

STRUCTURAL CALCULATIONS

FOR

MERCER ISLAND RESIDENCE TEMPORARY
SHORING WALL
6838 96TH AVE SE
MERCER ISLAND, WA 98040

PREPARED BY
PCS STRUCTURAL SOLUTIONS



JANUARY 6TH, 2023
21-201

active pressure: $0.33(125 \text{pcf}) = 41.3 \text{pcf}$ (level backfill)

active pressure: $0.52(125 \text{pcf}) = 65 \text{pcf}$ (2H:1V) (26.56°)

check active pressure at 3:1 slope (18.4°)

$$\left(\frac{65 - 41.3}{26.56^\circ - 0^\circ} \right) (18.4^\circ - 0^\circ) + 41.3 \text{pcf} = 57.7 \text{pcf} \rightarrow \text{use } \underline{58 \text{pcf}}$$

$$LL = 2'(125)(0.462) = 115.4 \text{psf}$$

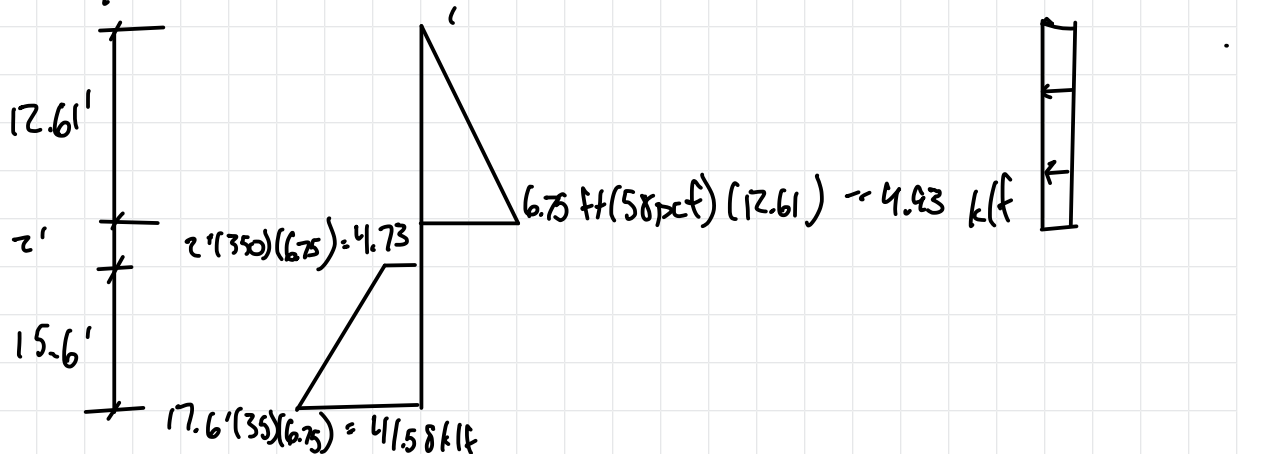
$$E = 18(8 \text{ft}) = 144 \text{psf} \rightarrow \text{seismic controls}$$

$$\text{Passive} = 350 \text{pcf}$$

Top of wall = 31.17' > height = 9.01ft
 Bottom of wall = 22.16'

$$\text{Max spacing} = 6.75 \text{ft}$$

Typical pile



CHOOSE W18x119 $\Delta_{\text{top}} = 0.9 \text{in}$ ✓ load

$$bf = 11.3 \text{in} \checkmark$$

$$M_a = 576.3 \text{ kip-ft} \quad V_a = 226 \text{ kip} \quad \text{Embed} = 17'-6"$$

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: 1/4/2023 File: G:\2021 Jobs\21201 Mercer Island Residence\Calcs\Temporary Shoring\SHORING SUITE 8\TYPICAL PILE.sh8

Title: Mercer Island Res
Subtitle: Typical Temporary Wall

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

Wall Type: 2. Soldier Pile, Drilled
 Wall Height: 12.61
 Pile Diameter: 2.50
 Pile Spacing: 6.75
 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: 0.66
 Elastic Module, E: 29000.00
 Moment of Inertia, I: 1910.00
 User Input Pile: W18X119

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

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	0	0	40	2.32	0.058000
2	0	.116	40	.1160	0.000000

* PASSIVE PRESSURE *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	14.63	.7	43.6	10.84	0.3500

* ACTIVE SPACE *

No.	Z depth	Spacing
1	0.00	6.75
2	12.61	2.50

* PASSIVE SPACE *

No.	Z depth	Spacing
1	12.61	6.75

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

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

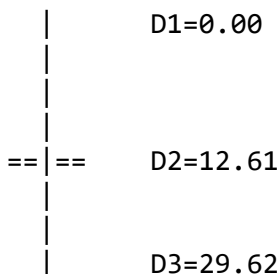
*For Deadman: Input1 = Horz. Width; Input2 = Passive Pressure;

*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



D1 - TOP DEPTH

D2 - EXCAVATION BASE
D3 - PILE TIP

MOMENT equilibrium AT DEPTH=26.78 WITH EMBEDMENT OF 14.17
FORCE equilibrium AT DEPTH=29.62 WITH EMBEDMENT OF 17.01

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 14.17

The program calculates an embedment for moment equilibrium, then increase the embedment by 1.2

The total design embedment is 17.01

Embedment Information:

If 20% increased, the total design embedment is 17.01

If 30% increased, the total design embedment is 18.43

If 40% increased, the total design embedment is 19.84

If 50% increased, the total design embedment is 21.26

* MOMENT IN PILE (per pile spacing)*

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

Overall Maximum Moment = 434.63 at 20.08

Maximum Shear = 145.60

Moment and Shear are per pile spacing: 6.8 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 = 434.63 at 20.08

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

Request Min. Section Modulus = 158.05 in³/pile = 2589.91 cm³/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=0.66

W18X119 has been found in Soldier Pile list!

(English Units):

Area= 35.1 in. Depth= 19 in. Width= 11.3 in. Height= 18 in.
Flange thickness= 1.06 in. Web thickness= 0.655 in.
Ix= 2190 in⁴/pile Sx= 231 in³/pile Iy= 253 in⁴/pile Sy= 44.9 in³/pile
(Metric Units):
Ix= 911.48 x100cm⁴/pile Sx= 3785.40 cm³/pile Iy= 105.30 x100cm⁴/pile Sy=
735.78 cm³/pile

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

W18X119 is capable to support the shoring!
Top deflection = 0.912(in)
Max. deflection = 0.912(in)

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

Max. Pressure above base = 0.85

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 = 0.42

Pile Spacing =6.8, Max. Moment in lagging = 2.41

For 4"x12" Timber, Section Modules S=23.47 in³. The request allowable bending strength, fb=M/S=1.23

For 6"x12" Timber, Section Modules S=57.98 in³. The request allowable bending strength, fb=M/S=0.50

If 30% loading is used for lagging design, Design Pressure = 0.25

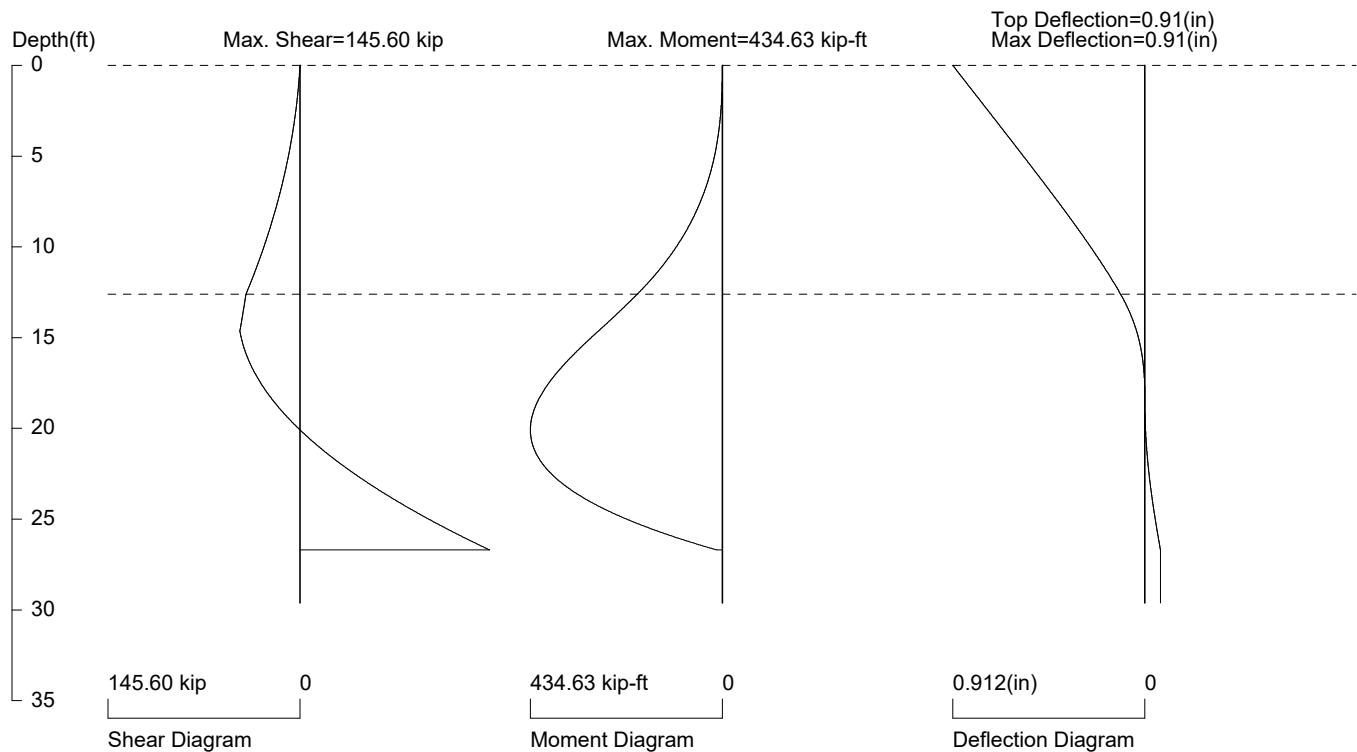
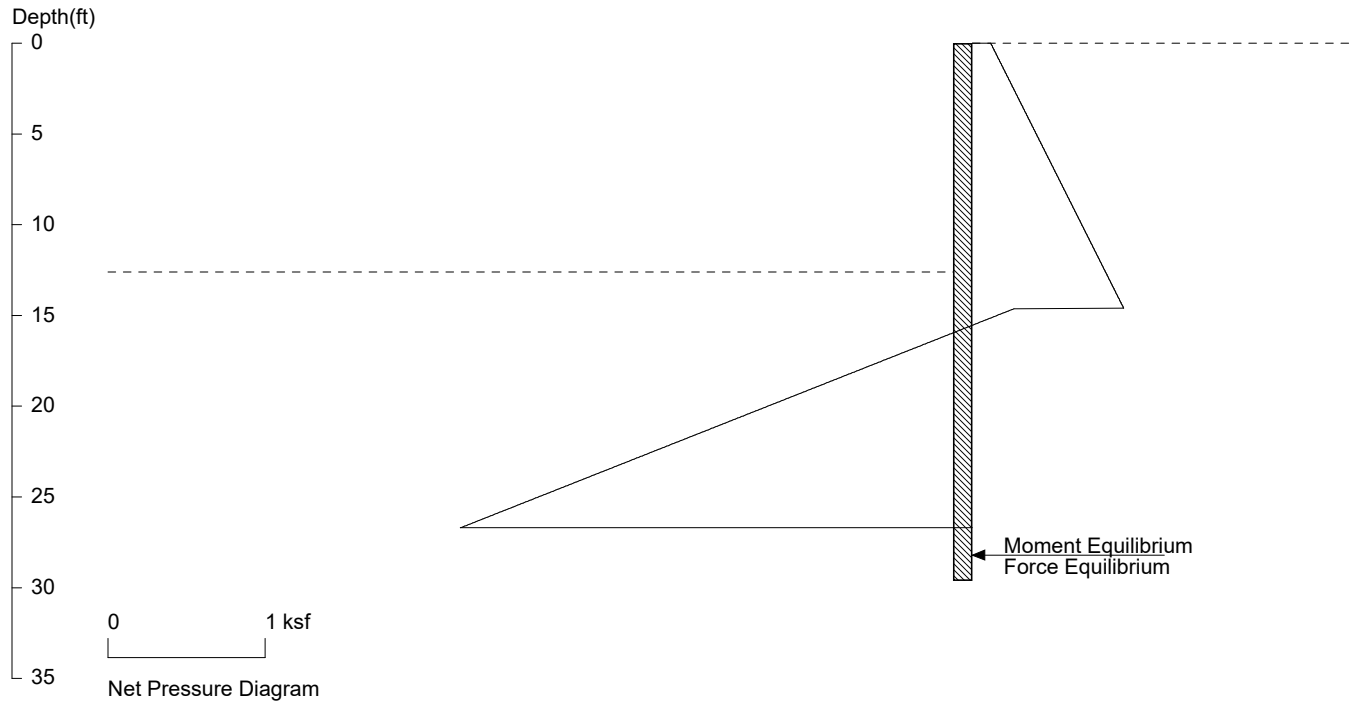
Pile Spacing =6.8, Max. Moment in lagging = 1.45

For 4"x12" Timber, Section Modules S=23.47 in³. The request allowable bending strength, fb=M/S=0.74

For 6"x12" Timber, Section Modules S=57.98 in³. The request allowable bending strength, fb=M/S=0.30

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

Mercer Island Res Typical Temporary Wall



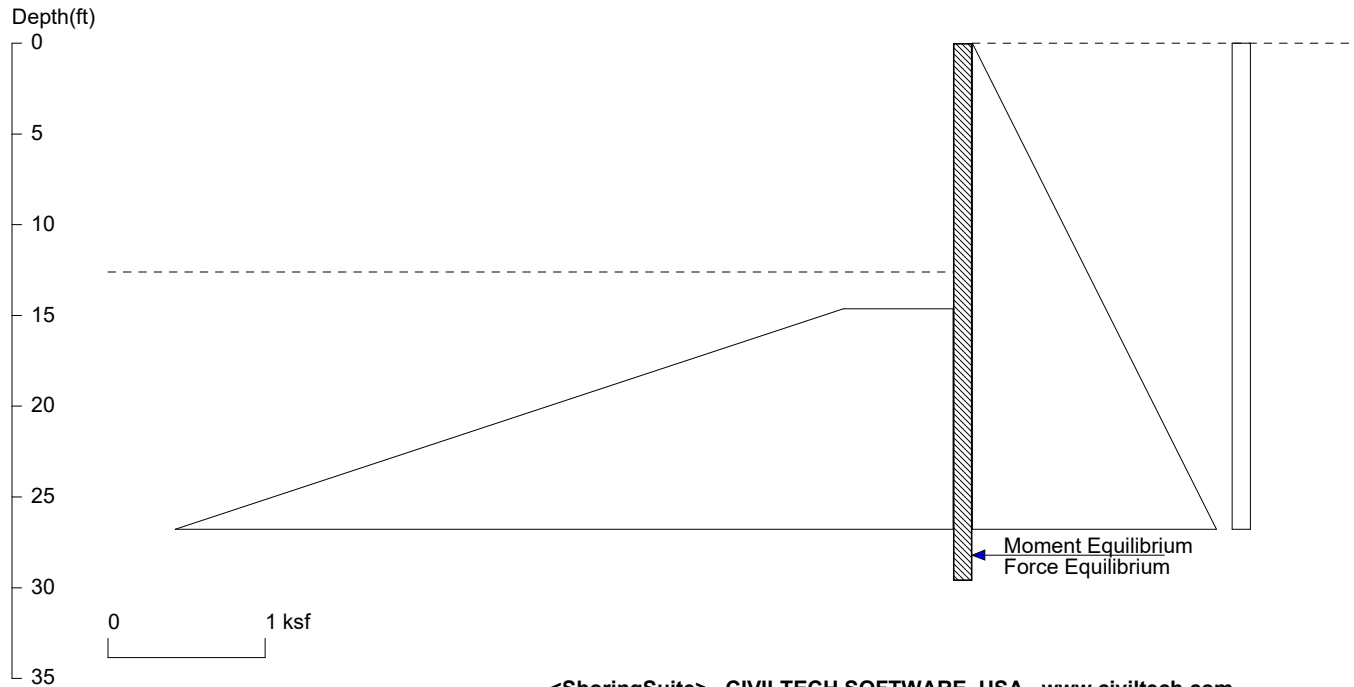
PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 6.8 foot or meter

User Input Pile, W18X119: E (ksi)=29000.0, I (in⁴)/pile=2190.0

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Mercer Island Res Typical Temporary Wall



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File: G:\2021 Jobs\21201 Mercer Island Residence\Calcs\Temporary Shoring\SHORING SUITE 8\TYPICAL PILE.sh8

Wall Height=12.6 Pile Diameter=2.5 Pile Spacing=6.8 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=17.01 Min. Pile Length=29.62

MOMENT IN PILE: Max. Moment=434.63 per Pile Spacing=6.8 at Depth=20.08

PILE SELECTION:

Request Min. Section Modulus = 158.0 in³/pile=2589.91 cm³/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=0.66

W18X119 has Section Modulus = 231.0 in³/pile=3785.40 cm³/pile. It is greater than Min. Requirements!

Top Deflection = 0.91(in) based on E (ksi)=29000.00 and I (in⁴)/pile=2190.0

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
0	0	40	2.32	0.058000
0	.116	40	.1160	0.000000

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
14.63	.7	43.6	10.84	0.3500

ACTIVE SPACING:

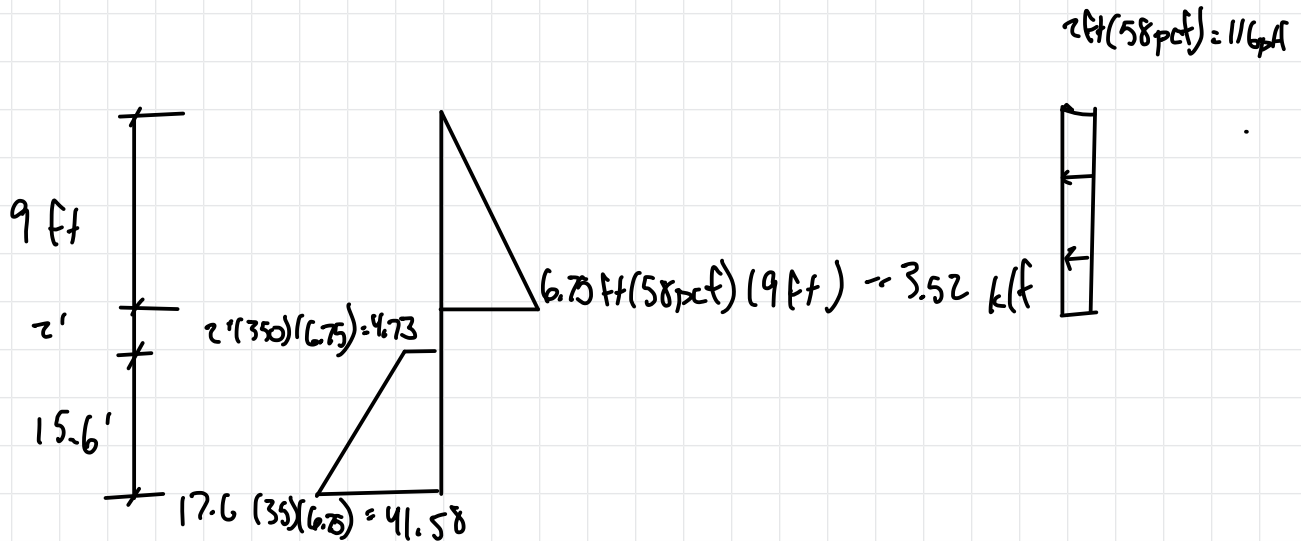
No.	Z depth	Spacing
1	0.00	6.75
2	12.61	2.50

PASSIVE SPACING:

No.	Z depth	Spacing
1	12.61	6.75

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

Check 9 ft Pile



CHOOSE W18x50 $\Delta_{top} = 0.57$ ✓ LOAD

bf = 7.5" ✓ Min size for lagging bearing

$M_a = 221.8$ kip-ft $V_a = 114.8$ kip-ft

Min Embed = 13'-6"

SHORING WALL CALCULATION SUMMARY
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4. TRENCHING AND SHORING MANUAL Revision 12, California Department of Transportation, January 2000
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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: 1/4/2023 File: G:\2021 Jobs\21201 Mercer Island Residence\Calcs\Temporary Shoring\SHORING SUITE 8\9FT PILE.sh8

Title: Mercer Island Res
Subtitle: 9ft Temporary Wall

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

Wall Type: 2. Soldier Pile, Drilled
 Wall Height: 9.00
 Pile Diameter: 2.50
 Pile Spacing: 6.75
 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: 0.66
 Elastic Module, E: 29000.00
 Moment of Inertia, I: 800.00
 User Input Pile: W18X50

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

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	0	0	40	2.32	0.058000
2	0	.116	40	.1160	0.000000

* PASSIVE PRESSURE *

No.	Z1 top	Top Pres.	Z2 bottom	Bottom Pres.	Slope
1	11	.7	42	11.55	0.3500

* ACTIVE SPACE *

No.	Z depth	Spacing
1	0.00	6.75
2	9.00	2.50

* PASSIVE SPACE *

No.	Z depth	Spacing
1	9.00	6.75

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

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

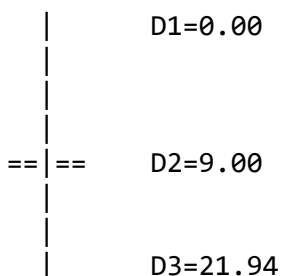
*For Deadman: Input1 = Horz. Width; Input2 = Passive Pressure;

*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



D1 - TOP DEPTH

D2 - EXCAVATION BASE
D3 - PILE TIP

MOMENT equilibrium AT DEPTH=19.79 WITH EMBEDMENT OF 10.79
FORCE equilibrium AT DEPTH=21.94 WITH EMBEDMENT OF 12.94

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 10.79

The program calculates an embedment for moment equilibrium, then increase the embedment by 1.2

The total design embedment is 12.94

Embedment Information:

If 20% increased, the total design embedment is 12.94

If 30% increased, the total design embedment is 14.02

If 40% increased, the total design embedment is 15.10

If 50% increased, the total design embedment is 16.18

* MOMENT IN PILE (per pile spacing)*

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

Overall Maximum Moment = 187.94 at 14.77

Maximum Shear = 83.78

Moment and Shear are per pile spacing: 6.8 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 = 187.94 at 14.77

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

Request Min. Section Modulus = 68.34 in³/pile = 1119.95 cm³/pile, Fy= 50 ksi = 345 MPa, Fb/Fy=0.66

W18X50 has been found in Soldier Pile list!

(English Units):

Area= 14.7 in. Depth= 18 in. Width= 7.5 in. Height= 18 in.
Flange thickness= 0.57 in. Web thickness= 0.355 in.
Ix= 800 in⁴/pile Sx= 88.9 in³/pile Iy= 40.1 in⁴/pile Sy= 10.7 in³/pile
(Metric Units):
Ix= 332.96 x100cm⁴/pile Sx= 1456.80 cm³/pile Iy= 16.69 x100cm⁴/pile Sy=
175.34 cm³/pile

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

W18X50 is capable to support the shoring!
Top deflection = 0.572(in)
Max. deflection = 0.572(in)

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

Max. Pressure above base = 0.64

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 = 0.32

Pile Spacing =6.8, Max. Moment in lagging = 1.81

For 4"x12" Timber, Section Modules S=23.47 in³. The request allowable bending strength, fb=M/S=0.93

For 6"x12" Timber, Section Modules S=57.98 in³. The request allowable bending strength, fb=M/S=0.38

If 30% loading is used for lagging design, Design Pressure = 0.19

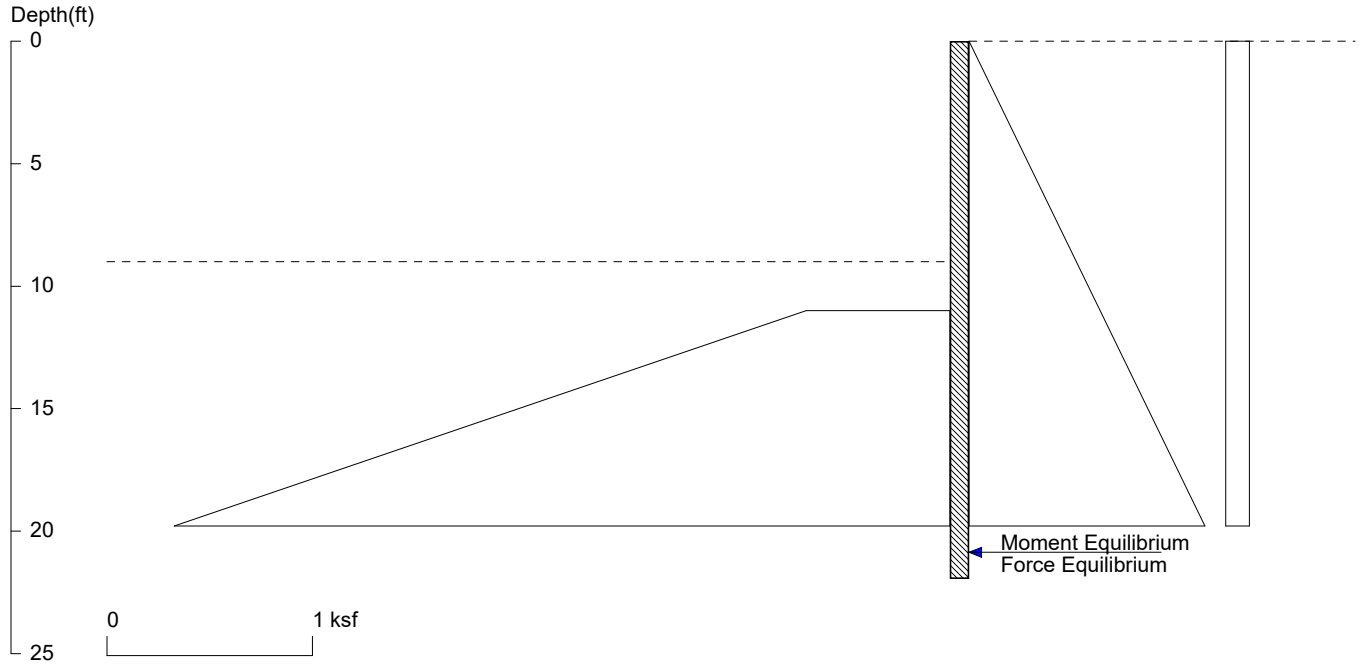
Pile Spacing =6.8, Max. Moment in lagging = 1.09

For 4"x12" Timber, Section Modules S=23.47 in³. The request allowable bending strength, fb=M/S=0.56

For 6"x12" Timber, Section Modules S=57.98 in³. The request allowable bending strength, fb=M/S=0.23

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

Mercer Island Res 9ft Temporary Wall



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Date: 1/4/2023

File: G:\2021 Jobs\21201 Mercer Island Residence\Calcs\Temporary Shoring\SHORING SUITE 8\9FT PILE.sh8

Wall Height=9.0 Pile Diameter=2.5 Pile Spacing=6.8 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=12.94 Min. Pile Length=21.94

MOMENT IN PILE: Max. Moment=187.94 per Pile Spacing=6.8 at Depth=14.77

PILE SELECTION:

Request Min. Section Modulus = 68.3 in³/pile=1119.95 cm³/pile, F_y= 50 ksi = 345 MPa, F_b/F_y=0.66
W18X50 has Section Modulus = 88.9 in³/pile=1456.80 cm³/pile. It is greater than Min. Requirements!
Top Deflection = 0.57(in) based on E (ksi)=29000.00 and I (in⁴)/pile=800.0

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
0	0	40	2.32	0.058000
0	.116	40	.1160	0.000000

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
11	.7	42	11.55	0.3500

ACTIVE SPACING:

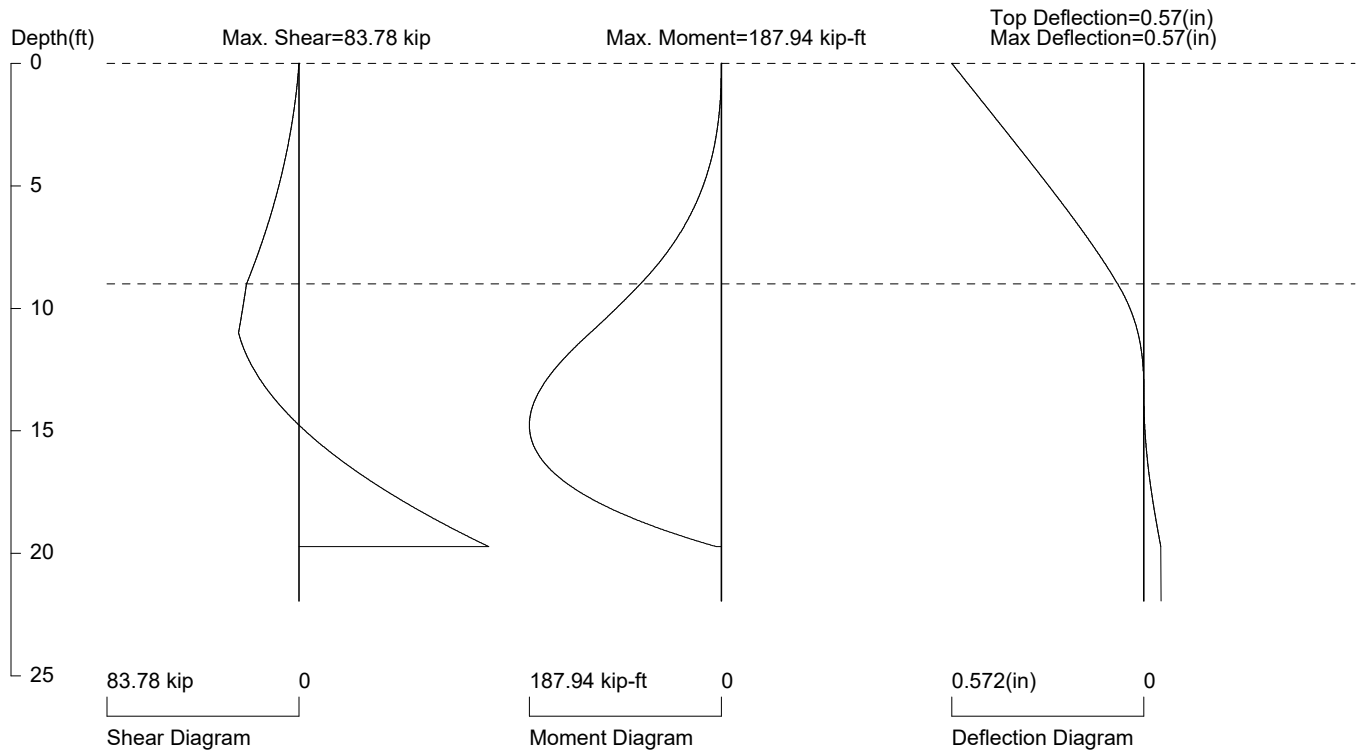
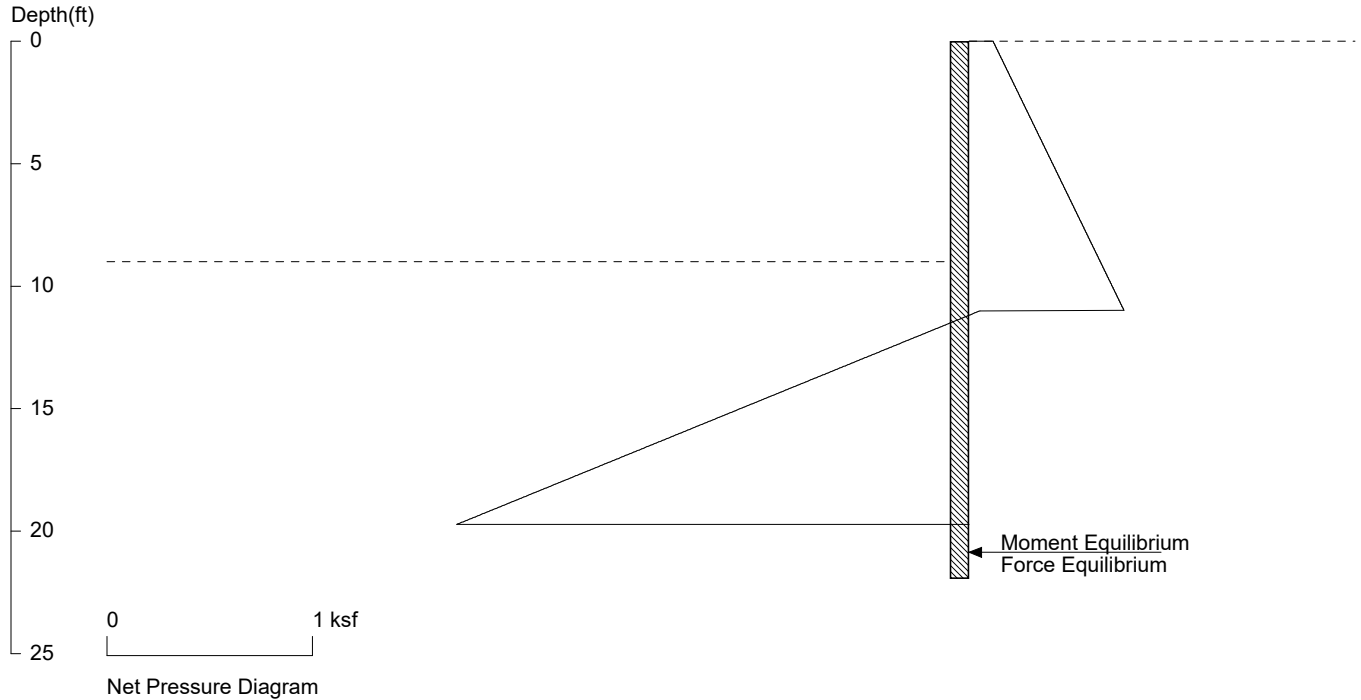
No.	Z depth	Spacing
1	0.00	6.75
2	9.00	2.50

PASSIVE SPACING:

No.	Z depth	Spacing
1	9.00	6.75

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

Mercer Island Res 9ft Temporary Wall



PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 6.8 foot or meter

User Input Pile, W18X50: E (ksi)=29000.0, I (in⁴)/pile=800.0

File: G:\2021 Jobs\21201 Mercer Island Residence\Calcs\Temporary Shoring\SHORING SUITE 8\9FT PILE.sh8

Check Pile capacity

W14x74

$$\frac{M_n}{\phi} = \frac{50 \text{ksi} (112 \text{in}^3)}{1.67} = 279.4 \text{kip-ft} \times 1.67$$

Try W18x119 for piles 29ft

$$\frac{M_n}{\phi} = \frac{50 \text{ksi} (231 \text{in}^3)}{1.67} = 573.9 \text{kip-ft} \quad \sqrt{6000} \geq 431.6 \text{kip-ft}$$

$$\frac{V_n}{\phi} = \frac{0.6 (50 \text{ksi}) (19 \text{in in}) (0.655 \text{in})}{1.67} = 223.5 \text{kip} \quad \sqrt{6000}$$

W18x50

$$\frac{M_n}{\phi} = \frac{50 \text{ksi} (88.9 \text{in}^3)}{1.67} = 221.8 \text{kip-ft} = 187.9 \text{kip-ft}$$

$$\frac{V_n}{\phi} = \frac{50 \text{ksi} (0.6) (18.0 \text{in}) (0.355)}{1.67} = 114.8 \text{kip} = 83.8 \text{kip} \quad \sqrt{6000}$$

Check lagging

Max soil pressure

$$H = 12.6 \text{ ft} (58 \text{ pcf}) (1 \text{ ft}) = 730.8 \text{ pft}$$

$$LL = 2 \text{ ft} (58 \text{ pcf}) (1 \text{ ft}) = 116 \text{ pft}$$

$$H+L = 846.8 \text{ pft}$$

$$\text{Pile spacing} = 6'-9''$$

$$M_a = \frac{846.8 \text{ pft} (6.75 \text{ ft})^2}{8} = 4822 \text{ lb-ft} = 57873 \text{ lb-in}$$

$$V_a = \frac{846.8 \text{ pft} (6.75 \text{ ft} - 0.33 \text{ ft}/2)}{2} = 2787.4 \#$$

Try flatwise 4x12

$$S = 22.97 \text{ in}^3$$

$$f_b = \frac{57873 \text{ lb-in}}{22.97 \text{ in}^3} = 2519 \text{ psi}$$

PER WSDOT 6-16.3(6)B, 4x12 LAGGING IS ACCEPTABLE FOR EXPOSED HEIGHTS UP TO 25' W/ CLEAR SPAN 8'

PER Geotech email 12-22-22, USE soil type 2

4x12 lagging ok for 12.6' expose

$$\frac{S_y, 4x12}{S_y, 4x12} = \frac{32 \text{ in}^3}{22.96 \text{ in}^3} = \frac{22}{12.6}$$

$$S_y, 4x12 = 22.96 \text{ in}^3$$

$$1.39 \leq 1.74 \quad \checkmark \text{ GOOD}$$



Project: Mercer Island Res Job No: 21201
Subject: _____ Sheet _____ Name: TLR
Originating Office: Seattle Tacoma Portland Date: 4-2023

USE 4x12 Douglas-Fir Larch NO. 2 ✓
Hem-Fir No 1 per WSDOT 9-09.2