.005	N/A
Layer 4 Hard Cohesive	815.2	35.8	4000	0	82.6	0.005	N/A
Bedrock	810.2	40.8	N/A	N/A	N/A	N/A	N/A
Bedrock Lateral Design Profile							
	Top Elev	Depth (ft)	q_u (psi)	E_m (psi)	Unit Wt (pcf)	RQD (%)	k _{rm}
Claystone	810.2	40.8	330	37400	150	64	0.0005
Claystone	807.3	43.7	1150	179800	160	100	0.0005
Sandstone/Claystone	800.8	50.2	1150	179800	160	91	0.0005
Claystone	798.1	52.9	330	37400	150	17	0.0005
Claystone	795.7	55.3	330	37400	150	86	0.0005

Depths referenced below the top of wall, starting at the lowered ground surface. ϵ_{50} and k values per LPile Technical Manual.

Wall Loading Computations

Earth Pressure Model = **CONVENTIONAL** (Conventional or UA SLOPE)

1) Soil Unit Weight = **130** pcf Weighted Average Along Cantilevered Wall Height

2) Determine Coefficient of Earth Pressure (K)

Restraint Condition = **ACTIVE** (Active or At-Rest)

Ka = **0.504**

3) Determine Equivalent Fluid Weight (G_H)

G_H = (γ_m) * (K_a)

G_H = **66** For application to CONVENTIONAL Earth Pressure Model

4) Artificially Lowered Ground Surface (ODOT GDM Section 903.3.2, pg. 9-14) for FS_{dh} < 1.30

Consider Lowered G. S.? **NO**

5) Modification of p-y curves (ODOT GDM Section 903.2, pg. 9-13)

P_m = 0.64 * (S/D)^{0.34} (Ref: Reese, Isenhower, & Wang - 2006)

D = **2.5** feet (shaft diameter or pile flange width)

Assumed Shaft Spacing = **6** feet (center-to-center pile spacing)

P_m = **0.86** For retaining wall, applies from top of wall to top of rock/bottom of drilled shafts

For a row of drilled shafts, applies below shear plane to top of rock/bottom of drilled shafts

Reduce p-multiplier? **NO** For application above shear plane if using a row of spaced drilled shafts instead of a retaining wall

6) Determine Lateral Thrust

Conventional Earth Pressure Theory

Exposed Wall Height (H) = **10** feet

Wall Height (H) + G_{SA} = **10.0**

P = 1/2 * G_H * H²

P = **3276** lbs/foot

P_{SH} = P * (Shaft Spacing) (earth loading)

P_{SH} = **19659** lbs/shaft

7) Resolve horizontal earth force to distributed triangular load (for LPILE)

w = 2 * P_{SH} / H

w = **3932** lbs/foot per shaft (Earth - Service Limit)

w = **328** lbs/inch per shaft (Earth - Service Limit)

γ_E = **1.5** Earth Load Factor

w = (2 * P_{SH} / H) * γ_E

w = **491** lbs/inch per shaft (Earth - Strength Limit)

8) Determine live-load traffic surcharge force (P_s)

Include traffic surcharge? **YES**

Surcharge Pressure (q_s) = **250** psf

P_s = K_a * q_s * H

P_s = **1260** lbs/foot

(surcharge resolved to distributed load)

P_s = **7561** lbs/shaft

9) Resolve surcharge to distributed rectangular load (for LPILE)

w = P_s / H

w = **756** lbs/foot per shaft (surcharge - unfactored)

w = **63** lbs/inch per shaft (surcharge - unfactored)

γ_S = **1.75** Surcharge Load Factor - Strength I

w = (P_s / L) * γ_S

w = **110** lbs/inch per shaft (Surcharge - Strength I)

Distributed Lateral Loads for LPILE

CONVENTIONAL		
Depth (ft.)	Service (lb/in)	Strength-I (lb/in)
0	63	110
10.0	391	602

Steel Beam and Cross-Section Properties

Assumed Pile Shape **HP 14x89**

Pile Availability

AISC Member Producers	3
Non-Member Producers	0

Shaft Geometry

Shaft Diameter	30 in
Longest Beam Dimension	20.162589 in
Clear Distance	4.9187054 in

Steel Beam Geometry

Beam Depth (D)	13.8 in
Web Thickness (t _w)	0.615 in
Flange Width (B _f)	14.7 in
Flange Thickness (t _f)	0.615 in
Area of Steel (A _s)	26.1 in ²

Steel Properties

Yield Strength of Steel	50 ksi
Moment of Inertia (I _{xx}) of Steel	904 in ⁴
Modulus of Elasticity of Steel (E)	29000 ksi
Modulus of Elasticity of Steel (E)	29000000 psi
EI (Steel Only)	2.622E+10 lb*in ²
Section Modulus (S _x)	131 in ³
Section Modulus (Z _x)	146 in ³
Shear-Buckling Coefficient (k)	5
Ratio of Shear-Buckling Resistance (C)	1
D/t _w	22.439024
1.12VEk/F _{yw}	60.313846
1.40VEk/F _{yw}	75.392307

Determined by AASHTO LRFD Bridge Specifications
Eqn's 6.10.9.3.2-4, 6.10.9.3.2-5, and 6.10.9.3.2-6

Shear Capacity Calculation

$$V_u \leq \phi V_{cr}$$
$$\phi_b = \boxed{1} \text{ AASHTO LRFD Bridge Design Spec's 6.5.4.2}$$
$$V_u = \text{shear in web due to factored permanent and construction loads applied to noncompact section (kips)}$$
$$V_{cr} = \text{shear buckling resistance determined from Equation 6.10.9.3.3-1 (AASHTO LRFD Bridge Design Spec's)}$$
$$V_n = V_{cr} = C V_p$$
$$V_p = 0.58 F_{yw} D t_w$$
$$V_p = \text{plastic shear force (kips)}$$
$$C = \text{ratio of shear-buckling resistance to shear yield strength determined by AASHTO Eqn's 6.10.9.3.2-4, 6.10.9.3.2-5, 6.10.9.3.2-5, or 6.10.9.3.2-6}$$
$$V_p = 0.58 * 50 * 13.8 * 0.615$$
$$V_p = \boxed{246.1} \text{ kips}$$
$$\phi V_{cr} = \phi * C * V_p$$
$$\phi V_{cr} = 1 * 1 * 246.1$$
$$\phi V_{cr} = \boxed{246.1} \text{ kips}$$
$$V_u = \boxed{49.244} \text{ kips (from LPILE)}$$
$$\boxed{} \text{ kips (from PYWALL)}$$
$$V_u < \phi V_{cr} \quad \text{OK}$$

Flexure Capacity Calculation

$$M_u \leq \phi M_n$$
$$\phi_b = \boxed{1} \text{ AASHTO LRFD Bridge Design Spec's 6.5.4.2}$$
$$M_u = \text{Moment due to the factored loads}$$
$$M_n = \text{Nominal flexural resistance of a section}$$
$$S_x = \text{Elastic section modulus about the x-axis}$$
$$\phi M_n = \phi * F_y * S_x$$
$$\phi M_n = 1 * 50 * 131$$
$$\phi M_n = \boxed{6550} \text{ in*kips}$$
$$M_u = \boxed{3653.9} \text{ in*kips (from LPILE)}$$
$$M_u = \boxed{} \text{ in*kips (from PYWALL)}$$
$$M_u < \phi M_n \quad \text{OK}$$

Deflection Criteria

Pile Length Above Rock = 40.8 ft	Exposed Wall Height = 10 ft
Pile Length Above Rock = 40.8 in	Exposed Wall Height = 120 in

1.)

Per the ODOT GDM, pile-head deflection in the service limit state limited to 1% or less of the shaft length above bedrock, or 1% of total drilled shaft length if not embedded in bedrock.

2.)

Following industry acceptance criteria, limit wall deflection to 1% of exposed wall height where ODOT landslide criteria does not govern. Alternatively, limit wall deflection to 1.5% of the exposed wall height in accordance with NCDOT guidelines. Use 1.5% wall deflection for PYWALL software.

ODOT Landslide Criteria Governs

NO

OK

1% Wall Height OR 2 inches- LPILE

2 in

$\delta = \boxed{1.81}$ in (from LPILE)

1.5% Wall Height - PYWALL

1.8 in

$\delta = \boxed{}$ in (from PYWALL)

Drilled Shafts Located Within 10 feet of Edge of Pavement

NO



Service Limit Analysis (Soldier Pile and Lagging Wall without Tiebacks)

=====

LPIle for Windows, Version 2019-11.002

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

Path to file locations:
\pwworking\east01\d3524061\

Name of input data file:
WAS-77-9.58 10' Wall Service Case.lp11

Name of output report file:
WAS-77-9.58 10' Wall Service Case.lp11

Name of plot output file:
WAS-77-9.58 10' Wall Service Case.lp11

Name of runtime message file:

WAS-77-9.58 10' Wall Service Case.lp11

Date and Time of Analysis

Date: November 3, 2023

Time: 14:44:17

Problem Title

Project Name: WAS-77-9.58

Job Number:

Client: ODOT D10

Engineer: HDR

Description: 10' Wall Service Case

Program Options and Settings

Computational Options:

- Conventional Analysis

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

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

Loading Type and Number of Cycles of Loading:

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

Output Options:

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

Pile Structural Properties and Geometry

- | | | |
|---|---|------------|
| Number of pile sections defined | = | 1 |
| Total length of pile | = | 35.000 ft |
| Depth of ground surface below top of pile | = | 10.0000 ft |

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

p-y curves are computed using pile diameter values interpolated with depth over

the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
-----	-----	-----
1	0.000	30.0000
2	35.000	30.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile	
Cross-sectional Shape	= Circular Pile
Length of section	= 35.000000 ft
Width of top of section	= 30.000000 in
Width of bottom of section	= 30.000000 in
Top Area	= 26.100000 sq. in
Bottom Area	= 26.100000 sq. in
Moment of Inertia at Top	= 904.000000 in^4
Moment of Inertia at Bottom	= 904.000000 in^4
Elastic Modulus	= 29000000. psi

Ground Slope and Pile Batter Angles

Ground Slope Angle	= 0.000 degrees
	= 0.000 radians
Pile Batter Angle	= 0.000 degrees
	= 0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 8 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer	=	10.000000 ft
Distance from top of pile to bottom of layer	=	15.800000 ft
Effective unit weight at top of layer	=	77.600000 pcf
Effective unit weight at bottom of layer	=	77.600000 pcf
Undrained cohesion at top of layer	=	1500. psf
Undrained cohesion at bottom of layer	=	1500. psf
Epsilon-50 at top of layer	=	0.007000
Epsilon-50 at bottom of layer	=	0.007000

Layer 2 is stiff clay without free water

Distance from top of pile to top of layer	=	15.800000 ft
Distance from top of pile to bottom of layer	=	35.800000 ft
Effective unit weight at top of layer	=	72.600000 pcf
Effective unit weight at bottom of layer	=	72.600000 pcf
Undrained cohesion at top of layer	=	3000. psf
Undrained cohesion at bottom of layer	=	3000. psf
Epsilon-50 at top of layer	=	0.005000
Epsilon-50 at bottom of layer	=	0.005000

Layer 3 is stiff clay without free water

Distance from top of pile to top of layer	=	35.800000 ft
Distance from top of pile to bottom of layer	=	40.800000 ft
Effective unit weight at top of layer	=	82.600000 pcf
Effective unit weight at bottom of layer	=	82.600000 pcf
Undrained cohesion at top of layer	=	4000. psf
Undrained cohesion at bottom of layer	=	4000. psf
Epsilon-50 at top of layer	=	0.005000
Epsilon-50 at bottom of layer	=	0.005000

Layer 4 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	40.800000	ft
Distance from top of pile to bottom of layer	=	43.700000	ft
Effective unit weight at top of layer	=	150.000000	pcf
Effective unit weight at bottom of layer	=	150.000000	pcf
Uniaxial compressive strength at top of layer	=	330.000000	psi
Uniaxial compressive strength at bottom of layer	=	330.000000	psi
Initial modulus of rock at top of layer	=	37400.	psi
Initial modulus of rock at bottom of layer	=	37400.	psi
RQD of rock at top of layer	=	64.000000	%
RQD of rock at bottom of layer	=	64.000000	%
k _{rm} of rock at top of layer	=	0.0005000	
k _{rm} of rock at bottom of layer	=	0.0005000	

Layer 5 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	43.700000	ft
Distance from top of pile to bottom of layer	=	50.200000	ft
Effective unit weight at top of layer	=	160.000000	pcf
Effective unit weight at bottom of layer	=	160.000000	pcf
Uniaxial compressive strength at top of layer	=	1150.	psi
Uniaxial compressive strength at bottom of layer	=	1150.	psi
Initial modulus of rock at top of layer	=	179800.	psi
Initial modulus of rock at bottom of layer	=	179800.	psi
RQD of rock at top of layer	=	100.000000	%
RQD of rock at bottom of layer	=	100.000000	%
k _{rm} of rock at top of layer	=	0.0005000	
k _{rm} of rock at bottom of layer	=	0.0005000	

Layer 6 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	50.200000	ft
Distance from top of pile to bottom of layer	=	52.900000	ft
Effective unit weight at top of layer	=	160.000000	pcf
Effective unit weight at bottom of layer	=	160.000000	pcf
Uniaxial compressive strength at top of layer	=	1150.	psi
Uniaxial compressive strength at bottom of layer	=	1150.	psi
Initial modulus of rock at top of layer	=	179800.	psi
Initial modulus of rock at bottom of layer	=	179800.	psi
RQD of rock at top of layer	=	91.000000	%
RQD of rock at bottom of layer	=	91.000000	%

k _{rm} of rock at top of layer	=	0.0005000
k _{rm} of rock at bottom of layer	=	0.0005000

Layer 7 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	52.900000 ft
Distance from top of pile to bottom of layer	=	55.300000 ft
Effective unit weight at top of layer	=	150.000000 pcf
Effective unit weight at bottom of layer	=	150.000000 pcf
Uniaxial compressive strength at top of layer	=	330.000000 psi
Uniaxial compressive strength at bottom of layer	=	330.000000 psi
Initial modulus of rock at top of layer	=	37400. psi
Initial modulus of rock at bottom of layer	=	37400. psi
RQD of rock at top of layer	=	17.000000 %
RQD of rock at bottom of layer	=	17.000000 %
k _{rm} of rock at top of layer	=	0.0005000
k _{rm} of rock at bottom of layer	=	0.0005000

Layer 8 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	55.300000 ft
Distance from top of pile to bottom of layer	=	95.000000 ft
Effective unit weight at top of layer	=	150.000000 pcf
Effective unit weight at bottom of layer	=	150.000000 pcf
Uniaxial compressive strength at top of layer	=	330.000000 psi
Uniaxial compressive strength at bottom of layer	=	330.000000 psi
Initial modulus of rock at top of layer	=	37400. psi
Initial modulus of rock at bottom of layer	=	37400. psi
RQD of rock at top of layer	=	86.000000 %
RQD of rock at bottom of layer	=	86.000000 %
k _{rm} of rock at top of layer	=	0.0005000
k _{rm} of rock at bottom of layer	=	0.0005000

(Depth of the lowest soil layer extends 60.000 ft below the pile tip)

**** Warning - Possible Input Data Error ****

Values entered for effective unit weight of rock were outside the limits of

50 pcf to 150 pcf.

The maximum input value, in layer 8, for effective unit weight = 160.00 pcf

This data may be erroneous. Please check your data.

Summary of Input Soil Properties								
Layer	Soil Type	Layer	Effective	Undrained	Uniaxial		E50	Rock Mass
Layer	Name	Depth	Unit Wt.	Cohesion	qu	RQD %	or	Modulus
Num.	(p-y Curve Type)	ft	pcf	psf	psi		krm	psi
1	Stiff Clay	10.0000	77.6000	1500.	--	--	0.00700	--
	w/o Free Water	15.8000	77.6000	1500.	--	--	0.00700	--
2	Stiff Clay	15.8000	72.6000	3000.	--	--	0.00500	--
	w/o Free Water	35.8000	72.6000	3000.	--	--	0.00500	--
3	Stiff Clay	35.8000	82.6000	4000.	--	--	0.00500	--
	w/o Free Water	40.8000	82.6000	4000.	--	--	0.00500	--
4	Weak	40.8000	150.0000	--	330.0000	64.0000	5.00E-04	37400.
	Rock	43.7000	150.0000	--	330.0000	64.0000	5.00E-04	37400.
5	Weak	43.7000	160.0000	--	1150.	100.0000	5.00E-04	179800.
	Rock	50.2000	160.0000	--	1150.	100.0000	5.00E-04	179800.
6	Weak	50.2000	160.0000	--	1150.	91.0000	5.00E-04	179800.

	Rock	52.9000	160.0000	--	1150.	91.0000	5.00E-04	179800.
7	Weak	52.9000	150.0000	--	330.0000	17.0000	5.00E-04	37400.
	Rock	55.3000	150.0000	--	330.0000	17.0000	5.00E-04	37400.
8	Weak	55.3000	150.0000	--	330.0000	86.0000	5.00E-04	37400.
	Rock	95.0000	150.0000	--	330.0000	86.0000	5.00E-04	37400.

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	10.000	0.8600	1.0000
2	40.800	0.8600	1.0000

Static Loading Type

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

Distributed Lateral Loading Used For All Load Cases

Distributed lateral load intensity defined using 2 points

Point	Depth X	Dist. Load
-------	---------	------------

No.	in	lb/in
1	0.000	63.000
2	120.000	391.000

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000	Yes	Yes

V = shear force applied normal to pile axis

M = bending moment applied to pile head

y = lateral deflection normal to pile axis

S = pile slope relative to original pile batter angle

R = rotational stiffness applied to pile head

Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).

Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

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

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	10.0000	0.00	N.A.	No	0.00	81279.
2	15.8000	3.2217	Yes	No	81279.	846627.
3	35.8000	25.8000	No	No	927906.	0.00
4	40.8000	30.8000	No	Yes	N.A.	N.A.
5	43.7000	33.7000	No	Yes	N.A.	N.A.
6	50.2000	40.2000	No	Yes	N.A.	N.A.
7	52.9000	42.9000	No	Yes	N.A.	N.A.
8	55.3000	45.3000	No	Yes	N.A.	N.A.

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

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

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

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

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

X feet	y inches	Moment in-lbs	Force lbs	S radians	Stress psi*	Stiffness in-lb^2	p lb/inch	Es*h lb/inch	Lat. Load lb/inch
0.00	1.8061	1.06E-05	0.00	-0.01056	1.75E-07	2.62E+10	0.00	0.00	65.8700
0.3500	1.7618	580.9734	294.7350	-0.01056	9.6400	2.62E+10	0.00	0.00	74.4800
0.7000	1.7174	2476.	631.6590	-0.01056	41.0803	2.62E+10	0.00	0.00	85.9600
1.0500	1.6731	5887.	1017.	-0.01056	97.6810	2.62E+10	0.00	0.00	97.4400
1.4000	1.6288	11017.	1450.	-0.01056	182.8023	2.62E+10	0.00	0.00	108.9200
1.7500	1.5844	18068.	1932.	-0.01055	299.8044	2.62E+10	0.00	0.00	120.4000
2.1000	1.5401	27243.	2462.	-0.01055	452.0474	2.62E+10	0.00	0.00	131.8800
2.4500	1.4958	38745.	3040.	-0.01054	642.8917	2.62E+10	0.00	0.00	143.3600
2.8000	1.4515	52775.	3666.	-0.01054	875.6972	2.62E+10	0.00	0.00	154.8400
3.1500	1.4073	69537.	4340.	-0.01053	1154.	2.62E+10	0.00	0.00	166.3200
3.5000	1.3631	89233.	5063.	-0.01051	1481.	2.62E+10	0.00	0.00	177.8000
3.8500	1.3190	112065.	5834.	-0.01050	1859.	2.62E+10	0.00	0.00	189.2800
4.2000	1.2749	138236.	6653.	-0.01048	2294.	2.62E+10	0.00	0.00	200.7600
4.5500	1.2310	167948.	7520.	-0.01045	2787.	2.62E+10	0.00	0.00	212.2400
4.9000	1.1871	201405.	8436.	-0.01042	3342.	2.62E+10	0.00	0.00	223.7200
5.2500	1.1434	238807.	9399.	-0.01039	3963.	2.62E+10	0.00	0.00	235.2000
5.6000	1.0999	280359.	10411.	-0.01035	4652.	2.62E+10	0.00	0.00	246.6800
5.9500	1.0565	326262.	11471.	-0.01030	5414.	2.62E+10	0.00	0.00	258.1600
6.3000	1.0133	376719.	12580.	-0.01024	6251.	2.62E+10	0.00	0.00	269.6400
6.6500	0.9705	431932.	13736.	-0.01018	7167.	2.62E+10	0.00	0.00	281.1200
7.0000	0.9279	492105.	14941.	-0.01010	8165.	2.62E+10	0.00	0.00	292.6000
7.3500	0.8856	557439.	16194.	-0.01002	9250.	2.62E+10	0.00	0.00	304.0800
7.7000	0.8437	628137.	17495.	-0.00992	10423.	2.62E+10	0.00	0.00	315.5600
8.0500	0.8022	704401.	18845.	-0.00982	11688.	2.62E+10	0.00	0.00	327.0400
8.4000	0.7612	786434.	20243.	-0.00970	13049.	2.62E+10	0.00	0.00	338.5200
8.7500	0.7208	874439.	21689.	-0.00957	14509.	2.62E+10	0.00	0.00	350.0000
9.1000	0.6809	968618.	23183.	-0.00942	16072.	2.62E+10	0.00	0.00	361.4800
9.4500	0.6416	1069173.	24725.	-0.00925	17741.	2.62E+10	0.00	0.00	372.9600
9.8000	0.6031	1176308.	26315.	-0.00907	19518.	2.62E+10	0.00	0.00	384.4400
10.1500	0.5654	1290223.	26308.	-0.00888	21409.	2.62E+10	-415.8423	3089.	27.8993
10.5000	0.5286	1397296.	24610.	-0.00866	23185.	2.62E+10	-420.7547	3343.	0.00
10.8500	0.4927	1496946.	22834.	-0.00843	24839.	2.62E+10	-425.0721	3624.	0.00
11.2000	0.4578	1589099.	21041.	-0.00818	26368.	2.62E+10	-428.7761	3934.	0.00
11.5500	0.4239	1673687.	19233.	-0.00792	27771.	2.62E+10	-431.8476	4278.	0.00
11.9000	0.3912	1750658.	17414.	-0.00765	29049.	2.62E+10	-434.2665	4662.	0.00
12.2500	0.3597	1819968.	15587.	-0.00736	30199.	2.62E+10	-436.0117	5091.	0.00
12.6000	0.3294	1881587.	13753.	-0.00706	31221.	2.62E+10	-437.0608	5573.	0.00
12.9500	0.3004	1935496.	11917.	-0.00676	32116.	2.62E+10	-437.3902	6116.	0.00
13.3000	0.2726	1981690.	10081.	-0.00644	32882.	2.62E+10	-436.9742	6732.	0.00

13.6500	0.2462	2020176.	8248.	-0.00612	33521.	2.62E+10	-435.7857	7433.	0.00
14.0000	0.2212	2050974.	6422.	-0.00580	34032.	2.62E+10	-433.7948	8237.	0.00
14.3500	0.1975	2074120.	4606.	-0.00547	34416.	2.62E+10	-430.9693	9164.	0.00
14.7000	0.1753	2089664.	2804.	-0.00513	34674.	2.62E+10	-427.2735	10240.	0.00
15.0500	0.1544	2097671.	1019.	-0.00480	34806.	2.62E+10	-422.6680	11498.	0.00
15.4000	0.1349	2098221.	-744.7761	-0.00446	34816.	2.62E+10	-417.1088	12982.	0.00
15.7500	0.1169	2091414.	-2483.	-0.00413	34703.	2.62E+10	-410.5465	14749.	0.00
16.1000	0.1003	2077365.	-4885.	-0.00379	34470.	2.62E+10	-733.4683	30720.	0.00
16.4500	0.08505	2050378.	-7934.	-0.00346	34022.	2.62E+10	-718.4692	35481.	0.00
16.8000	0.07120	2010717.	-10916.	-0.00314	33364.	2.62E+10	-701.1944	41365.	0.00
17.1500	0.05870	1958687.	-13819.	-0.00282	32500.	2.62E+10	-681.4546	48762.	0.00
17.5000	0.04751	1894636.	-16634.	-0.00251	31438.	2.62E+10	-658.9985	58251.	0.00
17.8500	0.03761	1818960.	-19348.	-0.00221	30182.	2.62E+10	-633.4776	70745.	0.00
18.2000	0.02893	1732109.	-21948.	-0.00193	28741.	2.62E+10	-604.3822	87756.	0.00
18.5500	0.02141	1634598.	-24416.	-0.00166	27123.	2.62E+10	-570.9159	112004.	0.00
18.9000	0.01499	1527015.	-26732.	-0.00141	25338.	2.62E+10	-531.7182	148966.	0.00
19.2500	0.00960	1410053.	-28865.	-0.00117	23397.	2.62E+10	-484.1457	211774.	0.00
19.6000	0.00516	1284550.	-30767.	-9.54E-04	21314.	2.62E+10	-421.8258	343289.	0.00
19.9500	0.00158	1151607.	-32324.	-7.59E-04	19109.	2.62E+10	-319.5534	847142.	0.00
20.3000	-0.00122	1013026.	-32358.	-5.86E-04	16809.	2.62E+10	303.6595	1047625.	0.00
20.6500	-0.00334	879803.	-30885.	-4.34E-04	14598.	2.62E+10	397.4828	500211.	0.00
21.0000	-0.00487	753590.	-29118.	-3.03E-04	12504.	2.62E+10	443.9422	383220.	0.00
21.3500	-0.00589	635209.	-27192.	-1.92E-04	10540.	2.62E+10	473.0900	337549.	0.00
21.7000	-0.00648	525173.	-25165.	-9.93E-05	8714.	2.62E+10	492.2551	319051.	0.00
22.0500	-0.00672	423821.	-23072.	-2.32E-05	7032.	2.62E+10	504.4843	315290.	0.00
22.4000	-0.00668	331368.	-20939.	3.73E-05	5498.	2.62E+10	511.3515	321735.	0.00
22.7500	-0.00641	247935.	-18786.	8.37E-05	4114.	2.62E+10	513.7737	336777.	0.00
23.1000	-0.00597	173564.	-16631.	1.17E-04	2880.	2.62E+10	512.3255	360274.	0.00
23.4500	-0.00542	108232.	-14490.	1.40E-04	1796.	2.62E+10	507.3819	393100.	0.00
23.8000	-0.00480	51849.	-12376.	1.53E-04	860.3302	2.62E+10	499.1912	437099.	0.00
24.1500	-0.00414	4272.	-10303.	1.57E-04	70.8929	2.62E+10	487.9139	495301.	0.00
24.5000	-0.00348	-34697.	-8284.	1.55E-04	575.7324	2.62E+10	473.6432	572426.	0.00
24.8500	-0.00284	-65312.	-6331.	1.47E-04	1084.	2.62E+10	456.4133	675831.	0.00
25.2000	-0.00224	-87876.	-4456.	1.35E-04	1458.	2.62E+10	436.1964	817300.	0.00
25.5500	-0.00171	-102745.	-2673.	1.19E-04	1705.	2.62E+10	412.8840	1016578.	0.00
25.9000	-0.00124	-110331.	-995.0851	1.02E-04	1831.	2.62E+10	386.2381	1309023.	0.00
26.2500	-8.47E-04	-111104.	563.1316	8.45E-05	1844.	2.62E+10	355.7699	1764370.	0.00
26.6000	-5.29E-04	-105601.	1923.	6.72E-05	1752.	2.62E+10	291.6984	2314624.	0.00
26.9500	-2.83E-04	-94952.	2867.	5.11E-05	1576.	2.62E+10	157.8205	2344160.	0.00
27.3000	-1.00E-04	-81520.	3317.	3.70E-05	1353.	2.62E+10	56.5840	2373695.	0.00
27.6500	2.77E-05	-67089.	3403.	2.51E-05	1113.	2.62E+10	-15.8349	2403230.	0.00
28.0000	1.10E-04	-52938.	3235.	1.54E-05	878.3930	2.62E+10	-63.9033	2432765.	0.00

28.3500	1.57E-04	-39914.	2907.	8.00E-06	662.2849	2.62E+10	-92.2513	2462299.	0.00
28.7000	1.78E-04	-28517.	2492.	2.52E-06	473.1787	2.62E+10	-105.3266	2491833.	0.00
29.0500	1.79E-04	-18978.	2046.	-1.29E-06	314.9015	2.62E+10	-107.1665	2521367.	0.00
29.4000	1.67E-04	-11330.	1608.	-3.71E-06	187.9919	2.62E+10	-101.2645	2550900.	0.00
29.7500	1.47E-04	-5468.	1206.	-5.06E-06	90.7222	2.62E+10	-90.5129	2580433.	0.00
30.1000	1.24E-04	-1202.	853.4632	-5.59E-06	19.9456	2.62E+10	-77.2022	2609965.	0.00
30.4500	1.00E-04	1702.	558.9154	-5.55E-06	28.2339	2.62E+10	-63.0586	2639498.	0.00
30.8000	7.76E-05	3493.	322.9488	-5.14E-06	57.9563	2.62E+10	-49.3065	2669030.	0.00
31.1500	5.72E-05	4414.	142.2418	-4.50E-06	73.2467	2.62E+10	-36.7445	2698562.	0.00
31.5000	3.98E-05	4688.	10.8460	-3.77E-06	77.7820	2.62E+10	-25.8249	2728093.	0.00
31.8500	2.55E-05	4505.	-78.5219	-3.04E-06	74.7584	2.62E+10	-16.7312	2757624.	0.00
32.2000	1.42E-05	4028.	-133.4994	-2.35E-06	66.8376	2.62E+10	-9.4486	2787156.	0.00
32.5500	5.70E-06	3384.	-161.3748	-1.76E-06	56.1512	2.62E+10	-3.8254	2816686.	0.00
32.9000	-5.53E-07	2673.	-168.6216	-1.28E-06	44.3451	2.62E+10	0.3746	2846217.	0.00
33.2500	-5.01E-06	1968.	-160.6292	-9.04E-07	32.6486	2.62E+10	3.4313	2875748.	0.00
33.6000	-8.15E-06	1323.	-141.5900	-6.40E-07	21.9565	2.62E+10	5.6349	2905278.	0.00
33.9500	-1.04E-05	778.2693	-114.5096	-4.72E-07	12.9138	2.62E+10	7.2605	2934808.	0.00
34.3000	-1.21E-05	361.3666	-81.3118	-3.81E-07	5.9961	2.62E+10	8.5480	2964338.	0.00
34.6500	-1.36E-05	95.2500	-43.0198	-3.44E-07	1.5805	2.62E+10	9.6863	2993868.	0.00
35.0000	-1.50E-05	0.00	0.00	-3.37E-07	0.00	2.62E+10	10.7993	1511699.	0.00

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 1:

Pile-head deflection	=	1.80611074 inches
Computed slope at pile head	=	-0.01055763 radians
Maximum bending moment	=	2098221. inch-lbs
Maximum shear force	=	-32358. lbs
Depth of maximum bending moment	=	15.40000000 feet below pile head
Depth of maximum shear force	=	20.30000000 feet below pile head
Number of iterations	=	31
Number of zero deflection points	=	3

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

Boundary Condition Type 1, Shear and Moment

Shear = 0. lbs
 Moment = 0. in-lbs
 Axial Load = 0. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
35.00000	1.80611074	2098221.	-32358.
33.25000	1.84711888	2143500.	-32969.
31.50000	1.78933239	2084535.	-32301.
29.75000	1.80303531	2096040.	-32447.
28.00000	1.79124220	2089745.	-32251.
26.25000	1.84428685	2132418.	-32397.
24.50000	1.84464026	2072002.	-33771.
22.75000	2.46248473	1975038.	-37827.
21.00000	5.53882533	1843920.	-40690.
19.25000	17.25507552	1681985.	-41113.

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

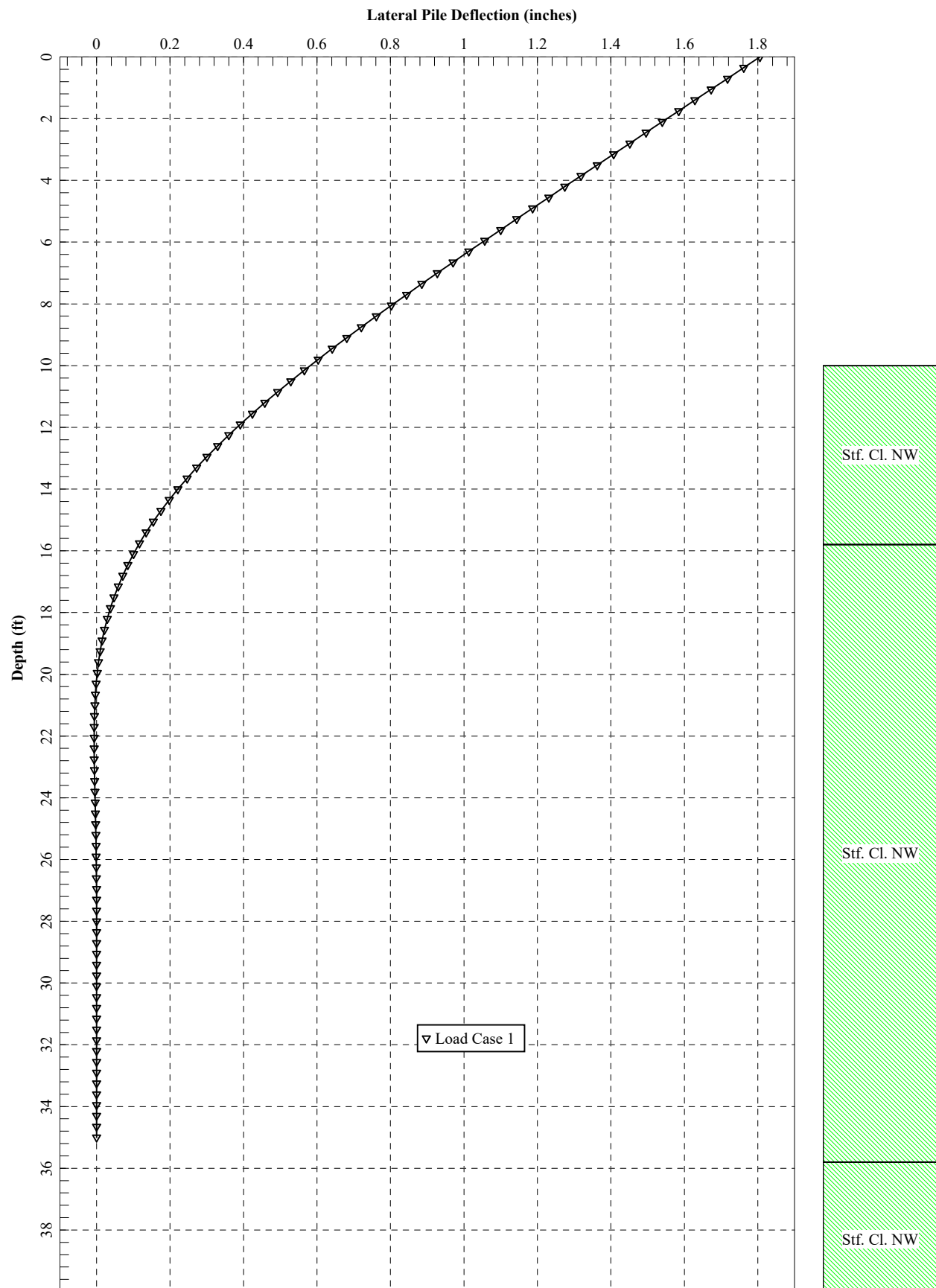
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
 Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
 Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
 Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
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

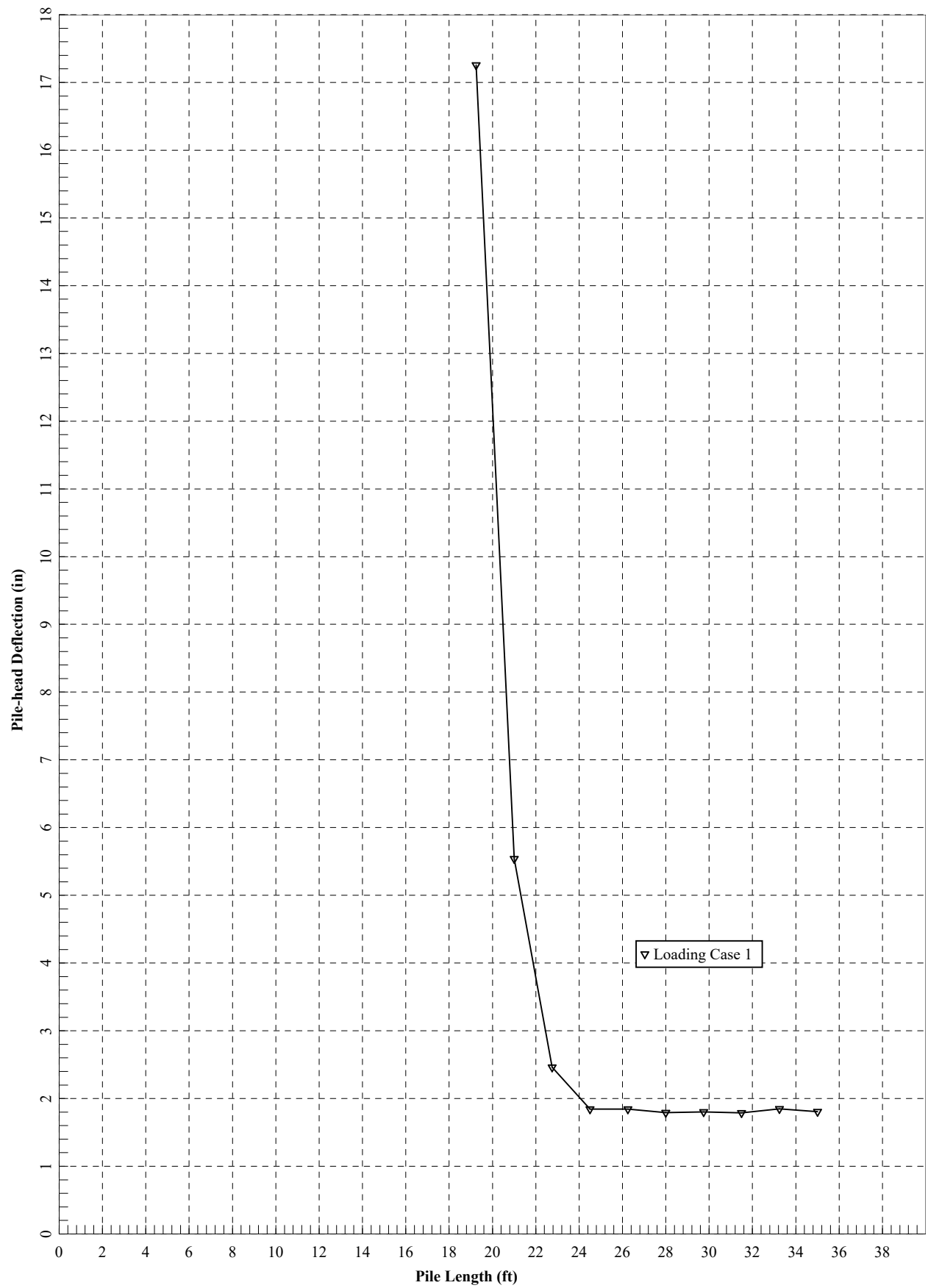
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	0.00	M, in-lb	0.00	0.00	1.8061	-0.01056	-32358.	2098221.

Maximum pile-head deflection = 1.8061107391 inches

Maximum pile-head rotation = -0.0105576257 radians = -0.604907 deg.

The analysis ended normally.







Strength Limit Analysis (Soldier Pile and Lagging Wall without Tiebacks)

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LPIle for Windows, Version 2019-11.002

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

Path to file locations:
\pwworking\east01\d3524061\

Name of input data file:
WAS-77-9.58 10' Wall Strength Case.lp11

Name of output report file:
WAS-77-9.58 10' Wall Strength Case.lp11

Name of plot output file:
WAS-77-9.58 10' Wall Strength Case.lp11

Name of runtime message file:

WAS-77-9.58 10' Wall Strength Case.lp11

Date and Time of Analysis

Date: November 3, 2023

Time: 14:45:43

Problem Title

Project Name: WAS-77-9.58

Job Number:

Client: ODOT D10

Engineer: HDR

Description: 10' Wall Strength Case

Program Options and Settings

Computational Options:

- Conventional Analysis

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

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

Loading Type and Number of Cycles of Loading:

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

Output Options:

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

Pile Structural Properties and Geometry

- | | | |
|---|---|------------|
| Number of pile sections defined | = | 1 |
| Total length of pile | = | 35.000 ft |
| Depth of ground surface below top of pile | = | 10.0000 ft |

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

p-y curves are computed using pile diameter values interpolated with depth over

the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
-----	-----	-----
1	0.000	30.0000
2	35.000	30.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile	
Cross-sectional Shape	= Circular Pile
Length of section	= 35.000000 ft
Width of top of section	= 30.000000 in
Width of bottom of section	= 30.000000 in
Top Area	= 26.100000 sq. in
Bottom Area	= 26.100000 sq. in
Moment of Inertia at Top	= 904.000000 in^4
Moment of Inertia at Bottom	= 904.000000 in^4
Elastic Modulus	= 29000000. psi

Ground Slope and Pile Batter Angles

Ground Slope Angle	= 0.000 degrees
	= 0.000 radians
Pile Batter Angle	= 0.000 degrees
	= 0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 8 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer	=	10.000000 ft
Distance from top of pile to bottom of layer	=	15.800000 ft
Effective unit weight at top of layer	=	77.600000 pcf
Effective unit weight at bottom of layer	=	77.600000 pcf
Undrained cohesion at top of layer	=	1500. psf
Undrained cohesion at bottom of layer	=	1500. psf
Epsilon-50 at top of layer	=	0.007000
Epsilon-50 at bottom of layer	=	0.007000

Layer 2 is stiff clay without free water

Distance from top of pile to top of layer	=	15.800000 ft
Distance from top of pile to bottom of layer	=	35.800000 ft
Effective unit weight at top of layer	=	72.600000 pcf
Effective unit weight at bottom of layer	=	72.600000 pcf
Undrained cohesion at top of layer	=	3000. psf
Undrained cohesion at bottom of layer	=	3000. psf
Epsilon-50 at top of layer	=	0.005000
Epsilon-50 at bottom of layer	=	0.005000

Layer 3 is stiff clay without free water

Distance from top of pile to top of layer	=	35.800000 ft
Distance from top of pile to bottom of layer	=	40.800000 ft
Effective unit weight at top of layer	=	82.600000 pcf
Effective unit weight at bottom of layer	=	82.600000 pcf
Undrained cohesion at top of layer	=	4000. psf
Undrained cohesion at bottom of layer	=	4000. psf
Epsilon-50 at top of layer	=	0.005000
Epsilon-50 at bottom of layer	=	0.005000

Layer 4 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	40.800000	ft
Distance from top of pile to bottom of layer	=	43.700000	ft
Effective unit weight at top of layer	=	150.000000	pcf
Effective unit weight at bottom of layer	=	150.000000	pcf
Uniaxial compressive strength at top of layer	=	330.000000	psi
Uniaxial compressive strength at bottom of layer	=	330.000000	psi
Initial modulus of rock at top of layer	=	37400.	psi
Initial modulus of rock at bottom of layer	=	37400.	psi
RQD of rock at top of layer	=	64.000000	%
RQD of rock at bottom of layer	=	64.000000	%
k _{rm} of rock at top of layer	=	0.0005000	
k _{rm} of rock at bottom of layer	=	0.0005000	

Layer 5 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	43.700000	ft
Distance from top of pile to bottom of layer	=	50.200000	ft
Effective unit weight at top of layer	=	160.000000	pcf
Effective unit weight at bottom of layer	=	160.000000	pcf
Uniaxial compressive strength at top of layer	=	1150.	psi
Uniaxial compressive strength at bottom of layer	=	1150.	psi
Initial modulus of rock at top of layer	=	179800.	psi
Initial modulus of rock at bottom of layer	=	179800.	psi
RQD of rock at top of layer	=	100.000000	%
RQD of rock at bottom of layer	=	100.000000	%
k _{rm} of rock at top of layer	=	0.0005000	
k _{rm} of rock at bottom of layer	=	0.0005000	

Layer 6 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	50.200000	ft
Distance from top of pile to bottom of layer	=	52.900000	ft
Effective unit weight at top of layer	=	160.000000	pcf
Effective unit weight at bottom of layer	=	160.000000	pcf
Uniaxial compressive strength at top of layer	=	1150.	psi
Uniaxial compressive strength at bottom of layer	=	1150.	psi
Initial modulus of rock at top of layer	=	179800.	psi
Initial modulus of rock at bottom of layer	=	179800.	psi
RQD of rock at top of layer	=	91.000000	%
RQD of rock at bottom of layer	=	91.000000	%

k _{rm} of rock at top of layer	=	0.0005000
k _{rm} of rock at bottom of layer	=	0.0005000

Layer 7 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	52.900000 ft
Distance from top of pile to bottom of layer	=	55.300000 ft
Effective unit weight at top of layer	=	150.000000 pcf
Effective unit weight at bottom of layer	=	150.000000 pcf
Uniaxial compressive strength at top of layer	=	330.000000 psi
Uniaxial compressive strength at bottom of layer	=	330.000000 psi
Initial modulus of rock at top of layer	=	37400. psi
Initial modulus of rock at bottom of layer	=	37400. psi
RQD of rock at top of layer	=	17.000000 %
RQD of rock at bottom of layer	=	17.000000 %
k _{rm} of rock at top of layer	=	0.0005000
k _{rm} of rock at bottom of layer	=	0.0005000

Layer 8 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	55.300000 ft
Distance from top of pile to bottom of layer	=	95.000000 ft
Effective unit weight at top of layer	=	150.000000 pcf
Effective unit weight at bottom of layer	=	150.000000 pcf
Uniaxial compressive strength at top of layer	=	330.000000 psi
Uniaxial compressive strength at bottom of layer	=	330.000000 psi
Initial modulus of rock at top of layer	=	37400. psi
Initial modulus of rock at bottom of layer	=	37400. psi
RQD of rock at top of layer	=	86.000000 %
RQD of rock at bottom of layer	=	86.000000 %
k _{rm} of rock at top of layer	=	0.0005000
k _{rm} of rock at bottom of layer	=	0.0005000

(Depth of the lowest soil layer extends 60.000 ft below the pile tip)

**** Warning - Possible Input Data Error ****

Values entered for effective unit weight of rock were outside the limits of

50 pcf to 150 pcf.

The maximum input value, in layer 8, for effective unit weight = 160.00 pcf

This data may be erroneous. Please check your data.

Summary of Input Soil Properties								
Layer	Soil Type	Layer	Effective	Undrained	Uniaxial		E50	Rock Mass
Layer	Name	Depth	Unit Wt.	Cohesion	qu	RQD %	or	Modulus
Num.	(p-y Curve Type)	ft	pcf	psf	psi		krm	psi
1	Stiff Clay	10.0000	77.6000	1500.	--	--	0.00700	--
	w/o Free Water	15.8000	77.6000	1500.	--	--	0.00700	--
2	Stiff Clay	15.8000	72.6000	3000.	--	--	0.00500	--
	w/o Free Water	35.8000	72.6000	3000.	--	--	0.00500	--
3	Stiff Clay	35.8000	82.6000	4000.	--	--	0.00500	--
	w/o Free Water	40.8000	82.6000	4000.	--	--	0.00500	--
4	Weak	40.8000	150.0000	--	330.0000	64.0000	5.00E-04	37400.
	Rock	43.7000	150.0000	--	330.0000	64.0000	5.00E-04	37400.
5	Weak	43.7000	160.0000	--	1150.	100.0000	5.00E-04	179800.
	Rock	50.2000	160.0000	--	1150.	100.0000	5.00E-04	179800.
6	Weak	50.2000	160.0000	--	1150.	91.0000	5.00E-04	179800.

	Rock	52.9000	160.0000	--	1150.	91.0000	5.00E-04	179800.
7	Weak	52.9000	150.0000	--	330.0000	17.0000	5.00E-04	37400.
	Rock	55.3000	150.0000	--	330.0000	17.0000	5.00E-04	37400.
8	Weak	55.3000	150.0000	--	330.0000	86.0000	5.00E-04	37400.
	Rock	95.0000	150.0000	--	330.0000	86.0000	5.00E-04	37400.

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	10.000	0.8600	1.0000
2	40.800	0.8600	1.0000

Static Loading Type

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

Distributed Lateral Loading Used For All Load Cases

Distributed lateral load intensity defined using 2 points

Point	Depth X	Dist. Load
-------	---------	------------

No.	in	lb/in
1	0.000	110.000
2	120.000	602.000

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000	Yes	Yes

V = shear force applied normal to pile axis

M = bending moment applied to pile head

y = lateral deflection normal to pile axis

S = pile slope relative to original pile batter angle

R = rotational stiffness applied to pile head

Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).

Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

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

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	10.0000	0.00	N.A.	No	0.00	81279.
2	15.8000	3.2217	Yes	No	81279.	846627.
3	35.8000	25.8000	No	No	927906.	0.00
4	40.8000	30.8000	No	Yes	N.A.	N.A.
5	43.7000	33.7000	No	Yes	N.A.	N.A.
6	50.2000	40.2000	No	Yes	N.A.	N.A.
7	52.9000	42.9000	No	Yes	N.A.	N.A.
8	55.3000	45.3000	No	Yes	N.A.	N.A.

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

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

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

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth	Deflect.	Bending	Shear	Slope	Total	Bending	Soil Res.	Soil Spr.	Distrib.
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X feet	y inches	Moment in-lbs	Force lbs	S radians	Stress psi*	Stiffness in-lb^2	p lb/inch	Es*h lb/inch	Lat. Load lb/inch
0.00	3.6616	-7.92E-06	0.00	-0.02011	1.31E-07	2.62E+10	0.00	0.00	114.3050
0.3500	3.5771	1008.	507.2025	-0.02011	16.7285	2.62E+10	0.00	0.00	127.2200
0.7000	3.4927	4261.	1078.	-0.02011	70.6942	2.62E+10	0.00	0.00	144.4400
1.0500	3.4082	10061.	1720.	-0.02011	166.9373	2.62E+10	0.00	0.00	161.6600
1.4000	3.3238	18713.	2436.	-0.02011	310.4981	2.62E+10	0.00	0.00	178.8800
1.7500	3.2393	30520.	3223.	-0.02010	506.4170	2.62E+10	0.00	0.00	196.1000
2.1000	3.1549	45787.	4083.	-0.02010	759.7342	2.62E+10	0.00	0.00	213.3200
2.4500	3.0705	64816.	5015.	-0.02009	1075.	2.62E+10	0.00	0.00	230.5400
2.8000	2.9862	87912.	6019.	-0.02007	1459.	2.62E+10	0.00	0.00	247.7600
3.1500	2.9019	115379.	7096.	-0.02006	1914.	2.62E+10	0.00	0.00	264.9800
3.5000	2.8177	147520.	8245.	-0.02004	2448.	2.62E+10	0.00	0.00	282.2000
3.8500	2.7336	184639.	9467.	-0.02001	3064.	2.62E+10	0.00	0.00	299.4200
4.2000	2.6496	227040.	10760.	-0.01998	3767.	2.62E+10	0.00	0.00	316.6400
4.5500	2.5658	275026.	12126.	-0.01994	4563.	2.62E+10	0.00	0.00	333.8600
4.9000	2.4821	328902.	13565.	-0.01989	5457.	2.62E+10	0.00	0.00	351.0800
5.2500	2.3987	388971.	15075.	-0.01983	6454.	2.62E+10	0.00	0.00	368.3000
5.6000	2.3155	455536.	16659.	-0.01976	7559.	2.62E+10	0.00	0.00	385.5200
5.9500	2.2327	528902.	18314.	-0.01969	8776.	2.62E+10	0.00	0.00	402.7400
6.3000	2.1502	609372.	20042.	-0.01959	10111.	2.62E+10	0.00	0.00	419.9600
6.6500	2.0681	697251.	21842.	-0.01949	11569.	2.62E+10	0.00	0.00	437.1800
7.0000	1.9865	792841.	23714.	-0.01937	13156.	2.62E+10	0.00	0.00	454.4000
7.3500	1.9054	896447.	25658.	-0.01923	14875.	2.62E+10	0.00	0.00	471.6200
7.7000	1.8249	1008373.	27675.	-0.01908	16732.	2.62E+10	0.00	0.00	488.8400
8.0500	1.7451	1128921.	29765.	-0.01891	18732.	2.62E+10	0.00	0.00	506.0600
8.4000	1.6661	1258396.	31926.	-0.01872	20880.	2.62E+10	0.00	0.00	523.2800
8.7500	1.5879	1397102.	34160.	-0.01851	23182.	2.62E+10	0.00	0.00	540.5000
9.1000	1.5106	1545343.	36467.	-0.01827	25642.	2.62E+10	0.00	0.00	557.7200
9.4500	1.4344	1703421.	38845.	-0.01801	28265.	2.62E+10	0.00	0.00	574.9400
9.8000	1.3593	1871642.	41296.	-0.01772	31056.	2.62E+10	0.00	0.00	592.1600
10.1500	1.2855	2050308.	41557.	-0.01741	34021.	2.62E+10	-510.6232	1668.	42.9561
10.5000	1.2131	2220725.	39488.	-0.01707	36848.	2.62E+10	-517.8698	1793.	0.00
10.8500	1.1421	2382006.	37299.	-0.01670	39524.	2.62E+10	-524.5051	1929.	0.00
11.2000	1.0728	2534035.	35083.	-0.01631	42047.	2.62E+10	-530.5119	2077.	0.00
11.5500	1.0051	2676706.	32844.	-0.01589	44414.	2.62E+10	-535.8719	2239.	0.00
11.9000	0.9393	2809924.	30583.	-0.01545	46625.	2.62E+10	-540.5665	2417.	0.00
12.2500	0.8754	2933607.	28305.	-0.01499	48677.	2.62E+10	-544.5763	2613.	0.00
12.6000	0.8134	3047683.	26010.	-0.01451	50570.	2.62E+10	-547.8809	2829.	0.00
12.9500	0.7535	3152095.	23704.	-0.01401	52302.	2.62E+10	-550.4590	3068.	0.00
13.3000	0.6957	3246796.	21388.	-0.01350	53874.	2.62E+10	-552.2884	3334.	0.00

13.6500	0.6401	3331755.	19066.	-0.01297	55284.	2.62E+10	-553.3455	3631.	0.00
14.0000	0.5867	3406953.	16742.	-0.01243	56531.	2.62E+10	-553.6054	3963.	0.00
14.3500	0.5356	3472386.	14418.	-0.01188	57617.	2.62E+10	-553.0416	4336.	0.00
14.7000	0.4869	3528063.	12098.	-0.01132	58541.	2.62E+10	-551.6260	4758.	0.00
15.0500	0.4405	3574009.	9786.	-0.01075	59303.	2.62E+10	-549.3287	5237.	0.00
15.4000	0.3966	3610265.	7486.	-0.01018	59905.	2.62E+10	-546.1174	5784.	0.00
15.7500	0.3550	3636887.	5201.	-0.00960	60347.	2.62E+10	-541.9577	6411.	0.00
16.1000	0.3160	3653949.	2010.	-0.00901	60630.	2.62E+10	-977.1925	12990.	0.00
16.4500	0.2793	3653774.	-2073.	-0.00843	60627.	2.62E+10	-967.2005	14543.	0.00
16.8000	0.2452	3636537.	-6110.	-0.00784	60341.	2.62E+10	-955.1744	16363.	0.00
17.1500	0.2134	3602451.	-10092.	-0.00726	59775.	2.62E+10	-941.0163	18516.	0.00
17.5000	0.1842	3551766.	-14010.	-0.00669	58934.	2.62E+10	-924.6100	21088.	0.00
17.8500	0.1572	3484770.	-17854.	-0.00613	57823.	2.62E+10	-905.8144	24194.	0.00
18.2000	0.1327	3401796.	-21613.	-0.00558	56446.	2.62E+10	-884.4539	27997.	0.00
18.5500	0.1104	3303220.	-25277.	-0.00504	54810.	2.62E+10	-860.3035	32726.	0.00
18.9000	0.09036	3189468.	-28833.	-0.00452	52923.	2.62E+10	-833.0651	38721.	0.00
19.2500	0.07246	3061021.	-32268.	-0.00402	50791.	2.62E+10	-802.3276	46507.	0.00
19.6000	0.05661	2918421.	-35564.	-0.00354	48425.	2.62E+10	-767.4956	56939.	0.00
19.9500	0.04273	2762282.	-38704.	-0.00308	45834.	2.62E+10	-727.6541	71518.	0.00
20.3000	0.03071	2593308.	-41663.	-0.00265	43031.	2.62E+10	-681.2786	93171.	0.00
20.6500	0.02043	2412316.	-44407.	-0.00225	40027.	2.62E+10	-625.5212	128569.	0.00
21.0000	0.01178	2220289.	-46884.	-0.00188	36841.	2.62E+10	-553.9782	197503.	0.00
21.3500	0.00462	2018490.	-48983.	-0.00154	33493.	2.62E+10	-445.5355	404941.	0.00
21.7000	-0.00118	1808833.	-49244.	-0.00124	30014.	2.62E+10	321.2372	1143068.	0.00
22.0500	-0.00576	1604841.	-47550.	-9.63E-04	26629.	2.62E+10	485.4501	353692.	0.00
22.4000	-0.00927	1409413.	-45365.	-7.21E-04	23386.	2.62E+10	555.0723	251516.	0.00
22.7500	-0.01183	1223777.	-42942.	-5.11E-04	20306.	2.62E+10	598.8325	212692.	0.00
23.1000	-0.01356	1048704.	-40363.	-3.29E-04	17401.	2.62E+10	628.8691	194816.	0.00
23.4500	-0.01458	884724.	-37678.	-1.74E-04	14680.	2.62E+10	649.8317	187135.	0.00
23.8000	-0.01502	732207.	-34919.	-4.41E-05	12149.	2.62E+10	664.0310	185727.	0.00
24.1500	-0.01496	591404.	-32112.	6.19E-05	9813.	2.62E+10	672.7876	188944.	0.00
24.5000	-0.01450	462469.	-29277.	1.46E-04	7674.	2.62E+10	676.9232	196124.	0.00
24.8500	-0.01373	345474.	-26434.	2.11E-04	5732.	2.62E+10	676.9776	207145.	0.00
25.2000	-0.01272	240422.	-23599.	2.58E-04	3989.	2.62E+10	673.3176	222259.	0.00
25.5500	-0.01156	147247.	-20786.	2.89E-04	2443.	2.62E+10	666.1951	242060.	0.00
25.9000	-0.01030	65823.	-18009.	3.06E-04	1092.	2.62E+10	655.7811	267516.	0.00
26.2500	-0.00899	-4032.	-15284.	3.11E-04	66.9044	2.62E+10	642.1853	300086.	0.00
26.6000	-0.00768	-62559.	-12622.	3.06E-04	1038.	2.62E+10	625.4665	341920.	0.00
26.9500	-0.00642	-110054.	-10036.	2.92E-04	1826.	2.62E+10	605.6369	396208.	0.00
27.3000	-0.00523	-146864.	-7541.	2.71E-04	2437.	2.62E+10	582.6586	467806.	0.00
27.6500	-0.00414	-173397.	-5149.	2.46E-04	2877.	2.62E+10	556.4328	564348.	0.00
28.0000	-0.00317	-190114.	-2874.	2.17E-04	3155.	2.62E+10	526.7727	698438.	0.00

28.3500	-0.00232	-197539.	-731.7890	1.85E-04	3278.	2.62E+10	493.3468	892266.	0.00
28.7000	-0.00161	-196261.	1261.	1.54E-04	3257.	2.62E+10	455.5503	1188619.	0.00
29.0500	-0.00103	-186947.	3083.	1.23E-04	3102.	2.62E+10	412.1813	1682042.	0.00
29.4000	-5.75E-04	-170363.	4681.	9.46E-05	2827.	2.62E+10	348.9290	2550900.	0.00
29.7500	-2.34E-04	-147623.	5717.	6.91E-05	2449.	2.62E+10	144.0359	2580433.	0.00
30.1000	6.30E-06	-122342.	6011.	4.75E-05	2030.	2.62E+10	-3.9132	2609965.	0.00
30.4500	1.65E-04	-97131.	5785.	2.99E-05	1612.	2.62E+10	-103.5132	2639498.	0.00
30.8000	2.58E-04	-73745.	5224.	1.62E-05	1224.	2.62E+10	-163.8078	2669030.	0.00
31.1500	3.01E-04	-53250.	4474.	6.08E-06	883.5660	2.62E+10	-193.5287	2698562.	0.00
31.5000	3.09E-04	-36168.	3646.	-1.09E-06	600.1245	2.62E+10	-200.5871	2728093.	0.00
31.8500	2.92E-04	-22624.	2822.	-5.80E-06	375.3947	2.62E+10	-191.7740	2757624.	0.00
32.2000	2.60E-04	-12463.	2057.	-8.61E-06	206.7969	2.62E+10	-172.6235	2787156.	0.00
32.5500	2.20E-04	-5347.	1385.	-1.00E-05	88.7259	2.62E+10	-147.3997	2816686.	0.00
32.9000	1.76E-04	-831.6002	824.8890	-1.05E-05	13.7987	2.62E+10	-119.1703	2846217.	0.00
33.2500	1.31E-04	1582.	385.7573	-1.05E-05	26.2475	2.62E+10	-89.9400	2875748.	0.00
33.6000	8.79E-05	2409.	69.1607	-1.01E-05	39.9684	2.62E+10	-60.8202	2905278.	0.00
33.9500	4.61E-05	2163.	-126.2286	-9.78E-06	35.8872	2.62E+10	-32.2223	2934808.	0.00
34.3000	5.76E-06	1348.	-202.4288	-9.50E-06	22.3746	2.62E+10	-4.0635	2964338.	0.00
34.6500	-3.37E-05	462.3992	-160.5286	-9.36E-06	7.6726	2.62E+10	24.0160	2993868.	0.00
35.0000	-7.28E-05	0.00	0.00	-9.32E-06	0.00	2.62E+10	52.4262	1511699.	0.00

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 1:

Pile-head deflection	=	3.66160733 inches
Computed slope at pile head	=	-0.02010988 radians
Maximum bending moment	=	3653949. inch-lbs
Maximum shear force	=	-49244. lbs
Depth of maximum bending moment	=	16.10000000 feet below pile head
Depth of maximum shear force	=	21.70000000 feet below pile head
Number of iterations	=	34
Number of zero deflection points	=	3

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

Boundary Condition Type 1, Shear and Moment

Shear = 0. lbs
 Moment = 0. in-lbs
 Axial Load = 0. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
35.00000	3.66160733	3653949.	-49244.
33.25000	3.72473604	3718902.	-49975.
31.50000	3.63265229	3633932.	-49050.
29.75000	3.66027147	3650802.	-48871.
28.00000	3.63301893	3641465.	-48324.
26.25000	4.00521593	3654600.	-53724.
24.50000	5.24461946	3424422.	-57908.
22.75000	10.27343309	3163142.	-61402.
21.00000	36.47195153	2982913.	-67071.

Summary of Pile-head Responses for Conventional Analyses

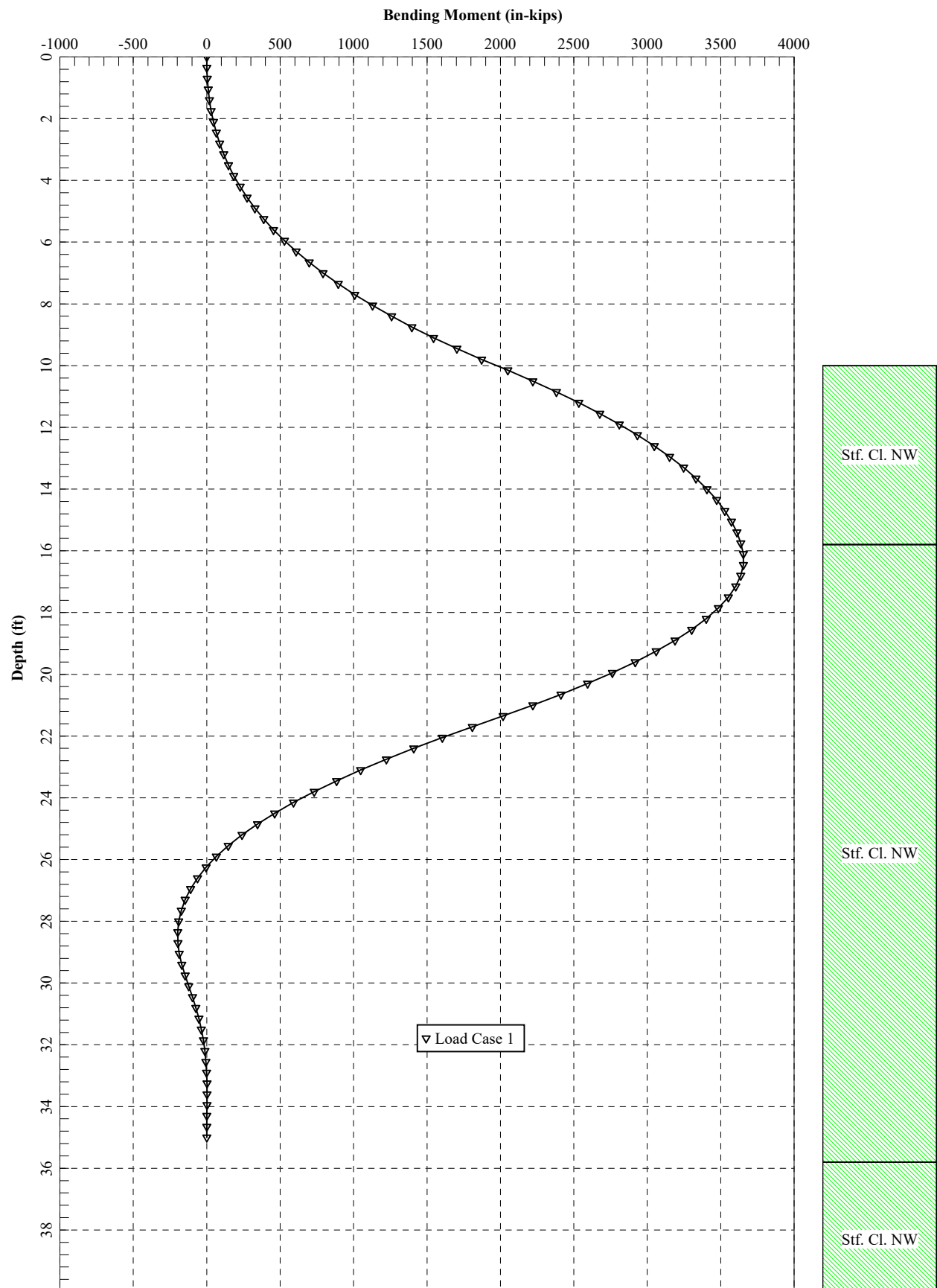
Definitions of Pile-head Loading Conditions:

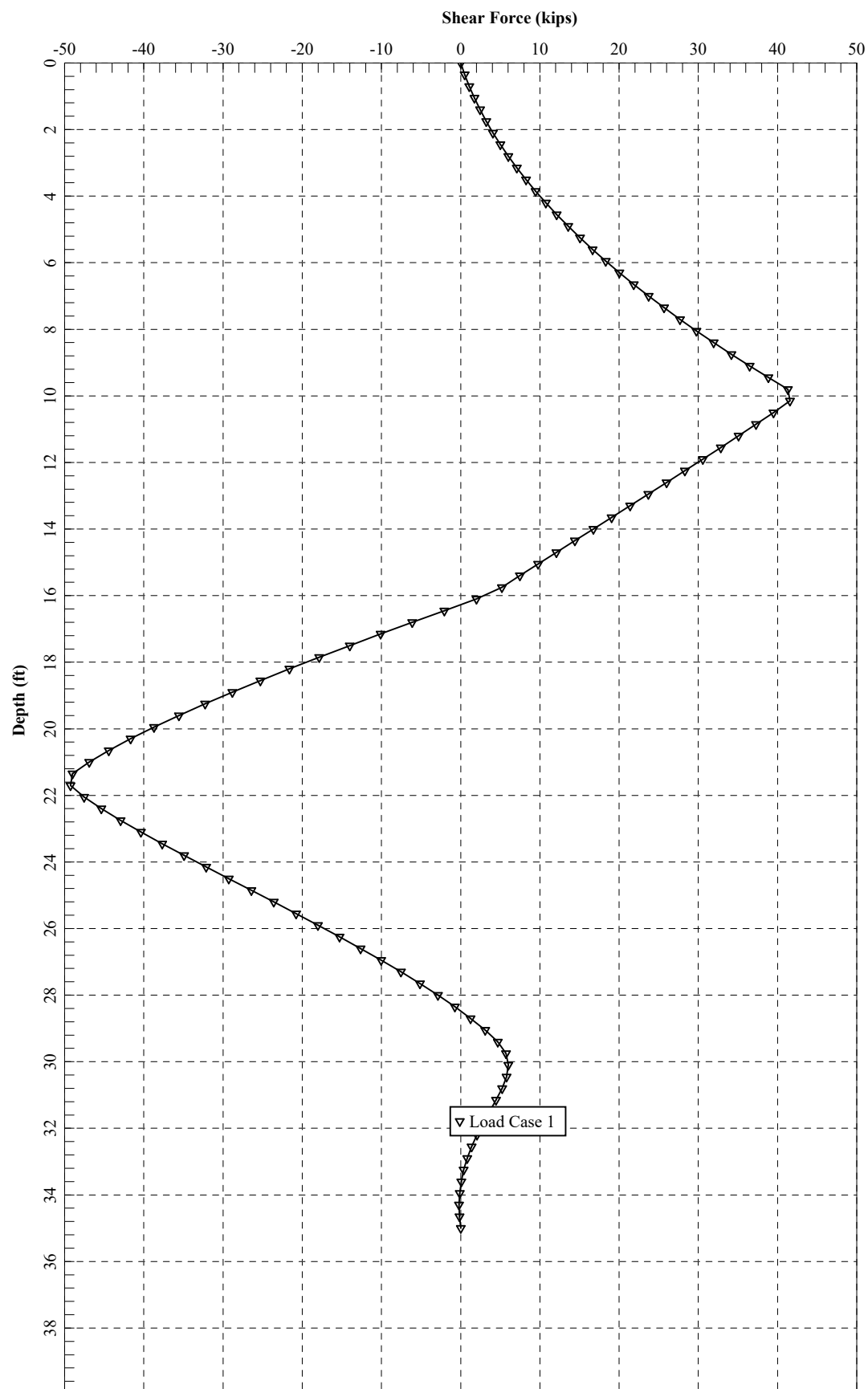
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
 Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
 Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
 Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
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

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	0.00	M, in-lb	0.00	0.00	3.6616	-0.02011	-49244.	3653949.

Maximum pile-head deflection = 3.6616073321 inches
 Maximum pile-head rotation = -0.0201098840 radians = -1.152211 deg.

The analysis ended normally.





Stf. Cl. NW

Stf. Cl. NW

Stf. Cl. NW

