Design Calculations for Drilled In Soldier Pile and Lagging Wall with Tieback Anchors

Southwest Corner of Congress Street Parking Garage

Maine Medical Center

Portland, Maine

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Reviewed for General Acceptance only. This review does not relieve the Subcontractor of the responsibility for making the work conform to the requirements of the contract. The Subcontractor is responsible for all dimensions, correct fabrication and accurate fit with the work of other trades.

SUBJECT TO ARCHITECTS APPROVAL

Signed [signature] Date Mar 02, 2021

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Design of Excavation Support at Southwest Corner
Congress Street Parking Garage
Maine Medical Center
Portland, Maine

1.0 Design Procedure and Assumptions

For construction of the new Congress Street parking garage a temporary excavation support system will be installed at the southwest corner of the site, tying into to the secant pile wall. The system will consist of drilled in soldier piles with a level of external bracing. The design height of support will be up to 34 feet. The system will be designed to resist lateral pressures due to soil and construction surcharge loadings.

For the cantilever conditions the lateral soil pressures on the system will be triangular based on rankine earth pressures. For the braced condition the lateral soil loading will be modeled as a trapezoidal loading based on apparent earth pressures. The apparent earth pressure diagram will be based on the recommended loading diagram detailed in Figure 24 from FHWA Geotechnical Engineering Circular No. 4, *"Ground Anchors and Anchored Systems"* (see page A1). The construction surcharge loading on the system will be modeled as a vertical loading of 300 psf, as per note 5C on Contract Drawing SE00-01. The resulting lateral loading will be determined using the LPRES program.

The total lateral loadings on the excavation support system will be modeled and the resulting forces on the system will be determined using the CT-Shoring Computer Program. The lateral loads on the excavation support system will be analyzed for each stage of excavation to determine the maximum loading on each member for design. From the calculated forces the soldier piles and bracing will be designed based on allowable stress design.

2.0 Design Parameters and Variables

The soil conditions along the SOE alignment are taken from borings B-16-5, B-17-13 and B-IMP-5. Based on the boring information the soil profile will consist of approximately 16 feet of loose to medium dense granular fill over 10 feet of silty clay. Below the clay layer is approximately 16 feet of medium dense silty sand over a medium dense to very dense glacial till. The design parameters for these soils will be taken from Note 5A on Contract Drawing SE00-01. The design groundwater table will be set Elev. +53, as per Note 5C on Drawing SE00-01.

Based on review comment the clay layer will be ignored and the design soil profile will consist of 20 feet of fill over 22 feet of silty sand over the glacial till layer.

Soil Design Parameters

o Granular Fill (0' to 20') Unit Weight = $\gamma_{fill} := 130 \cdot pcf$

Buoyant Unit Weight = $\gamma_{bf} := \gamma_{fill} - \gamma_w$

$$\gamma_{bf} = 68 \cdot pcf$$

Friction Angle = $\phi_f := 34 \cdot deg$

Active Pressure Coefficient = $K_{af} := 0.28$

Passive Pressure Coefficient = $K_{pf} := \tan\left(45 \cdot deg + \frac{\phi_f}{2}\right)^2$

$K_{pf} = 3.54$

o Clay
(Not present)

Unit Weight = $\gamma_{clay} := 125 \cdot pcf$

Buoyant Unit Weight = $\gamma_{bc} := \gamma_{clay} - \gamma_w$

$\gamma_{bc} = 63 \cdot pcf$

Shear Strength = $S_u := 1000 \cdot psf$

Active Pressure Coefficient = $K_{ac} := 1.00$

Passive Pressure Coefficient = $K_{pc} := 1.00$

o Sand
(20' to 42')

Unit Weight = $\gamma_{sand} := 135 \cdot pcf$

Buoyant Unit Weight = $\gamma_{bs} := \gamma_{sand} - \gamma_w$

$\gamma_{bs} = 73 \cdot pcf$

Friction Angle = $\phi_s := 33 \cdot deg$

Active Pressure Coefficient = $K_{as} := 0.26$

Passive Pressure Coefficient = $K_{ps} := \tan\left(45 \cdot deg + \frac{\phi_s}{2}\right)^2$

$K_{ps} = 3.39$

o Glacial Till
(Below 42')

Unit Weight = $\gamma_{till} := 145 \cdot pcf$

Buoyant Unit Weight = $\gamma_{bt} := \gamma_{till} - \gamma_w$

$\gamma_{bt} = 83 \cdot pcf$

Friction Angle = $\phi_t := 38 \cdot deg$

Active Pressure Coefficient = $K_{at} := 0.22$

Passive Pressure Coefficient = $K_{pt} := 10.7$

3.0 Design of Excavation Support System

The design height of the excavation support will be up to 34 feet. The soldier piles will have one to two levels of external bracing. The soldier piles will be drilled in place at 7-foot spacing along the south wall and 8-foot spacing along Gilman Street. The soil loading will be modeled as a triangular loading for the cantilever condition and trapezoidal loading for the braced condition, as described in section 1.0. The active and passive soil pressures below subgrade will be based on the soil properties given above. The passive pressures below subgrade will be mobilized over 3 pile diameter width (per Brom's Theory) or the pile spacing, whichever is less. The water table will be set at elev. 53 or subgrade, whichever is lower. An analysis will be run for each stage of excavation and the final condition in each design case. The allowable lateral deflection of the system along the south wall and Gilman Street is 1/2 inch.

Surcharge Loading

The construction surcharge loading on the system will be modeled as a 30-foot wide vertical strip loading of 300 psf. The resulting lateral loading on the system will be determined using the LPRES program which utilizes Bousinesq equations. The results are exported to the CT-Shoring analyses and are given on page A2 of these calculations.

Design of Soldier Pile and Lagging System

The initial excavation for bracing installation will extend down to 2 feet below the bracing level. The final height of braced support will vary from 24 to 34 feet. Several design cases will be run for these varying conditions.

Design Case 1 - Soldier Piles 1 and 2 on South Wale

The design height of support will be 34 feet with two levels of bracing. Due to existing utilities the top level of bracing will be installed at a depth of 11 feet and the lower level of bracing at 22 feet. The piles will be installed at 7-foot spacing for this area.

Design Case 1a - Cantilever Height of Support of 13 Feet

The design cantilever height of support will be 13 feet for installation of tiebacks at 11 feet. Ground water level will be set at subgrade.

Top of Soldier Piles = $El_t := 66 \cdot ft$

Subgrade Elevation = $El_s := 53 \cdot ft$

Height of Excavation = $H := El_t - El_s$

$$H = 13\,ft$$

Water Table Elev. = $El_w := 52 \cdot ft$

Active Pressure

Active Pressure at Subgrade = $P_{a1} := K_{af} \cdot (13 \cdot ft \cdot \gamma_{fill})$

$$P_{a1} = 473 \cdot psf$$

Slope of Active in Fill = $S_{a1} := K_{af} \cdot \gamma_{bf}$

$$S_{a1} = 19 \cdot \frac{psf}{ft}$$

Active Pressure at Sand = $P_{a2} := K_{as} \cdot (13 \cdot ft \cdot \gamma_{fill} + 7 \cdot ft \cdot \gamma_{bf})$

$$P_{a2} = 562 \cdot psf$$

Slope of Active in Sand Below Water = $S_{a2} := K_{as} \cdot \gamma_{bs}$

$$S_{a2} = 19 \cdot \frac{psf}{ft}$$

Active Pressure at Till = $P_{a3} := K_{at} \cdot (13 \cdot ft \cdot \gamma_{fill} + 7 \cdot ft \cdot \gamma_{bf} + 22 \cdot ft \cdot \gamma_{bs})$

$$P_{a3} = 827 \cdot psf$$

Slope of Active in Till = $S_{a3} := K_{at} \cdot \gamma_{bt}$

$$S_{a3} = 18 \cdot \frac{psf}{ft}$$

Passive Earth Pressures

Slope of Passive in Fill = $S_{p1} := K_{pf} \cdot \gamma_{bf}$

$$S_{p1} = 239 \cdot \frac{psf}{ft}$$

Passive Pressure at Sand = $P_{p2} := K_{ps} \cdot (7 \cdot ft \cdot \gamma_{bf})$

$$P_{p2} = 1605 \cdot psf$$

Slope of Passive in Sand Below Water = $S_{p2} := K_{ps} \cdot \gamma_{bs}$

$$S_{p2} = 246 \cdot \frac{psf}{ft}$$

Passive Pressure at Till = $P_{p3} := K_{pt} \cdot (7 \cdot ft \cdot \gamma_{bf} + 22 \cdot ft \cdot \gamma_{bs})$

$$P_{p3} = 22153 \cdot psf$$

Slope of Passive in Till = $S_{p3} := K_{pt} \cdot \gamma_{bt}$

$$S_{p3} = 884 \cdot \frac{psf}{ft}$$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages B1 to B4 of these calculations.

Maximum Bending Moment = $M_{1a} := 323.74 \cdot kft$

Minimum Soldier Pile Length = $L_{1a} := 30.70 \cdot ft$

<u>Design Case 1b - Braced Height of Support of 26 Feet</u>

The braced design height of support will be 26 feet with a level of bracing at 11 feet.

Top of Soldier Piles = $El_t = 66\,ft$

Subgrade Elevation = $El_s := 40 \cdot ft$

Height of Excavation = $H := El_t - El_s$

$$H = 26\,ft$$

Water Table Elev. = $El_w := 40 \cdot ft$

Apparent Earth Pressure = $P_a := 0.65 \cdot K_{af} \cdot \gamma_{fill} \cdot H$

$$P_a = 24 \cdot H \cdot pcf$$

$$P_a = 615 \cdot psf$$

Total Apparent Soil Load = $TL_{soil} := P_a \cdot H$

$$TL_{soil} = 16 \cdot klf$$

Maximum Apparent Soil Pressure = $p := \dfrac{TL_{soil}}{\frac{2}{3} \cdot H}$

$$p = 923 \cdot psf$$

Active Pressure

Active Pressure at Subgrade = $P_{a1} := K_{as} \cdot (20 \cdot ft \cdot \gamma_{fill} + 6 \cdot ft \cdot \gamma_{sand})$

$P_{a1} = 887 \cdot psf$

Slope of Active in Sand = $S_{a1} := K_{as} \cdot \gamma_{bs}$

$S_{a1} = 19 \cdot \frac{psf}{ft}$

Active Pressure at Till = $P_{a2} := K_{at} \cdot (20 \cdot ft \cdot \gamma_{fill} + 6 \cdot ft \cdot \gamma_{sand} + 16 \cdot ft \cdot \gamma_{bs})$

$P_{a2} = 1006 \cdot psf$

Slope of Active in Till = $S_{a2} := K_{at} \cdot \gamma_{bt}$

$S_{a2} = 18 \cdot \frac{psf}{ft}$

Passive Earth Pressures

Slope of Passive in Sand = $S_{p1} := K_{ps} \cdot \gamma_{bs}$

$S_{p1} = 246 \cdot \frac{psf}{ft}$

Passive Pressure at Till = $P_{p2} := K_{pt} \cdot (16 \cdot ft \cdot \gamma_{bs})$

$P_{p2} = 12429 \cdot psf$

Slope of Passive in Till = $S_{p2} := K_{pt} \cdot \gamma_{bt}$

$S_{p2} = 884 \cdot \frac{psf}{ft}$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages B5 to B8 of these calculations.

Maximum Bending Moment = $M_{1b} := 206.67 \cdot kft$

Lateral Brace Loading = $B_{1b} := 16.8 \cdot klf$

Minimum Soldier Pile Length = $L_{1b} := 34.12 \cdot ft$

Design Case 1c - Braced Height of Support of 34 Feet

The design height of support will be 34 feet with a level of bracing at 11 feet and 24 feet.

Top of Soldier Piles = $El_t = 66\,ft$

Subgrade Elevation = $El_s := 32 \cdot ft$

Height of Excavation = $H := El_t - El_s$

$H = 34\,ft$

Water Table Elev. = $El_w := 32 \cdot ft$

Apparent Earth Pressure = $P_a := 0.65 \cdot K_{af} \cdot \gamma_{fill} \cdot H$

$P_a = 24 \cdot H \cdot pcf$

$P_a = 804 \cdot psf$

Total Apparent Soil Load = $TL_{soil} := P_a \cdot H$

$TL_{soil} = 27.4 \cdot klf$

Maximum Apparent Soil Pressure = $p := \dfrac{TL_{soil}}{\frac{2}{3} \cdot H}$

$p = 1207 \cdot psf$

Active Pressure

Active Pressure at Subgrade = $P_{a1} := K_{as} \cdot (20 \cdot ft \cdot \gamma_{fill} + 14 \cdot ft \cdot \gamma_{sand})$

$P_{a1} = 1167 \cdot psf$

Slope of Active in Sand = $S_{a1} := K_{as} \cdot \gamma_{bs}$

$S_{a1} = 19 \cdot \dfrac{psf}{ft}$

Active Pressure at Till = $P_{a2} := K_{at} \cdot (20 \cdot ft \cdot \gamma_{fill} + 14 \cdot ft \cdot \gamma_{sand} + 8 \cdot ft \cdot \gamma_{bs})$

$P_{a2} = 1116 \cdot psf$

Slope of Active in Till = $S_{a2} := K_{at} \cdot \gamma_{bt}$

$S_{a2} = 18 \cdot \dfrac{psf}{ft}$

Passive Earth Pressures

Slope of Passive in Sand = $S_{p1} := K_{ps} \cdot \gamma_{bs}$

$$S_{p1} = 246 \cdot \frac{psf}{ft}$$

Passive Pressure at Till = $P_{p2} := K_{pt} \cdot (8 \cdot ft \cdot \gamma_{bs})$

$$P_{p2} = 6215 \cdot psf$$

Slope of Passive in Till = $S_{p2} := K_{pt} \cdot \gamma_{bt}$

$$S_{p2} = 884 \cdot \frac{psf}{ft}$$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages B9 to B12 of these calculations.

Maximum Bending Moment = $M_{1c} := 277.20 \cdot kft$

Lateral Brace Loading = $B_{1c} := 21.0 \cdot klf$

$$B_{1c2} := 11.1 \cdot klf$$

Minimum Soldier Pile Length = $L_{1c} := 42.18 \cdot ft$

Design Loads for Excavation Support System

Maximum Bending Moment = $M_{max} := \max(M_{1a}, M_{1b}, M_{1c})$

$$M_{max} = 323.7 \cdot kft$$

Bracing Loads = $B_{top} := \max(B_{1b}, B_{1c})$

$$B_{top} = 21 \cdot klf$$

$$B_{bottom} := B_{1c2}$$

$$B_{bottom} = 11.1 \cdot klf$$

Minimum Soldier Pile Length = $L_{min} := \max(L_{1a}, L_{1b}, L_{1c})$

$$L_{min} = 42.2 \, ft$$

Soldier Pile Design

The soldier pile design will determine the required pile section and length based on the analysis above along with determining the estimated maximum deflection.

Soldier Pile Section

The required soldier pile section will be determined based on AISC allowable bending stresses for design of the temporary excavation support system.

Yield Strength = $F_y := 50 \cdot ksi$ (ASTM A572 Steel)

Maximum Bending Moment = $M_b := M_{max}$

$$M_b = 323.74 \cdot kft$$

Required Section Modulus = $S_x := \dfrac{M_b}{0.667 \cdot F_y}$

$$S_x = 116.49 \cdot in^3$$

Use W24x104 Section with S_x = 258 in^3

Soldier Pile Length

The required soldier pile length is determined by the CT-Shoring Program. The results of this analysis are given above.

Minimum Soldier Pile Length = $L_{min} = 42.18\,ft$

Provide 43-Foot Long Soldier Piles

Estimated Lateral Deflection of Soldier Pile Wall

Lateral deflection of soldier pile wall will be estimated using the CT-Shoring program. The moment of inertia for the W24x104 soldier pile section is input (S_x = 3100 in^4) and the program generates an estimated lateral deflections for the cantilever and braced conditions. The results are on pages B13 to B15 of these calculations.

Estimated Cantilever Deflection = $\delta_{1a} := 0.48 \cdot in$

Estimated Maximum Stage 1 Deflection = $\delta_{1b} := 0.08 \cdot in$

Estimated Maximum Final Braced Deflection = $\delta_{1c} := 0.18 \cdot in$

Based on this result the estimated maximum lateral of the soldier pile wall will be less than 1/2 inch. This is only an estimate and the actual deflection may vary based on specific soil and surcharge conditions.

Use W24x104 with 43-Foot Length for Piles 1 and 2

Design of Top Level of Tieback Anchors

The tiebacks will be installed at a depth of 11 feet and at 7-foot spacing. The design of the tieback anchors will be done based on the bracing design load determined above.

Bracing Design Load = $B_{top} = 21 \cdot klf$

Spacing of Tiebacks = $S_{tb} := 7 \cdot ft$

Vertical Installation Angle of Tiebacks = $\alpha := 13 \cdot deg$

Horizontal Installation Angle of Tieback = $\beta := 8 \cdot deg$

Design Load per Tieback = $DL := \dfrac{B_{top} \cdot S_{tb}}{\cos(\alpha) \cdot \cos(\beta)}$

$DL = 152 \cdot kips$

The tieback tendons will consist of 7-wire strand (f_u=270 ksi). The specification sheet for these tendons is on page A3 of these calculations. For the given design load a 5-strand tendon will be used which has an allowable design tensile load of up to 175.8 kips (60% GUTS).

Tieback Design Load = 152 kips

Estimate of Tieback Free Length

The tiebacks will be installed at 23 feet above subgrade. The active soil wedge failure plane will extend up from subgrade at approximately 30 degrees from vertical. The minimum required free length will be calculated here per PTI Section 6.8.1.

Height Above Subgrade to Tieback = $H_{tb} := 23 \cdot ft$

Angle of Failure Plane to Vertical = $\omega := 30 \cdot deg$

Minimum of Free Length = $L_{u.min} := \dfrac{\tan(\omega) \cdot H_{tb}}{\cos(\alpha)} + 5 \cdot ft$

$L_{u.min} = 18.6\,ft$

The minimum required free length, as per Section 6.8 of PTI *"Recommendations for Prestressed Rock and Soil Anchors"*, is 15 feet for strand anchors. Therefore the free length for the top row of tiebacks shall be 20 feet.

Tieback Free Length = 20 feet

Estimate of Tieback Bond Length

The above tieback loads are to be achieved with regrouted tiebacks drilled into the clay and sand layers. The estimated bond length will be determined based on the allowable grout to soil bond stress. The estimated bond stress will be taken from Table 5.3 of FHWA NHI-05-039 *"Micropile Design and Construction"* for anchors with one phase of secondary grouting, i.e. regrouted (Type C, see page A4).

Maximum Tieback Load = $DL = 152 \cdot kips$

Tieback Diameter = $d_{bond} := 4.5 \cdot in$

Estimated Bond Stress = $\beta := 20 \cdot psi$ (Tiebacks in Clay/Sand, Type C Grouting)

Factor of Safety = $FS := 1.50$

Allowable Bond Stress = $\varepsilon := \frac{\beta}{FS}$

$$\varepsilon = 13 \cdot psi$$

Estimated Capacity Per Foot of Anchor = $\lambda := \varepsilon \cdot (\pi \cdot d_{bond})$

$$\lambda = 2.26 \cdot klf$$

Estimated Bond Length for Tiebacks = $L_{bond} := \frac{DL}{\lambda}$

$$L_{bond} = 67 \cdot ft$$

The estimated bond length of 67 feet for the 152 kip tiebacks is given for informational purposes. All tiebacks will be tested in the field to verify that they can provide the required tieback reaction. For construction a bond length of 65 feet will be recommend.

Estimated Tieback Bond Length = 65 feet

Wale Design

The wale will span between the soldier piles to transfer the lateral bracing loads. The tiebacks will be located 1.3 feet from the soldier pile centerline. The wale will be designed for the resulting bending moment. The bending moment in the wale is calculated based on a simple beam with two equal concentrated loads symmetrically placed. The allowable bending stress in the wale will be 0.60 x F_y.

Distance from Tieback to Piles = $a := 1.3 \cdot ft$

Applied Bending Moment = $M_b := DL \cdot a$

$$M_b = 198 \cdot kft$$

Safety Factor For Flexure = $\Omega_b := 1.67$

Trial Section: 2 - C15x33.9 Channel

Yield Strength of Wale = $F_y := 50 \cdot ksi$

Modulus of Elasticity = $E := 29000 \cdot ksi$

Depth of Section = $d := 15.0 \cdot in$

Web Thickness = $t_w := 0.400 \cdot in$

Flange Width = $b_f := 3.40 \cdot in$

Flange Thickness = $t_f := 0.650 \cdot in$

Major Axis Elastic Section Modulus = $S_x := 42.0 \cdot in^3$

Major Axis Elastic Section Modulus = $Z_x := 50.8 \cdot in^3$

Minor Axis Radius of Gyration = $r_y := 0.901 \cdot in$

Minor Axis Moment of Inertia = $I_y := 8.07 \cdot in^4$

Distance Between Flange Centroids = $h_o := d - t_f = 14.35 \cdot in$

Torsional Stiffness Constant = $J := 1.01 \cdot in^4$

Torsional Shear Constant = $C_w := 358 \cdot in^6$

Lateral Torsional Buckling Modification Factor = $C_b := 1.0$

Effective Radius of Gyration = $r_{ts} := \sqrt{\frac{\sqrt{I_y \cdot C_w}}{S_x}} = 1.13 \cdot in$ (AISC Eq. F2-7)

For Channel = $c := \frac{h_o}{2} \cdot \sqrt{\frac{I_y}{C_w}} = 1.08$

Limiting Width Thickness Ratios: $\lambda_p := 0.38 \cdot \sqrt{\frac{E}{F_y}} = 9$ (AISC Table B4.1)

$\lambda_r := 1.0 \cdot \sqrt{\frac{E}{F_y}} = 24$

Flange to Web Thickness Ratio = $\frac{b_f}{2t_f} = 3$ < $\lambda_p = 9$ (compact section)

Yielding Moment

Nominal Plastic Moment = $M_p := F_y \cdot Z_x$ (AISC Eq. F2-1)

$$M_p = 212 \cdot kft$$

Lateral Torsional Buckling Moment

Length Between Brace Points = $L_b := 7 \cdot ft$ (Support Bracket Spacing)

Limiting Lengths for Flexure:

$$L_p := 1.76 \cdot r_y \cdot \sqrt{\frac{E}{F_y}} = 38.2 \cdot in$$ (AISC Eq. F2-5)

$$L_r := 1.95 \cdot r_{ts} \cdot \frac{E}{0.7 \cdot F_y} \cdot \sqrt{\frac{J \cdot c}{S_x \cdot h_o}} \cdot \sqrt{1 + \sqrt{1 + 6.76 \cdot \left(\frac{0.7 \cdot F_y}{E} \cdot \frac{S_x \cdot h_o}{J \cdot c}\right)^2}}$$ (AISC Eq. F2-6)

$$L_r = 11.2\,ft$$

Critical Flexural Stress = $F_{cr} := \frac{C_b \cdot \pi^2 \cdot E}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2}$ (AISC Eq. F2-4)

$$F_{cr} = 69.2 \cdot ksi$$

Nominal Flexural Strength = (AISC Eq. F2-1, F2-2 and F2-3)

$$M_n := \begin{cases} F_y \cdot Z_x & \text{if } L_b < L_p \\ C_b \cdot \left[M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\frac{L_b - L_p}{L_r - L_p}\right)\right] & \text{if } L_p < L_b < L_r \\ F_{cr} \cdot S_x & \text{otherwise} \end{cases}$$

$$M_n = 169 \cdot kft$$

Allowable Flexural Strength for 2 Channel = $M_c := \frac{2M_n}{\Omega_b}$

$$M_c = 203 \cdot kft \quad \geq \quad M_b = 198 \cdot kft$$

Use 2-C15x33.9 Channels for Wale

Design of Bottom Level of Tieback Anchors

The tiebacks will be installed at a depth of 23 feet and at 7-foot spacing. The design of the tieback anchors will be done based on the bracing design load determined above.

Bracing Design Load = $B_{bottom} = 11.1 \cdot klf$

Spacing of Tiebacks = $S_{tb} := 7 \cdot ft$

Vertical Installation Angle of Tiebacks = $\alpha := 25 \cdot deg$

Horizontal Installation Angle of Tieback = $\beta := 0 \cdot deg$

Design Load per Tieback = $DL := \dfrac{B_{bottom} \cdot S_{tb}}{\cos(\alpha) \cdot \cos(\beta)}$

$$DL = 86 \cdot kips$$

The tieback tendons will consist of 7-wire strand (f_u=270 ksi). The specification sheet for these tendons is on page A3 of these calculations. For the given design load a 3-strand tendon will be used which has an allowable design tensile load of up to 105.5 kips (60% GUTS).

Tieback Design Load = 86 kips

Estimate of Tieback Free Length

The tiebacks will be installed at 10 feet above subgrade. The active soil wedge failure plane will extend up from subgrade at approximately 30 degrees from vertical. The minimum required free length will be calculated here per PTI Section 6.8.1.

Height Above Subgrade to Tieback = $H_{tb} := 10 \cdot ft$

Angle of Failure Plane to Vertical = $\omega := 30 \cdot deg$

Minimum of Free Length = $L_{u.min} := \dfrac{\tan(\omega) \cdot H_{tb}}{\cos(\alpha)} + 5 \cdot ft$

$$L_{u.min} = 11.4\,ft$$

The minimum required free length, as per Section 6.8 of PTI *"Recommendations for Prestressed Rock and Soil Anchors"*, is 15 feet for strand anchors. Therefore the free length for the bottom row of tiebacks shall be 15 feet.

Tieback Free Length = 15 feet

Estimate of Tieback Bond Length

The above tieback loads are to be achieved with regrouted tiebacks drilled into the sand and till layers. The estimated bond length will be determined based on the allowable grout to soil bond stress. The estimated bond stress will be taken from Table 5.3 of FHWA NHI-05-039 *"Micropile Design and Construction"* for anchors with one phase of secondary grouting, i.e. regrouted (Type C, see page A4).

Maximum Tieback Load = $DL = 86 \cdot kips$

Tieback Diameter = $d_{bond} := 4.5 \cdot in$

Estimated Bond Stress = $\beta := 30 \cdot psi$ (Tiebacks in Sand, Type C Grouting)

Factor of Safety = $FS := 1.50$

Allowable Bond Stress = $\varepsilon := \frac{\beta}{FS}$

$\varepsilon = 20 \cdot psi$

Estimated Capacity Per Foot of Anchor = $\lambda := \varepsilon \cdot (\pi \cdot d_{bond})$

$\lambda = 3.39 \cdot klf$

Estimated Bond Length for Tiebacks = $L_{bond} := \frac{DL}{\lambda}$

$L_{bond} = 25 \cdot ft$

The estimated bond length of 25 feet for the 86 kip tiebacks is given for informational purposes. All tiebacks will be tested in the field to verify that they can provide the required tieback reaction. For construction a bond length of 25 feet will be recommend.

Estimated Tieback Bond Length = 25 feet

Wale Design

The wale will span between the soldier piles to transfer the lateral bracing loads. The tiebacks will be located 1-foot from the soldier pile centerline. The wale will be designed for the resulting bending moment. The bending moment in the wale is calculated based on a simple beam with two equal concentrated loads symmetrically placed. The allowable bending stress in the wale will be 0.60 x F_y.

Distance from Tieback to Piles = $a := 1 \cdot ft$

Applied Bending Moment = $M_b := DL \cdot a$

$M_b = 86 \cdot kft$

Safety Factor For Flexure = $\Omega_b := 1.67$

Trial Section: 2 - C15x33.9 Channel

Yield Strength of Wale = $F_y := 50 \cdot ksi$

Modulus of Elasticity = $E := 29000 \cdot ksi$

Depth of Section = $d := 15.0 \cdot in$

Web Thickness = $t_w := 0.400 \cdot in$

Flange Width = $b_f := 3.40 \cdot in$

Flange Thickness = $t_f := 0.650 \cdot in$

Major Axis Elastic Section Modulus = $S_x := 42.0 \cdot in^3$

Major Axis Elastic Section Modulus = $Z_x := 50.8 \cdot in^3$

Minor Axis Radius of Gyration = $r_y := 0.901 \cdot in$

Minor Axis Moment of Inertia = $I_y := 8.07 \cdot in^4$

Distance Between Flange Centroids = $h_o := d - t_f = 14.35 \cdot in$

Torsional Stiffness Constant = $J := 1.01 \cdot in^4$

Torsional Shear Constant = $C_w := 358 \cdot in^6$

Lateral Torsional Buckling Modification Factor = $C_b := 1.0$

Effective Radius of Gyration = $r_{ts} := \sqrt{\frac{\sqrt{I_y \cdot C_w}}{S_x}} = 1.13 \cdot in$ (AISC Eq. F2-7)

For Channel = $c := \frac{h_o}{2} \cdot \sqrt{\frac{I_y}{C_w}} = 1.08$

Limiting Width Thickness Ratios: $\lambda_p := 0.38 \cdot \sqrt{\frac{E}{F_y}} = 9$ (AISC Table B4.1)

$\lambda_r := 1.0 \cdot \sqrt{\frac{E}{F_y}} = 24$

Flange to Web Thickness Ratio = $\frac{b_f}{2t_f} = 3$ < $\lambda_p = 9$ (compact section)

Yielding Moment

Nominal Plastic Moment = $M_p := F_y \cdot Z_x$ (AISC Eq. F2-1)

$$M_p = 212 \cdot kft$$

Lateral Torsional Buckling Moment

Length Between Brace Points = $L_b := 7 \cdot ft$ (Support Bracket Spacing)

Limiting Lengths for Flexure:

$$L_p := 1.76 \cdot r_y \cdot \sqrt{\frac{E}{F_y}} = 38.2 \cdot in$$ (AISC Eq. F2-5)

$$L_r := 1.95 \cdot r_{ts} \cdot \frac{E}{0.7 \cdot F_y} \cdot \sqrt{\frac{J \cdot c}{S_x \cdot h_o}} \cdot \sqrt{1 + \sqrt{1 + 6.76 \cdot \left(\frac{0.7 \cdot F_y}{E} \cdot \frac{S_x \cdot h_o}{J \cdot c}\right)^2}}$$ (AISC Eq. F2-6)

$$L_r = 11.2\,ft$$

Critical Flexural Stress = $F_{cr} := \frac{C_b \cdot \pi^2 \cdot E}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2}$ (AISC Eq. F2-4)

$$F_{cr} = 69.2 \cdot ksi$$

Nominal Flexural Strength = (AISC Eq. F2-1, F2-2 and F2-3)

$$M_n := \begin{cases} F_y \cdot Z_x & \text{if } L_b < L_p \\ C_b \cdot \left[M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\frac{L_b - L_p}{L_r - L_p}\right)\right] & \text{if } L_p < L_b < L_r \\ F_{cr} \cdot S_x & \text{otherwise} \end{cases}$$

$$M_n = 169 \cdot kft$$

Allowable Flexural Strength for 2 Channel = $M_c := \frac{2M_n}{\Omega_b}$

$$M_c = 203 \cdot kft \quad \geq \quad M_b = 86 \cdot kft$$

<u>Use 2-C15x33.9 Channels for Wale</u>

Design Case 2 - Soldier Piles 3 and 4 at South Wall

The design height of support will be 30 feet with a level of bracing at 11 feet.

Design Case 2a - Cantilever Height of Support of 13 Feet

The design cantilever height of support will be 13 feet for installation of tiebacks at 11 feet. This condition was analyzed in Design Case 1a and the results will be used here. The results are taken from pages B1 to B4

Maximum Bending Moment = $M_{2a} := M_{1a}$

$$M_{2a} = 323.7 \cdot kft$$

Minimum Soldier Pile Length = $L_{2a} := L_{1a}$

$$L_{2a} = 30.7\,ft$$

Design Case 2b - Braced Height of Support of 30 Feet

The braced design height of support will be 30 feet with a level of bracing at 11 feet.

Top of Soldier Piles = $El_t := 62 \cdot ft$

Subgrade Elevation = $El_s := 32 \cdot ft$

Height of Excavation = $H := El_t - El_s$

$$H = 30\,ft$$

Water Table Elev. = $El_w := 32 \cdot ft$

Apparent Earth Pressure = $P_a := 0.65 \cdot K_{af} \cdot \gamma_{fill} \cdot H$

$$P_a = 24 \cdot H \cdot pcf$$

$$P_a = 710 \cdot psf$$

Total Apparent Soil Load = $TL_{soil} := P_a \cdot H$

$$TL_{soil} = 21.3 \cdot klf$$

Maximum Apparent Soil Pressure = $p := \dfrac{TL_{soil}}{\frac{2}{3} \cdot H}$

$$p = 1065 \cdot psf$$

Active Pressure

Active Pressure at Subgrade = $P_{a1} := K_{as} \cdot (20 \cdot ft \cdot \gamma_{fill} + 10 \cdot ft \cdot \gamma_{sand})$

$P_{a1} = 1027 \cdot psf$

Slope of Active in Sand = $S_{a1} := K_{as} \cdot \gamma_{bs}$

$S_{a1} = 19 \cdot \frac{psf}{ft}$

Active Pressure at Till = $P_{a2} := K_{at} \cdot (20 \cdot ft \cdot \gamma_{fill} + 10 \cdot ft \cdot \gamma_{sand} + 12 \cdot ft \cdot \gamma_{bs})$

$P_{a2} = 1061 \cdot psf$

Slope of Active in Till = $S_{a2} := K_{at} \cdot \gamma_{bt}$

$S_{a2} = 18 \cdot \frac{psf}{ft}$

Passive Earth Pressures

Slope of Passive in Sand Below Water = $S_{p1} := K_{ps} \cdot \gamma_{bs}$

$S_{p1} = 246 \cdot \frac{psf}{ft}$

Passive Pressure at Till = $P_{p2} := K_{pt} \cdot (12 \cdot ft \cdot \gamma_{bs})$

$P_{p2} = 9322 \cdot psf$

Slope of Passive in Till = $S_{p2} := K_{pt} \cdot \gamma_{bt}$

$S_{p2} = 884 \cdot \frac{psf}{ft}$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages C1 to C4 of these calculations.

Maximum Bending Moment = $M_{2b} := 250.26 \cdot kft$

Lateral Brace Loading = $B_{2b} := 20.8 \cdot klf$

Minimum Soldier Pile Length = $L_{2b} := 39.51 \cdot ft$

Design Loads for Excavation Support System

Maximum Bending Moment = $M_{max} := \max(M_{2a}, M_{2b})$

$M_{max} = 323.7 \cdot kft$

Bracing Loads = $B := B_{2b}$

$B = 20.8 \cdot klf$

Minimum Soldier Pile Length = $L_{min} := \max(L_{2a}, L_{2b})$

$L_{min} = 39.5\, ft$

Soldier Pile Design

The soldier pile design will determine the required pile section and length based on the analysis above along with determining the estimated maximum deflection.

Soldier Pile Section

The required soldier pile section will be determined based on AISC allowable bending stresses for design of the temporary excavation support system.

Yield Strength = $F_y := 50 \cdot ksi$ (ASTM A572 Steel)

Maximum Bending Moment = $M_b := M_{max}$

$M_b = 323.74 \cdot kft$

Required Section Modulus = $S_x := \dfrac{M_b}{0.667 \cdot F_y}$

$S_x = 116.49 \cdot in^3$

Use W24x104 Section with S_x = 258 in^3

Soldier Pile Length

The required soldier pile length is determined by the CT-Shoring Program. The results of this analysis are given above.

Minimum Soldier Pile Length = $L_{min} = 39.51\, ft$

Provide 40-Foot Long Soldier Piles

Estimated Lateral Deflection of Soldier Pile Wall

Lateral deflection of soldier pile wall will be estimated using the CT-Shoring program. The moment of inertia for the W24x104 soldier pile section is input (S_x = 3100 in^4) and the program generates an estimated lateral deflections for the cantilever and braced conditions. The results for the cantilever deflection are taken from page B13 and for the braced deflection are taken from page C5 of these calculations.

Estimated Cantilever Deflection = $\delta_{2a} := \delta_{1a}$

$$\delta_{2a} = 0.48 \cdot \text{in}$$

Estimated Braced Deflection = $\delta_{2b} := 0.23 \cdot \text{in}$

Based on this result the estimated maximum lateral of the soldier pile wall will be less than 1/2 inch. This is only an estimate and the actual deflection may vary based on specific soil and surcharge conditions.

Use W24x104 with Length of 40 Feet for Piles 3 and 4

Design of Tieback Anchors

The tiebacks will be installed at a depth of 11 feet and at 7-foot spacing. The design of the tieback anchors will be done based on the bracing design load determined above.

Bracing Design Load = $B = 20.8 \cdot \text{klf}$

Spacing of Tiebacks = $S_{tb} := 7 \cdot \text{ft}$

Vertical Installation Angle of Tiebacks = $\alpha := 26 \cdot \text{deg}$

Horizontal Installation Angle of Tieback = $\beta := 2 \cdot \text{deg}$

Design Load per Tieback = $DL := \dfrac{B \cdot S_{tb}}{\cos(\alpha) \cdot \cos(\beta)}$

$$DL = 162 \cdot \text{kips}$$

The tieback tendons will consist of 7-wire strand (f_u=270 ksi). The specification sheet for these tendons is on page A3 of these calculations. For the given design load a 5-strand tendon will be used which has an allowable tensile load of up to 175.8 kips (60% GUTS).

Tieback Design Load = 162 kips

Estimate of Tieback Free Length

The tiebacks will be installed at 19 feet above subgrade. The active soil wedge failure plane will extend up from subgrade at approximately 30 degrees from vertical. The minimum required free length will be calculated here per PTI Section 6.8.1.

Height Above Subgrade to Tieback = $H_{tb} := 19 \cdot ft$

Angle of Failure Plane to Vertical = $\omega := 30 \cdot deg$

Minimum of Free Length = $L_{u.min} := \dfrac{\tan(\omega) \cdot H_{tb}}{\cos(\alpha)} + 5 \cdot ft$

$L_{u.min} = 17.2\, ft$

The minimum required free length, as per Section 6.8 of PTI *"Recommendations for Prestressed Rock and Soil Anchors"*, is 15 feet for strand anchors. Therefore the free length of tiebacks shall be 20 feet.

Tieback Free Length = 20 feet

Estimate of Tieback Bond Length

The above tieback loads are to be achieved with grouted tiebacks drilled into the sand and till layers. The required bond length will be determined based on the allowable grout to soil bond stress. The estimated bond stress will be taken from Table 5.3 of FHWA NHI-05-039 *"Micropile Design and Construction"* for anchors with one phase of secondary grouting, i.e. regrouted (Type C, see page A4).

Maximum Tieback Load = $DL = 162 \cdot kips$

Tieback Diameter = $d_{bond} := 4.5 \cdot in$

Estimated Bond Stress = $\beta := 30 \cdot psi$ (Tiebacks in Sand, Type C Grouting)

Factor of Safety = $FS := 1.50$

Allowable Bond Stress = $\varepsilon := \dfrac{\beta}{FS}$

$\varepsilon = 20 \cdot psi$

Estimated Capacity Per Foot of Anchor = $\lambda := \varepsilon \cdot (\pi \cdot d_{bond})$

$\lambda = 3.39 \cdot klf$

Estimated Bond Length for Tiebacks = $L_{bond} := \frac{DL}{\lambda}$

$L_{bond} = 48 \cdot ft$

The estimated bond length of 48 feet for the 162 kip tiebacks is given for informational purposes. All tiebacks will be tested in the field to verify that they can provide the required tieback reaction.

Estimated Tieback Bond Length = 48 feet

Wale Design

The wale will span between the soldier piles to transfer the lateral bracing loads. The tiebacks will be located 1.3 feet from the soldier pile centerline. The wale will be designed for the resulting bending moment. The bending moment in the wale is calculated based on a simple beam with two equal concentrated loads symmetrically placed. The allowable bending stress in the wale will be 0.60 x F_y.

Distance from Tieback to Piles = $a := 1.3 \cdot ft$

Applied Bending Moment = $M_b := DL \cdot a$

$M_b = 211 \cdot kft$

Safety Factor For Flexure = $\Omega_b := 1.67$

Trial Section: 2 - C15x50 Channel

Yield Strength of Wale = $F_y := 50 \cdot ksi$

Modulus of Elasticity = $E := 29000 \cdot ksi$

Depth of Section = $d := 15.0 \cdot in$

Web Thickness = $t_w := 0.716 \cdot in$

Flange Width = $b_f := 3.72 \cdot in$

Flange Thickness = $t_f := 0.650 \cdot in$

Major Axis Elastic Section Modulus = $S_x := 53.8 \cdot in^3$

Major Axis Elastic Section Modulus = $Z_x := 68.5 \cdot in^3$

Minor Axis Radius of Gyration = $r_y := 0.865 \cdot in$

Minor Axis Moment of Inertia = $I_y := 11.0 \cdot in^4$

Distance Between Flange Centroids = $h_o := d - t_f = 14.35 \cdot in$

Torsional Stiffness Constant = $J := 2.65 \cdot in^4$

Torsional Shear Constant = $C_w := 492 \cdot in^6$

Lateral Torsional Buckling Modification Factor = $C_b := 1.0$

Effective Radius of Gyration = $r_{ts} := \sqrt{\frac{\sqrt{I_y \cdot C_w}}{S_x}} = 1.17 \cdot in$ (AISC Eq. F2-7)

For Channel = $c := \frac{h_o}{2} \cdot \sqrt{\frac{I_y}{C_w}} = 1.07$

Limiting Width Thickness Ratios: $\lambda_p := 0.38 \cdot \sqrt{\frac{E}{F_y}} = 9$ (AISC Table B4.1)

$\lambda_r := 1.0 \cdot \sqrt{\frac{E}{F_y}} = 24$

Flange to Web Thickness Ratio = $\frac{b_f}{2t_f} = 3 < \lambda_p = 9$ (compact section)

Yielding Moment

Nominal Plastic Moment = $M_p := F_y \cdot Z_x$ (AISC Eq. F2-1)

$M_p = 285 \cdot kft$

Lateral Torsional Buckling Moment

Length Between Brace Points = $L_b := 7 \cdot ft$ (Support Bracket Spacing)

Limiting Lengths for Flexure:

$L_p := 1.76 \cdot r_y \cdot \sqrt{\frac{E}{F_y}} = 36.7 \cdot in$ (AISC Eq. F2-5)

$L_r := 1.95 \cdot r_{ts} \cdot \frac{E}{0.7 \cdot F_y} \cdot \sqrt{\frac{J \cdot c}{S_x \cdot h_o}} \cdot \sqrt{1 + \sqrt{1 + 6.76 \cdot \left(\frac{0.7 \cdot F_y}{E} \cdot \frac{S_x \cdot h_o}{J \cdot c}\right)^2}}$ (AISC Eq. F2-6)

$L_r = 14.5 \, ft$

Critical Flexural Stress = $F_{cr} := \frac{C_b \cdot \pi^2 \cdot E}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2}$ (AISC Eq. F2-4)

$F_{cr} = 87.4 \cdot ksi$

Nominal Flexural Strength = (AISC Eq. F2-1, F2-2 and F2-3)

$$M_n := \begin{cases} F_y \cdot Z_x & \text{if } L_b < L_p \\ C_b \cdot \left[M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\frac{L_b - L_p}{L_r - L_p}\right)\right] & \text{if } L_p < L_b < L_r \\ F_{cr} \cdot S_x & \text{otherwise} \end{cases}$$

$M_n = 241 \cdot kft$

Allowable Flexural Strength for 2 Channel = $M_c := \frac{2M_n}{\Omega_b}$

$M_c = 289 \cdot kft \quad \geq \quad M_b = 211 \cdot kft$

Use 2-C15x50 Channels for Wale

Design Case 3 - Soldier Piles 5 and 6 at South Wall

The design height of support will be 27 feet with a level of bracing at 11 feet.

Design Case 3a - Cantilever Height of Support of 13 Feet

The design cantilever height of support will be 13 feet for installation of tiebacks at 11 feet. This condition was analyzed in Design Case 1a and the results will be used here. The results are taken from pages B1 to B4

Maximum Bending Moment = $M_{3a} := M_{1a}$

$M_{3a} = 323.7 \cdot kft$

Minimum Soldier Pile Length = $L_{3a} := L_{1a}$

$L_{3a} = 30.7 \cdot ft$

Design Case 3b - Braced Height of Support of 27 Feet

The braced design height of support will be 27 feet with a level of bracing at 11 feet.

Top of Soldier Piles = $El_t := 59 \cdot ft$

Subgrade Elevation = $El_s := 32 \cdot ft$

Height of Excavation = $H := El_t - El_s$

$H = 27\,ft$

Water Table Elev. = $El_w := 32 \cdot ft$

Apparent Earth Pressure = $P_a := 0.65 \cdot K_{af} \cdot \gamma_{fill} \cdot H$

$P_a = 24 \cdot H \cdot pcf$

$P_a = 639 \cdot psf$

Total Apparent Soil Load = $TL_{soil} := P_a \cdot H$

$TL_{soil} = 17.2 \cdot klf$

Maximum Apparent Soil Pressure = $p := \dfrac{TL_{soil}}{\frac{2}{3} \cdot H}$

$p = 958 \cdot psf$

Active Pressure

Active Pressure at Subgrade = $P_{a1} := K_{as} \cdot (20 \cdot ft \cdot \gamma_{fill} + 7 \cdot ft \cdot \gamma_{sand})$

$P_{a1} = 922 \cdot psf$

Slope of Active in Sand = $S_{a1} := K_{as} \cdot \gamma_{bs}$

$S_{a1} = 19 \cdot \dfrac{psf}{ft}$

Active Pressure at Till = $P_{a2} := K_{at} \cdot (20 \cdot ft \cdot \gamma_{fill} + 7 \cdot ft \cdot \gamma_{sand} + 15 \cdot ft \cdot \gamma_{bs})$

$P_{a2} = 1019 \cdot psf$

Slope of Active in Till = $S_{a2} := K_{at} \cdot \gamma_{bt}$

$S_{a2} = 18 \cdot \dfrac{psf}{ft}$

Passive Earth Pressures

Slope of Passive in Sand = $S_{p1} := K_{ps} \cdot \gamma_{bs}$

$S_{p1} = 246 \cdot \dfrac{psf}{ft}$

Passive Pressure at Till = $P_{p2} := K_{pt} \cdot (15 \cdot ft \cdot \gamma_{bs})$

$$P_{p2} = 11652 \cdot psf$$

Slope of Passive in Till = $S_{p2} := K_{pt} \cdot \gamma_{bt}$

$$S_{p2} = 884 \cdot \frac{psf}{ft}$$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages D1 to D4 of these calculations.

Maximum Bending Moment = $M_{3b} := 230.70 \cdot kft$

Lateral Brace Loading = $B_{3b} := 17.7 \cdot klf$

Minimum Soldier Pile Length = $L_{3b} := 34.96 \cdot ft$

Design Loads for Excavation Support System

Maximum Bending Moment = $M_{max} := \max(M_{3a}, M_{3b})$

$$M_{max} = 323.7 \cdot kft$$

Bracing Loads = $B := B_{3b}$

$$B = 17.7 \cdot klf$$

Minimum Soldier Pile Length = $L_{min} := \max(L_{3a}, L_{3b})$

$$L_{min} = 35\,ft$$

Soldier Pile Design

The soldier pile design will determine the required pile section and length based on the analysis above along with determining the estimated maximum deflection.

Soldier Pile Section

The required soldier pile section will be determined based on AISC allowable bending stresses for design of the temporary excavation support system.

Yield Strength = $F_y := 50 \cdot ksi$ (ASTM A572 Steel)

Maximum Bending Moment = $M_b := M_{max}$

$$M_b = 323.74 \cdot kft$$

Required Section Modulus = $S_x := \dfrac{M_b}{0.667 \cdot F_y}$

$$S_x = 116.49 \cdot in^3$$

<u>Use W24x104 Section with S_x = 258 in^3</u>

<u>Soldier Pile Length</u>

The required soldier pile length is determined by the CT-Shoring Program. The results of this analysis are given above.

Minimum Soldier Pile Length = $L_{min} = 34.96\,ft$

<u>Provide 35-Foot Long Soldier Piles</u>

<u>Estimated Lateral Deflection of Soldier Pile Wall</u>

Lateral deflection of soldier pile wall will be estimated using the CT-Shoring program. The moment of inertia for the W24x104 soldier pile section is input (S_x = 3100 in^4) and the program generates an estimated lateral deflections for the cantilever and braced conditions. The results for the cantilever deflection are taken from page B13 and for the braced deflection are taken from page D5 of these calculations.

Estimated Cantilever Deflection = $\delta_{3a} := \delta_{1a}$

$$\delta_{3a} = 0.48 \cdot in$$

Estimated Braced Deflection = $\delta_{3b} := 0.10 \cdot in$

Based on this result the estimated maximum lateral of the soldier pile wall will be less than 1/2 inch. This is only an estimate and the actual deflection may vary based on specific soil and surcharge conditions.

<u>Use W24x104 with Length of 35 Feet for Piles 5 and 6</u>

<u>Design of Tieback Anchors</u>

The tiebacks will be installed at a depth of 11 feet and at 7-foot spacing. The design of the tieback anchors will be done based on the bracing design load determined above.

Bracing Design Load = $B = 17.7 \cdot klf$

Spacing of Tiebacks = $S_{tb} := 7 \cdot ft$

Vertical Installation Angle of Tiebacks = $\alpha := 28 \cdot deg$

Horizontal Installation Angle of Tieback = $\beta := 8 \cdot deg$

Design Load per Tieback = $DL := \dfrac{B \cdot S_{tb}}{\cos(\alpha) \cdot \cos(\beta)}$

$DL = 142 \cdot kips$

The tieback tendons will consist of 7-wire strand (f_u=270 ksi). The specification sheet for these tendons is on page A3 of these calculations. For the given design load a 5-strand tendon will be used which has an allowable tensile load of up to 175.8 kips (60% GUTS).

Tieback Design Load = 142 kips

Estimate of Tieback Free Length

The tiebacks will be installed at 16 feet above subgrade. The active soil wedge failure plane will extend up from subgrade at approximately 30 degrees from vertical. The minimum required free length will be calculated here per PTI Section 6.8.1.

Height Above Subgrade to Tieback = $H_{tb} := 16 \cdot ft$

Angle of Failure Plane to Vertical = $\omega := 30 \cdot deg$

Minimum of Free Length = $L_{u.min} := \dfrac{\tan(\omega) \cdot H_{tb}}{\cos(\alpha)} + 5 \cdot ft$

$L_{u.min} = 15.5\,ft$

The minimum required free length, as per Section 6.8 of PTI *"Recommendations for Prestressed Rock and Soil Anchors"*, is 15 feet for strand anchors. Therefore the free length of tiebacks shall be 15 feet.

Tieback Free Length = 15 feet

Estimate of Tieback Bond Length

The above tieback loads are to be achieved with grouted tiebacks drilled into the sand and till layers. The required bond length will be determined based on the allowable grout to soil bond stress. The estimated bond stress will be taken from Table 5.3 of FHWA NHI-05-039 *"Micropile Design and Construction"* for anchors with one phase of secondary grouting, i.e. regrouted (Type C, see page A4).

Maximum Tieback Load = $DL = 142 \cdot kips$

Tieback Diameter = $d_{bond} := 4.5 \cdot in$

Estimated Bond Stress = $\beta := 30 \cdot psi$ (Tiebacks in Sand, Type C Grouting)

Factor of Safety = $FS := 1.50$

Allowable Bond Stress = $\varepsilon := \frac{\beta}{FS}$

$\varepsilon = 20 \cdot psi$

Estimated Capacity Per Foot of Anchor = $\lambda := \varepsilon \cdot (\pi \cdot d_{bond})$

$\lambda = 3.39 \cdot klf$

Estimated Bond Length for Tiebacks = $L_{bond} := \frac{DL}{\lambda}$

$L_{bond} = 42 \cdot ft$

The estimated bond length of 39 feet for the 133 kip tiebacks is given for informational purposes. All tiebacks will be tested in the field to verify that they can provide the required tieback reaction.

Estimated Tieback Bond Length = 40 feet

Wale Design

The wale will span between the soldier piles to transfer the lateral bracing loads. The tiebacks will be located 1.3 feet from the soldier pile centerline. The wale will be designed for the resulting bending moment. The bending moment in the wale is calculated based on a simple beam with two equal concentrated loads symmetrically placed. The allowable bending stress in the wale will be 0.60 x F_y.

Distance from Tieback to Piles = $a := 1.3 \cdot ft$

Applied Bending Moment = $M_b := DL \cdot a$

$M_b = 184 \cdot kft$

Safety Factor For Flexure = $\Omega_b := 1.67$

Trial Section: 2 - C15x33.9 Channel

Yield Strength of Wale = $F_y := 50 \cdot ksi$

Modulus of Elasticity = $E := 29000 \cdot ksi$

Depth of Section = $d := 15.0 \cdot in$

Web Thickness = $t_w := 0.400 \cdot in$

Flange Width = $b_f := 3.40 \cdot in$

Flange Thickness = $t_f := 0.650 \cdot in$

Major Axis Elastic Section Modulus = $S_x := 42.0 \cdot in^3$

Major Axis Elastic Section Modulus = $Z_x := 50.8 \cdot in^3$

Minor Axis Radius of Gyration = $r_y := 0.901 \cdot in$

Minor Axis Moment of Inertia = $I_y := 8.07 \cdot in^4$

Distance Between Flange Centroids = $h_o := d - t_f = 14.35 \cdot in$

Torsional Stiffness Constant = $J := 1.01 \cdot in^4$

Torsional Shear Constant = $C_w := 358 \cdot in^6$

Lateral Torsional Buckling Modification Factor = $C_b := 1.0$

Effective Radius of Gyration = $r_{ts} := \sqrt{\frac{\sqrt{I_y \cdot C_w}}{S_x}} = 1.13 \cdot in$ (AISC Eq. F2-7)

For Channel = $c := \frac{h_o}{2} \cdot \sqrt{\frac{I_y}{C_w}} = 1.08$

Limiting Width Thickness Ratios: $\lambda_p := 0.38 \cdot \sqrt{\frac{E}{F_y}} = 9$ (AISC Table B4.1)

$$\lambda_r := 1.0 \cdot \sqrt{\frac{E}{F_y}} = 24$$

Flange to Web Thickness Ratio = $\frac{b_f}{2t_f} = 3 \quad < \quad \lambda_p = 9$ (compact section)

Yielding Moment

Nominal Plastic Moment = $M_p := F_y \cdot Z_x$ (AISC Eq. F2-1)

$$M_p = 212 \cdot kft$$

Lateral Torsional Buckling Moment

Length Between Brace Points = $L_b := 7 \cdot ft$ (Support Bracket Spacing)

Limiting Lengths for Flexure:

$$L_p := 1.76 \cdot r_y \cdot \sqrt{\frac{E}{F_y}} = 38.2 \cdot in$$ (AISC Eq. F2-5)

$$L_r := 1.95 \cdot r_{ts} \cdot \frac{E}{0.7 \cdot F_y} \cdot \sqrt{\frac{J \cdot c}{S_x \cdot h_o}} \cdot \sqrt{1 + \sqrt{1 + 6.76 \cdot \left(\frac{0.7 \cdot F_y}{E} \cdot \frac{S_x \cdot h_o}{J \cdot c}\right)^2}}$$ (AISC Eq. F2-6)

$$L_r = 11.2\,ft$$

Critical Flexural Stress = $$F_{cr} := \frac{C_b \cdot \pi^2 \cdot E}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2}$$ (AISC Eq. F2-4)

$$F_{cr} = 69.2 \cdot ksi$$

Nominal Flexural Strength = (AISC Eq. F2-1, F2-2 and F2-3)

$$M_n := \begin{cases} F_y \cdot Z_x & \text{if } L_b < L_p \\ C_b \cdot \left[M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\frac{L_b - L_p}{L_r - L_p}\right)\right] & \text{if } L_p < L_b < L_r \\ F_{cr} \cdot S_x & \text{otherwise} \end{cases}$$

$$M_n = 169 \cdot kft$$

Allowable Flexural Strength for 2 Channel = $M_c := \frac{2M_n}{\Omega_b}$

$$M_c = 203 \cdot kft \quad \geq \quad M_b = 184 \cdot kft$$

Use 2-C15x33.9 Channels for Wale

Design Case 4 - Soldier Piles 7 to 10 Along Gilman Street

The design height of support will be 24 feet with a level of bracing at 8 feet.

Design Case 4a - Cantilever Height of Support of 10 Feet

The design cantilever height of support will be 10 feet for installation of tiebacks at 8 feet.

Top of Soldier Piles = $El_t := 56 \cdot ft$

Subgrade Elevation = $El_s := 46 \cdot ft$

Height of Excavation = $H := El_t - El_s$

$H = 10\,ft$

Water Table Elev. = $El_w := 46 \cdot ft$

Active Pressure

Active Pressure at Bottom of Subgrade = $P_{a1} := K_{af} \cdot (10 \cdot ft \cdot \gamma_{fill})$

$P_{a1} = 364 \cdot psf$

Slope of Active in Fill = $S_{a1} := K_{af} \cdot \gamma_{bf}$

$S_{a1} = 19 \cdot \frac{psf}{ft}$

Active Pressure at Sand = $P_{a2} := K_{as} \cdot (10 \cdot ft \cdot \gamma_{fill} + 10 \cdot ft \cdot \gamma_{bf})$

$P_{a2} = 514 \cdot psf$

Slope of Active in Sand Below Water = $S_{a2} := K_{as} \cdot \gamma_{bs}$

$S_{a2} = 19 \cdot \frac{psf}{ft}$

Active Pressure at Till = $P_{a3} := K_{at} \cdot (10 \cdot ft \cdot \gamma_{fill} + 10 \cdot ft \cdot \gamma_{bf} + 22 \cdot ft \cdot \gamma_{bs})$

$P_{a3} = 786 \cdot psf$

Slope of Active in Till = $S_{a3} := K_{at} \cdot \gamma_{bt}$

$S_{a3} = 18 \cdot \frac{psf}{ft}$

Passive Earth Pressures

Slope of Passive in Fill = $S_{p1} := K_{pf} \cdot \gamma_{bf}$

$S_{p1} = 239 \cdot \frac{psf}{ft}$

Passive Pressure at Sand = $P_{p3} := K_{ps} \cdot (10 \cdot ft \cdot \gamma_{bf})$

$P_{p3} = 2293 \cdot psf$

Slope of Passive in Sand Below Water = $S_{p3} := K_{ps} \cdot \gamma_{bs}$

$$S_{p3} = 246 \cdot \frac{psf}{ft}$$

Passive Pressure at Till = $P_{p4} := K_{pt} \cdot (10 \cdot ft \cdot \gamma_{bf} + 22 \cdot ft \cdot \gamma_{bs})$

$$P_{p4} = 24323 \cdot psf$$

Slope of Passive in Till = $S_{p4} := K_{pt} \cdot \gamma_{bt}$

$$S_{p4} = 884 \cdot \frac{psf}{ft}$$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages E1 to E4 of these calculations.

Maximum Bending Moment = $M_{4a} := 190.42 \cdot kft$

Minimum Soldier Pile Length = $L_{4a} := 24.04 \cdot ft$

Design Case 4b - Braced Height of Support of 24 Feet

The braced design height of support will be 24 feet with a level of bracing at 8 feet.

Top of Soldier Piles = $El_t = 56\,ft$

Subgrade Elevation = $El_s := 32 \cdot ft$

Height of Excavation = $H := El_t - El_s$

$$H = 24\,ft$$

Water Table Elev. = $El_w := 32 \cdot ft$

Apparent Earth Pressure = $P_a := 0.65 \cdot K_{af} \cdot \gamma_{fill} \cdot H$

$$P_a = 24 \cdot H \cdot pcf$$

$$P_a = 568 \cdot psf$$

Total Apparent Soil Load = $TL_{soil} := P_a \cdot H$

$$TL_{soil} = 13.6 \cdot klf$$

Maximum Apparent Soil Pressure = $p := \frac{TL_{soil}}{\frac{2}{3} \cdot H}$

$p = 852 \cdot psf$

Active Pressure

Active Pressure at Subgrade = $P_{a1} := K_{as} \cdot (20 \cdot ft \cdot \gamma_{fill} + 4 \cdot ft \cdot \gamma_{sand})$

$P_{a1} = 816 \cdot psf$

Slope of Active in Sand = $S_{a1} := K_{as} \cdot \gamma_{bs}$

$S_{a1} = 19 \cdot \frac{psf}{ft}$

Active Pressure at Till = $P_{a2} := K_{at} \cdot (20 \cdot ft \cdot \gamma_{fill} + 4 \cdot ft \cdot \gamma_{sand} + 18 \cdot ft \cdot \gamma_{bs})$

$P_{a2} = 978 \cdot psf$

Slope of Active in Till = $S_{a2} := K_{at} \cdot \gamma_{bt}$

$S_{a2} = 18 \cdot \frac{psf}{ft}$

Passive Earth Pressures

Slope of Passive in Sand = $S_{p1} := K_{ps} \cdot \gamma_{bs}$

$S_{p1} = 246 \cdot \frac{psf}{ft}$

Passive Pressure at Till = $P_{p2} := K_{pt} \cdot (18 \cdot ft \cdot \gamma_{bs})$

$P_{p2} = 13983 \cdot psf$

Slope of Passive in Till = $S_{p2} := K_{pt} \cdot \gamma_{bt}$

$S_{p2} = 884 \cdot \frac{psf}{ft}$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages E5 to E8 of these calculations.

Maximum Bending Moment = $M_{4b} := 141.60 \cdot kft$

Lateral Brace Loading = $B_{4b} := 13.7 \cdot klf$

Minimum Soldier Pile Length = $L_{4b} := 31.47 \cdot ft$

Design Loads for Excavation Support System

Maximum Bending Moment = $M_{max} := \max(M_{4a}, M_{4b})$

$M_{max} = 190.4 \cdot kft$

Bracing Loads = $B := B_{4b}$

$B = 13.7 \cdot klf$

Minimum Soldier Pile Length = $L_{min} := \max(L_{4a}, L_{4b})$

$L_{min} = 31.5\,ft$

Soldier Pile Design

The soldier pile design will determine the required pile section and length based on the analysis above along with determining the estimated maximum deflection.

Soldier Pile Section

The required soldier pile section will be determined based on AISC allowable bending stresses for design of the temporary excavation support system.

Yield Strength = $F_y := 50 \cdot ksi$ (ASTM A572 Steel)

Maximum Bending Moment = $M_b := M_{max}$

$M_b = 190.42 \cdot kft$

Required Section Modulus = $S_x := \dfrac{M_b}{0.667 \cdot F_y}$

$S_x = 68.52 \cdot in^3$

Use HP14x102 Section with $S_x = 150\ in^3$

Soldier Pile Length

The required soldier pile length is determined by the CT-Shoring Program. The results of this analysis are given above.

Minimum Soldier Pile Length = $L_{min} = 31.47\,ft$

Provide 32-Foot Long Soldier Piles

Estimated Lateral Deflection of Soldier Pile Wall

Lateral deflection of soldier pile wall will be estimated using the CT-Shoring program. The moment of inertia for the HP14x102 soldier pile section is input (S_x = 1050 in^4) and the program generates an estimated lateral deflections for the cantilever and braced conditions. The results are on pages E9 and E10 of these calculations.

Estimated Cantilever Deflection = $\delta_{4a} := 0.51 \cdot in$

Estimated Braced Deflection = $\delta_{4b} := 0.32 \cdot in$

Based on this result the estimated maximum lateral of the soldier pile wall will be less than 1/2 inch. This is only an estimate and the actual deflection may vary based on specific soil and surcharge conditions.

Use HP14x102 with Length of 32 Feet for Piles 7 to 10

Design of Tieback Anchors

The tiebacks will be installed at a depth of 8 feet and at 8-foot spacing. The design of the tieback anchors will be done based on the bracing design load determined above.

Bracing Design Load = $B = 13.7 \cdot klf$

Spacing of Tiebacks = $S_{tb} := 8 \cdot ft$

Installation Angle of Tiebacks = $\alpha := 20 \cdot deg$

Design Load per Tieback = $DL := \dfrac{B \cdot S_{tb}}{\cos(\alpha)}$

$DL = 117 \cdot kips$

The tieback tendons will consist of 7-wire strand (f_u=270 ksi). The specification sheet for these tendons is on pages A3 and A4 of these calculations. For the given design load a 4-strand tendon will be used which has an allowable tensile load of up to 140.6 kips (60% GUTS).

Tieback Design Load = 117 kips

Estimate of Tieback Free Length

The tiebacks will be installed at 16 feet above subgrade. The active soil wedge failure plane will extend up from subgrade at approximately 30 degrees from vertical. The minimum required free length will be calculated here per PTI Section 6.8.1.

Height Above Subgrade to Tieback = $H_{tb} := 16 \cdot ft$

Angle of Failure Plane to Vertical = $\omega := 30 \cdot deg$

Minimum of Free Length = $L_{u.min} := \dfrac{\tan(\omega) \cdot H_{tb}}{\cos(\alpha)} + 5 \cdot ft$

$L_{u.min} = 14.8\,ft$

The minimum required free length, as per Section 6.8 of PTI *"Recommendations for Prestressed Rock and Soil Anchors"*, is 15 feet for strand anchors. Therefore the free length of tiebacks shall be 15 feet.

Tieback Free Length = 15 feet

Estimate of Tieback Bond Length

The above tieback loads are to be achieved with regrouted tiebacks drilled into the clay layer. The required bond length will be determined based on the allowable grout to soil bond stress. The estimated bond stress will be taken from Table 5.3 of FHWA NHI-05-039 *"Micropile Design and Construction"* for anchors with one phase of secondary grouting, i.e. regrouted (Type C, see page A4).

Maximum Tieback Load = $DL = 117 \cdot kips$

Tieback Diameter = $d_{bond} := 4.5 \cdot in$

Estimated Bond Stress = $\beta := 20 \cdot psi$ (Tiebacks in Clay, Type C Grouting)

Factor of Safety = $FS := 1.50$

Allowable Bond Stress = $\varepsilon := \dfrac{\beta}{FS}$

$\varepsilon = 13 \cdot psi$

Estimated Capacity Per Foot of Anchor = $\lambda := \varepsilon \cdot (\pi \cdot d_{bond})$

$\lambda = 2.26 \cdot klf$

Estimated Bond Length for Tiebacks = $L_{bond} := \dfrac{DL}{\lambda}$

$L_{bond} = 52 \cdot ft$

The estimated bond length of 52 feet for the 117 kip tiebacks is given for informational purposes. All tiebacks will be tested in the field to verify that they can provide the required tieback reaction. For construction a bond length of 50 feet will be used.

Estimated Tieback Bond Length = 50 feet

Wale Design

The wale will span between the soldier piles to transfer the lateral bracing loads. The tiebacks will be located 1-foot from the soldier pile centerline. The wale will be designed for the resulting bending moment. The bending moment in the wale is calculated based on a simple beam with two equal concentrated loads symmetrically placed. The allowable bending stress in the wale will be 0.60 x F_y.

Distance from Tieback to Piles = $a := 1 \cdot ft$

Applied Bending Moment = $M_b := DL \cdot a$

$M_b = 117 \cdot kft$

Safety Factor For Flexure = $\Omega_b := 1.67$

Trial Section: 2 - C15x33.9 Channel

Yield Strength of Wale = $F_y := 50 \cdot ksi$

Modulus of Elasticity = $E := 29000 \cdot ksi$

Depth of Section = $d := 15.0 \cdot in$

Web Thickness = $t_w := 0.400 \cdot in$

Flange Width = $b_f := 3.40 \cdot in$

Flange Thickness = $t_f := 0.650 \cdot in$

Major Axis Elastic Section Modulus = $S_x := 42.0 \cdot in^3$

Major Axis Elastic Section Modulus = $Z_x := 50.8 \cdot in^3$

Minor Axis Radius of Gyration = $r_y := 0.901 \cdot in$

Minor Axis Moment of Inertia = $I_y := 8.07 \cdot in^4$

Distance Between Flange Centroids = $h_o := d - t_f = 14.35 \cdot in$

Torsional Stiffness Constant = $J := 1.01 \cdot in^4$

Torsional Shear Constant = $C_w := 358 \cdot in^6$

Lateral Torsional Buckling Modification Factor = $C_b := 1.0$

Effective Radius of Gyration = $r_{ts} := \sqrt{\frac{\sqrt{I_y \cdot C_w}}{S_x}} = 1.13 \cdot in$ (AISC Eq. F2-7)

For Channel = $c := \frac{h_o}{2} \cdot \sqrt{\frac{I_y}{C_w}} = 1.08$

Limiting Width Thickness Ratios: $\lambda_p := 0.38 \cdot \sqrt{\frac{E}{F_y}} = 9$ (AISC Table B4.1)

$$\lambda_r := 1.0 \cdot \sqrt{\frac{E}{F_y}} = 24$$

Flange to Web Thickness Ratio = $\frac{b_f}{2t_f} = 3 \quad < \quad \lambda_p = 9$ (compact section)

Yielding Moment

Nominal Plastic Moment = $M_p := F_y \cdot Z_x$ (AISC Eq. F2-1)

$$M_p = 212 \cdot kft$$

Lateral Torsional Buckling Moment

Length Between Brace Points = $L_b := 8 \cdot ft$ (Support Bracket Spacing)

Limiting Lengths for Flexure:

$$L_p := 1.76 \cdot r_y \cdot \sqrt{\frac{E}{F_y}} = 38.2 \cdot in$$ (AISC Eq. F2-5)

$$L_r := 1.95 \cdot r_{ts} \cdot \frac{E}{0.7 \cdot F_y} \cdot \sqrt{\frac{J \cdot c}{S_x \cdot h_o}} \cdot \sqrt{1 + \sqrt{1 + 6.76 \cdot \left(\frac{0.7 \cdot F_y}{E} \cdot \frac{S_x \cdot h_o}{J \cdot c}\right)^2}}$$ (AISC Eq. F2-6)

$$L_r = 11.2\,ft$$

Critical Flexural Stress = $F_{cr} := \frac{C_b \cdot \pi^2 \cdot E}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2}$ (AISC Eq. F2-4)

$$F_{cr} = 56.4 \cdot ksi$$

Nominal Flexural Strength = (AISC Eq. F2-1, F2-2 and F2-3)

$$M_n := \begin{cases} F_y \cdot Z_x & \text{if } L_b < L_p \\ C_b \cdot \left[M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\frac{L_b - L_p}{L_r - L_p} \right) \right] & \text{if } L_p < L_b < L_r \\ F_{cr} \cdot S_x & \text{otherwise} \end{cases}$$

$$M_n = 158 \cdot \text{kft}$$

Allowable Flexural Strength for 2 Channel = $M_c := \frac{2M_n}{\Omega_b}$

$$M_c = 189 \cdot \text{kft} \quad \geq \quad M_b = 117 \cdot \text{kft}$$

<u>Use 2-C15x33.9 Channels for Wale</u>

Bearing Plate Design

The tieback bearing plate will be designed to span the 6-inch gap between the double channel wale section. The tieback load will be applied to a wedge plate that will be set on the bearing plate. The tieback load will be applied as a uniform load over the width of the wedge plate. The resulting bending moment will be used for design of the bearing plate.

Maximum Tieback Load = $P_b := 162 \cdot \text{kips}$ (Design Case 2)

Span Between Channels = $L_c := 6 \cdot \text{in}$

Diameter of Wedge Plate = $A := 3.15 \cdot \text{in}$

Uniform Load Over Wedge Plate = $w := \frac{P_b}{A}$

$$w = 51.4 \cdot \text{kpi}$$

Bending Moment in Plate = $M_b := \frac{DL}{2} \cdot \left(\frac{L_c - A}{2} + \frac{\frac{DL}{2}}{2.w} \right)$

$$M_b = 9.68 \cdot \text{kft}$$

Yield Stress of Bearing Plate = $F_y := 50 \cdot \text{ksi}$

Side Dimension of Bearing Plate at Wedge Plate Hole = $x := 12 \cdot \text{in} - A$

$$x = 8.85 \cdot \text{in}$$

Minimum Required Plate Thickness = $t_{min} := \sqrt{\dfrac{6 \cdot M_b}{x \cdot (0.75 \cdot F_y)}}$

$t_{min} = 1.45 \cdot in$

<u>Provide 12"x12"x1.5" (Gr. 50) Tieback Bearing Plates</u>

<u>Wale Support Bracket Design</u>

The tieback wale will be set on chairs that will be welded to each soldier pile. Each chair will be designed for the vertical load in shear. The required weld will be determined here based on the maximum tieback load determined above.

Weld Force Per Bracket = $P_b = 162\,kips$ (Design Case 2)

Vertical Shear Loading = $F_v := P_b \cdot \sin(\alpha)$

$F_v = 55 \cdot kips$

Ultimate Strength of Weld = $F_u := 70 \cdot ksi$

Allowable Stress on Weld = $F_w := 30\% \cdot F_u$

$F_w = 21 \cdot ksi$

Weld Size = $W := \dfrac{1}{4} \cdot in$

Required Weld Length at Each Pile = $L_w := \dfrac{F_v}{\cos(45 \cdot deg) \cdot F_w \cdot W}$

$L_w = 14.9 \cdot in$

<u>Provide 16 Inches of 1/4-inch E70 Weld Per Bracket</u>

<u>Check Web Crippling at Bracket</u>

The wale will be supported by tee sections of HP12x53 used for brackets. The bracket will be analyzed for local web yielding or web crippling. AISC Manual (13th Ed.) will be used to analyze local web yielding and web crippling at the bracket to pile connection.

<u>For HP12x74</u> $d := 10 \cdot in$ $t_w := 0.435 \cdot in$

$b_f := 12.0 \cdot in$ $t_f := 0.435 \cdot in$ $k := 1.125 \cdot in$

<u>For 2-C15x33.9</u> $N := 2 \cdot (3.40 \cdot in)$

$N = 6.8 \cdot in$

Normal Force = $R := 162 \cdot kips$

Modulus of Elasticity = $E := 29000 \cdot ksi$

Web Local Yielding:
(AISC Eq. J10-2)

Safety Factor for Web Yielding = $\Omega_{wy} := 1.50$

Nominal Strength = $R_n := (5 \cdot k + N) F_y \cdot t_w$

$R_n = 270 \cdot kips$

Allowable Strength = $\frac{R_n}{\Omega_{wy}} = 180 \cdot kips$ > $R = 162 \cdot kip$ *OK*

Web Crippling:
(AISC Eq. J10-3)

Safety Factor for Web Crippling = $\Omega_{wc} := 2.00$

Nominal Strength = $R_n := 0.80 \cdot t_w^{\,2} \cdot \left[1 + 3 \cdot \left(\frac{N}{d} \right) \cdot \left(\frac{t_w}{t_f} \right)^{1.5} \right] \cdot \sqrt{\frac{E \cdot F_y \cdot t_f}{t_w}}$

$R_n = 554 \cdot kips$

Allowable Strength = $\frac{R_n}{\Omega_{wc}} = 277 \cdot kips$ > $R = 162 \cdot kip$ *OK*

No Web Yielding or Web Crippling for HP12x53 bracket

Design of Timber Lagging

The timber lagging will be used between the soldier piles to retain the earth. Lagging will be designed to resist the lateral loadings due to soil loading. The loading will be reduced by 1/2 to account for arching, as per FHWA RD 75-128. The required lagging will be determined for a height of support of 34 feet and a pile spacing of 7 feet.

The timber lagging will consist of mixed hardwoods. For design the working stress values given for spruce, pine and fir will be used, as given in AASHTO *"Standard Specifications for Highway Bridges"*, Table 13.5.1A (copy on page A5). The load factors used in the design are standard factors used in timber design and can be found in AITC *"Timber Construction Manual"*, *"Design of Wood Structures"* by Breyer or AASHTO *"Standard Specifications for Highway Bridges"*.

Allowable Bending Stress for 3-Inch Thick Lagging

Working Stress for Lagging = $F_{wb} := 875 \cdot psi$

Size Factor = $C_F := 1.1$ (3"x10" Lagging)

Flat Use Factor = $C_{fu} := 1.2$ (3"x10" Lagging)

Load Duration Factor = $C_D := 1.15$ (2 month for load combination)

Wet Service Factor = $C_M := \begin{cases} 1.00 & \text{if } F_{wb} \cdot C_F < 1150 \cdot psi \\ 0.85 & \text{otherwise} \end{cases}$

$C_M = 1.00$

Allowable Bending Stress = $F_b := F_{wb} \cdot C_{fu} \cdot C_F \cdot C_D \cdot C_M$

$F_b = 1328 \cdot psi$

Lagging Design

Soldier Pile Spacing = $S_{pile} := 7 \cdot ft$

Pile Flange Width = $b_f := 12.8 \cdot in$ (W24x104 Soldier Pile)

Design Span for Lagging = $L := S_{pile} - b_f$

$L = 5.93\,ft$

Height of Soil Retailed = $H_{soil} := 34 \cdot ft$

Soil Loading = $P_{soil} := 24 \cdot pcf \cdot H$

$P_{soil} = 576 \cdot psf$

Maximum Bending Moment = $M_{max} := \left[\frac{\left[\left(P_{soil}\right) \cdot \frac{1}{2}\right] \cdot L^2 \cdot 1 \cdot ft}{8}\right]$

$M_{max} = 1.27 \cdot kft$

Required Section Modulus = $S_x := \frac{M_{max}}{F_b}$

$S_x = 11.4 \cdot in^3$

Required Thickness = $t := \sqrt{\dfrac{S_x \cdot 6}{12 \cdot in}}$

$$t = 2.4 \cdot in$$

<u>Use 3" Thick Timbers for Lagging</u>

- ***<u>Lagging Connection to Pile Design</u>***

  The lagging attachment detail will consist of a 1/2" diameter threaded rod welded to the pile flange. The required weld will be designed here.

Force On Weld = $P_w := (P_{soil}) \cdot 4 \cdot ft \cdot 1 \cdot ft$

$$P_w = 2304 \cdot lbf$$

Ultimate Strength of Weld = $F_u := 70 \cdot ksi$

Allowable Stress on Weld = $F_w := 30\% \cdot F_u$

$$F_w = 21 \cdot ksi$$

Diameter of Threaded Rod = $d_{rod} := 0.5 \cdot in$

Welded Circumference of Rod = $C := \pi \cdot d_{rod}$

$$C = 1.6 \cdot in$$

Required Weld Size = $W := \dfrac{P_w}{\cos(45 \cdot deg) \cdot F_w \cdot C}$

$$W = 0.10 \cdot in$$

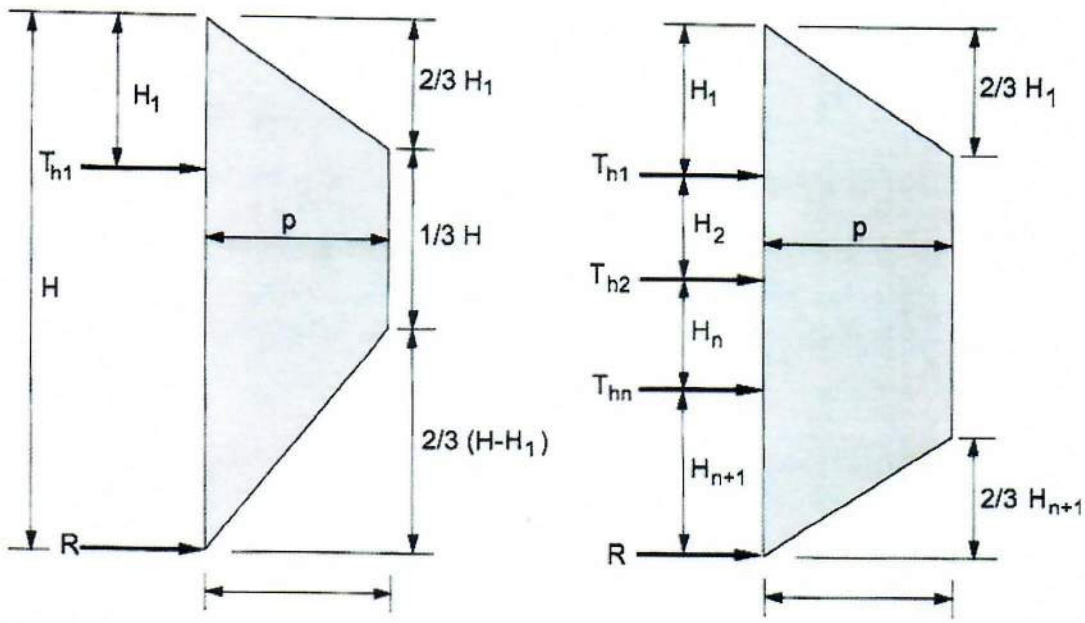
<u>Provide 1/8-inch E70 Full Perimeter Weld Per Rod</u>

<u>END OF CALCULATIONS</u>

A1

$$p = 0.65 K_A \gamma H \quad \text{(Equation 10b)}$$

where ϕ' is the effective stress friction angle of the sand. Using this value of lateral earth pressure, the total lateral earth load from the rectangular apparent earth pressure diagram (figure 23a) for sands is $0.65\ K_a \gamma H^2$. The recommended apparent earth pressure envelope for single level anchored walls and walls with two or more levels of ground anchors is trapezoidal and is shown in figure 24.



$$p = \frac{\text{TOTAL LOAD}}{2/3\ H} \approx K_A \gamma H$$

(a) Walls with one level of ground anchors

$$p = \frac{\text{TOTAL LOAD}}{H - 1/3\ H_1 - 1/3\ H_{n+1}}$$

(b) Walls with multiple levels of ground anchors

H_1 = Distance from ground surface to uppermost ground anchor

H_{n+1} = Distance from base of excavation to lowermost ground anchor

T_{hi} = Horizontal load in ground anchor i

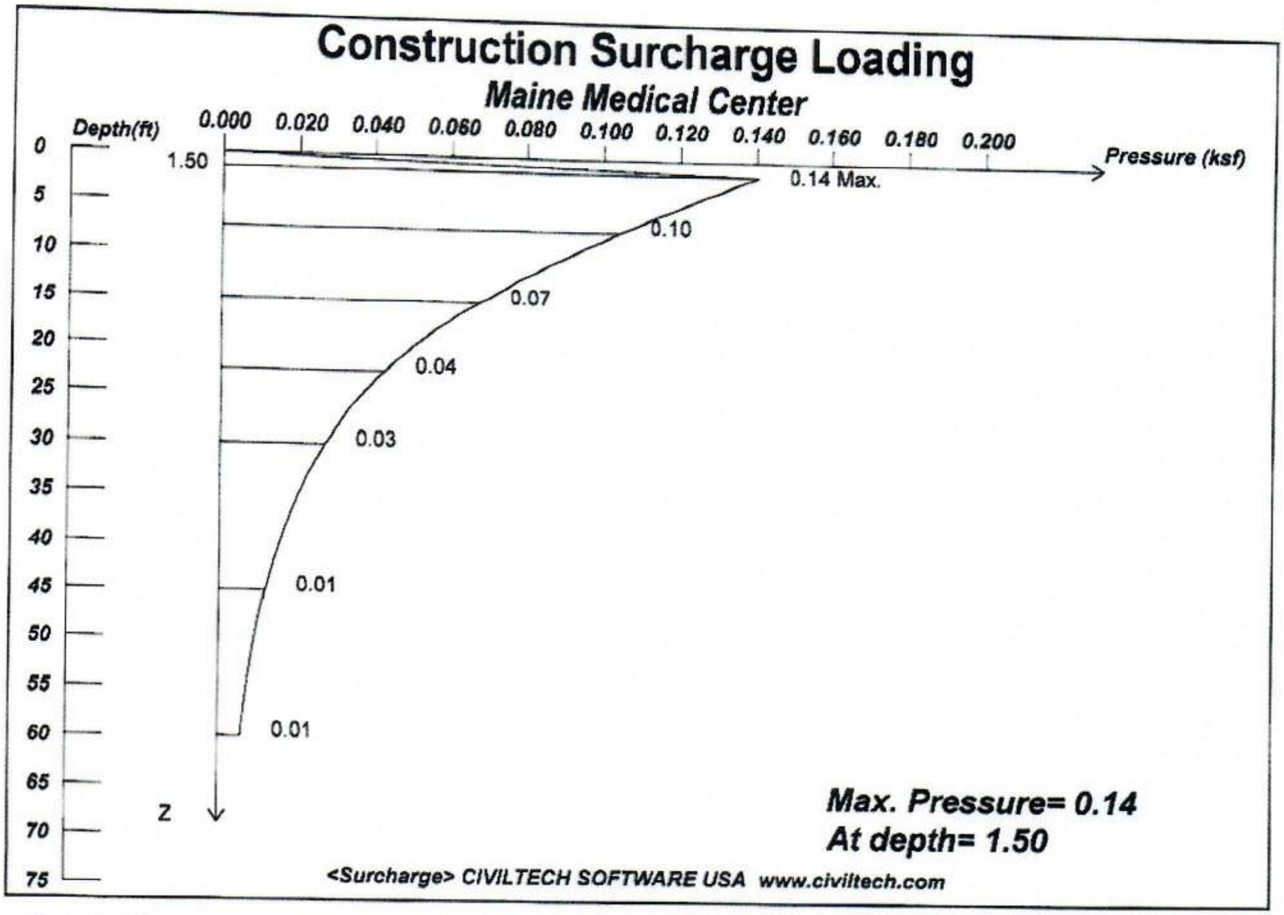
R = Reaction force to be resisted by subgrade (i.e., below base of excavation)

p = Maximum ordinate of diagram

TOTAL LOAD = $0.65\ K_A \gamma H^2$

Figure 24. Recommended apparent earth pressure diagram for sands.

A2



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Date: 12/10/2020 File: C:\Shoring8\Ework\2019\19115 Construction Surcharge.lp8

Wall Height, H= 30 Load Depth, D= 0

Load Factor of Surcharge Loading = 1

Flexible Wall Condition -- Movement or deflection are allowed.

Max. Pressure = 0.140 at depth = 1.50

X	Width	Strip Load
.0	30.0	.30

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

A3

Multi-Strand Anchors - ASTM A416						
No. of 0.6" Strands	Nominal Cross Section Area (Aps) in² mm²	Ultimate Strength (Fpu x Aps) kips kN	Maximum Jacking Load (0.8 x Fpu x Aps) kips kN	Maximum Design Load (0.6 x Fpu x Aps) kips kN	Minimum Lockoff Load (0.5 x Fpu x Aps) kips kN	Nominal Steel Weight (Bare Strand) lbs/ft kg/m
1	0.217 140	58.6 261	46.9 209	35.2 156	29.3 130	0.74 1.10
2	0.434 280	117.2 521	93.8 417	70.3 313	58.6 261	1.48 2.20
3	0.651 420	175.8 782	140.6 626	105.5 469	87.9 391	2.22 3.31
4	0.868 560	234.4 1043	187.5 834	140.6 626	117.2 521	2.96 4.41
5	1.085 700	293.0 1303	234.4 1043	175.8 782	146.5 652	3.70 5.51
6	1.302 840	351.6 1564	281.3 1251	211.0 938	175.8 782	4.44 6.61
7	1.519 980	410.2 1825	328.2 1460	246.1 1095	205.1 912	5.18 7.71
8	1.736 1120	468.8 2085	375.0 1668	281.3 1251	234.4 1043	5.92 8.82
9	1.953 1260	527.4 2346	421.9 1877	316.4 1408	263.7 1173	6.66 9.92
10	2.170 1400	586.0 2607	468.8 2085	351.6 1564	293.0 1303	7.40 11.02
11	2.387 1540	644.6 2867	515.7 2294	386.8 1720	322.3 1434	8.14 12.12
12	2.604 1680	703.2 3128	562.6 2503	421.9 1877	351.6 1564	8.88 13.22
13	2.821 1820	761.8 3389	609.4 2711	457.1 2033	380.9 1694	9.62 14.33
14	3.038 1960	820.4 3649	656.3 2920	492.2 2190	410.2 1825	10.36 15.43
15	3.255 2100	879.0 3910	703.2 3128	527.4 2346	439.5 1955	11.10 16.53
16	3.472 2240	937.6 4171	750.1 3337	562.6 2503	468.8 2085	11.84 17.63
17	3.689 2380	996.2 4432	797.0 3545	597.7 2659	498.1 2216	12.58 18.73
18	3.906 2520	1054.8 4692	843.8 3754	632.9 2815	527.4 2346	13.32 19.84
19	4.123 2660	1113.4 4953	890.7 3962	668.0 2972	556.7 2476	14.06 20.94

Aps – Area Prestressing Steel, Fpu – Minimum Ultimate Tensile Strength
Strand Anchors utilize 0.6" (15.2mm) dia. 7-wire, Low Relaxation 270 KSI Steel Strand conforming to ASTM A 416.
*Maximum lockoff load shall not exceed (0.7 x Fpu x Aps), maximum jacking load shall not exceed (0.8xFpu x Aps)
Now available: Hot Melt Extrusion Coated Strand. Consult your sales representative for information on load distributive or removable strand anchors.

Please note: As we continuously improve the design of our products, product details are subject to change.

Table 5-3. Summary of Typical α_{bond} (Grout-to-Ground Bond) Values for Micropile Design.

Soil / Rock Description	Grout-to-Ground Bond Ultimate Strengths, kPa (psi)			
	Type A	Type B	Type C	Type D
Silt & Clay (some sand) (soft, medium plastic)	35-70 (5-10)	35-95 (5-14)	50-120 (5-17.5)	50-145 (5-21)
Silt & Clay (some sand) (stiff, dense to very dense)	50-120 (5-17.5)	70-190 (10-27.5)	95-190 (14-27.5)	95-190 (14-27.5)
Sand (some silt) (fine, loose-medium dense)	70-145 (10-21)	70-190 (10-27.5)	95-190 (14-27.5)	95- 240 (14-35)
Sand (some silt, gravel) (fine-coarse, med.-very dense)	95-215 (14-31)	120-360 (17.5-52)	145-360 (21-52)	145-385 (21-56)
Gravel (some sand) (medium-very dense)	95-265 (14-38.5)	120-360 (17.5-52)	145-360 (21-52)	145-385 (21-56)
Glacial Till (silt, sand, gravel) (medium-very dense, cemented)	95-190 (14-27.5)	95-310 (14-45)	120-310 (17.5-45)	120-335 (17.5-48.5)
Soft Shales (fresh-moderate fracturing, little to no weathering)	205-550 (30-80)	N/A	N/A	N/A
Slates and Hard Shales (fresh-moderate fracturing, little to no weathering)	515-1,380 (75-200)	N/A	N/A	N/A
Limestone (fresh-moderate fracturing, little to no weathering)	1,035-2,070 (150-300)	N/A	N/A	N/A
Sandstone (fresh-moderate fracturing, little to no weathering)	520-1,725 (75.5-250)	N/A	N/A	N/A
Granite and Basalt (fresh-moderate fracturing, little to no weathering)	1,380-4,200 (200-609)	N/A	N/A	N/A

Type A: Gravity grout only
Type B: Pressure grouted through the casing during casing withdrawal
Type C: Primary grout placed under gravity head, then one phase of secondary "global" pressure grouting
Type D: Primary grout placed under gravity head, then one or more phases of secondary "global" pressure grouting

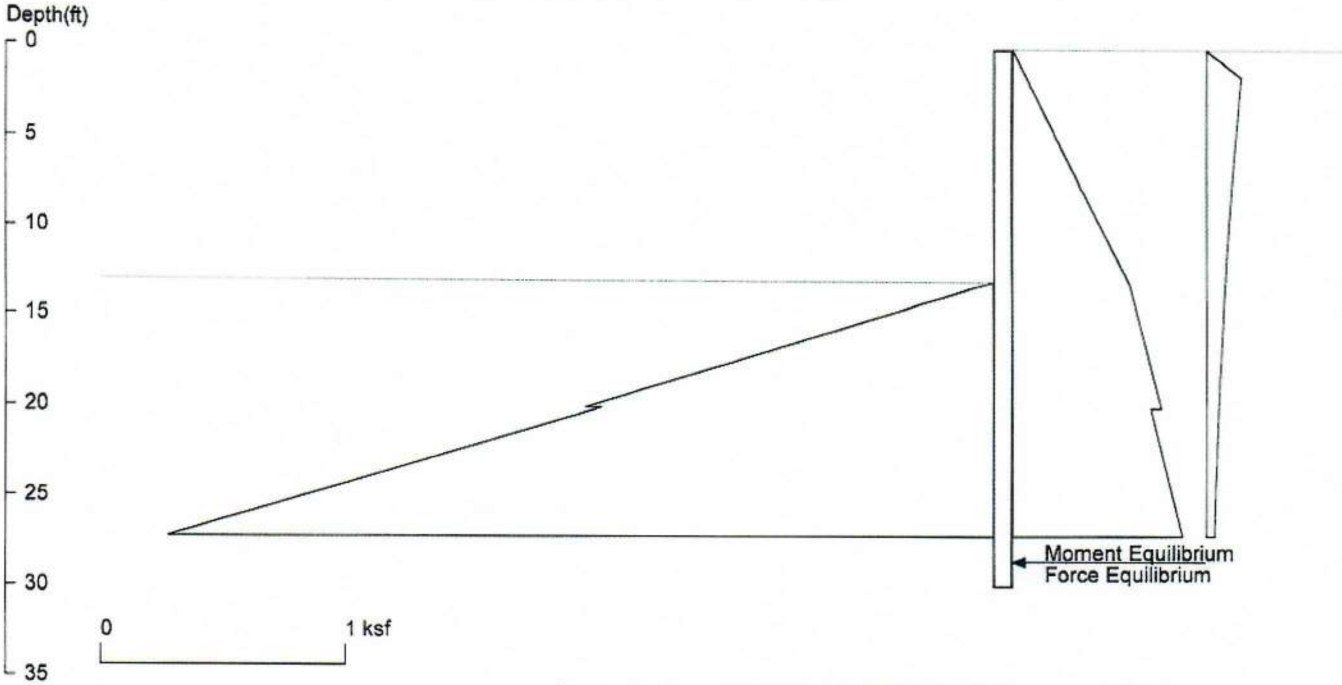
TABLE 13.5.1A Tabulated Design Values for Visually Graded Lumber and Timbers (Continued)

Species and Commercial Grade	Size Classification	Design Values in Pounds per Square Inch (psi): Bending F_b	Tension Parallel to Grain F_t	Shear Parallel to Grain F_v	Compression Perpendicular to Grain $F_{c\perp}$	Compression Parallel to Grain F_c	Modulus of Elasticity E	Grading Rules Agency
SOUTHERN PINE (Dry or Wet Service Conditions)								
Dense Select Structural	5" × 5" & larger	1750	1200	110	440	1100	1,600,000	SPIB
Select Structural		1500	1000	110	375	950	1,500,000	
No. 1		1350	900	110	375	825	1,500,000	
No. 2		850	550	100	375	525	1,200,000	
SPRUCE-PINE-FIR								
Select Structural	2"–4" thick 2" & wider	1250	675	70	425	1400	1,500,000	NLGA
No. 1/No. 2		875	425	70	425	1100	1,400,000	
Select Structural	Beams and Stringers	1100	650	65	425	775	1,300,000	
No. 1		900	450	65	425	625	1,300,000	
No. 2		600	300	65	425	425	1,000,000	
Select Structural	Posts and Timbers	1050	700	65	425	800	1,300,000	
No. 1		850	550	65	425	700	1,300,000	
No. 2		500	325	65	425	500	1,000,000	
SPRUCE-PINE-FIR (SOUTH)								
Select Structural	2"–4" thick 2" & wider	1300	575	70	335	1200	1,300,000	NELMA
No. 1		850	400	70	335	1050	1,200,000	
No. 2		750	325	70	335	975	1,100,000	
Select Structural	Beams and Stringers	1050	625	65	335	675	1,200,000	WCLIB NSLB
No. 1		900	450	65	335	575	1,200,000	
No. 2		575	300	65	335	350	1,000,000	
Select Structural	Posts and Timbers	1000	675	65	335	700	1,200,000	WWPA
No. 1		800	550	65	335	625	1,200,000	
No. 2		350	225	65	335	225	1,000,000	
YELLOW POPLAR								
Select Structural	2"–4" thick 2" & wider	1000	575	75	420	900	1,500,000	NLSB
No. 1		725	425	75	420	725	1,400,000	
No. 2		700	400	75	420	575	1,300,000	

A5

Gilman Street Parking Garage
Maine Medical Center - Portland, ME

B1



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Wall Height=13.0 Pile Diameter=3.3 Pile Spacing=7.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=14.25 Min. Pile Length=27.25
MOMENT IN PILE: Max. Moment=323.74 per Pile Spacing=7.0 at Depth=20.37

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	13	0.473	0.036385
13	0.473	20	0.606	0.019
20	0.562	42	0.958	0.018
*	Sur-	charg	*	
0.000	0.000	1.500	0.140	0.093644
1.500	0.140	3.000	0.131	-0.00629
3.000	0.131	4.500	0.122	-0.00617
4.500	0.122	6.000	0.113	-0.00599
6.000	0.113	7.500	0.104	-0.00576
7.500	0.104	9.000	0.096	-0.00550
9.000	0.096	10.50	0.088	-0.00520
10.50	0.088	12.00	0.081	-0.00489
12.00	0.081	13.50	0.074	-0.00456
13.50	0.074	15.00	0.068	-0.00423
15.00	0.068	16.50	0.062	-0.00391
16.50	0.062	18.00	0.056	-0.00359
18.00	0.056	19.50	0.051	-0.00329
19.50	0.051	21.00	0.047	-0.00300
21.00	0.047	22.50	0.043	-0.00273
22.50	0.043	24.00	0.039	-0.00248
24.00	0.039	25.50	0.036	-0.00225
25.50	0.036	27.00	0.033	-0.00204

B2

27.00	0.033	28.50	0.030	-0.00185
28.50	0.030	30.00	0.027	-0.00167
30.00	0.027	33.00	0.023	-0.00144

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
13	0	20	1.673	0.239
20	1.605	42	7.017	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	7.00
2	13.00	3.25

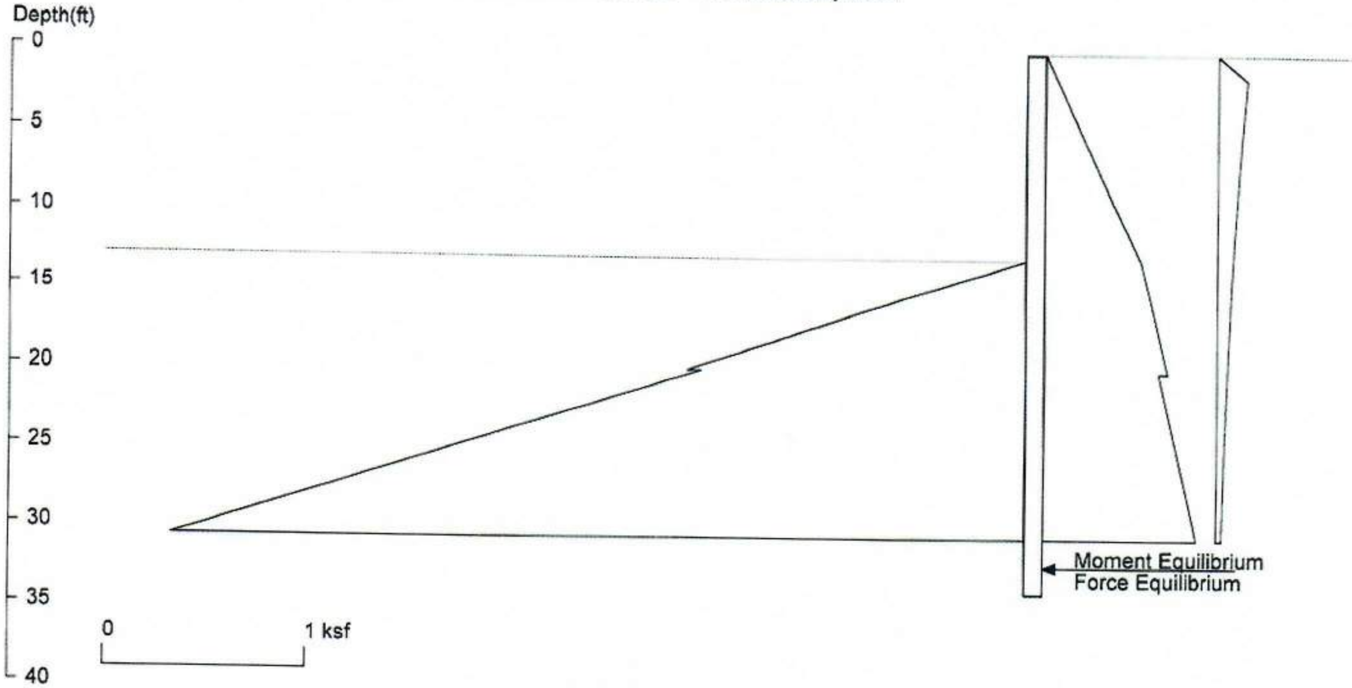
PASSIVE SPACING:

No.	Z depth	Spacing
1	13.00	7.00

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

Gilman Street Parking Garage
Maine Medical Center - Portland, ME

B3



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Wall Height=13.0 Pile Diameter=3.3 Pile Spacing=7.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=17.70 Min. Pile Length=30.70
MOMENT IN PILE: Max. Moment=377.90 per Pile Spacing=7.0 at Depth=22.51

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	13	0.473	0.036385
13	0.473	20	0.606	0.019
20	0.562	42	0.958	0.018
*	Sur-	charg	*	
0.000	0.000	1.500	0.140	0.093644
1.500	0.140	3.000	0.131	-0.00629
3.000	0.131	4.500	0.122	-0.00617
4.500	0.122	6.000	0.113	-0.00599
6.000	0.113	7.500	0.104	-0.00576
7.500	0.104	9.000	0.096	-0.00550
9.000	0.096	10.50	0.088	-0.00520
10.50	0.088	12.00	0.081	-0.00489
12.00	0.081	13.50	0.074	-0.00456
13.50	0.074	15.00	0.068	-0.00423
15.00	0.068	16.50	0.062	-0.00391
16.50	0.062	18.00	0.056	-0.00359
18.00	0.056	19.50	0.051	-0.00329
19.50	0.051	21.00	0.047	-0.00300
21.00	0.047	22.50	0.043	-0.00273
22.50	0.043	24.00	0.039	-0.00248
24.00	0.039	25.50	0.036	-0.00225
25.50	0.036	27.00	0.033	-0.00204

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27.00	0.033	28.50	0.030	-0.00185
28.50	0.030	30.00	0.027	-0.00167
30.00	0.027	33.00	0.023	-0.00144
33.00	0.023	36.00	0.019	-0.00118

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
13	0	20	1.673	0.239
20	1.605	42	7.017	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	7.00
2	13.00	3.25

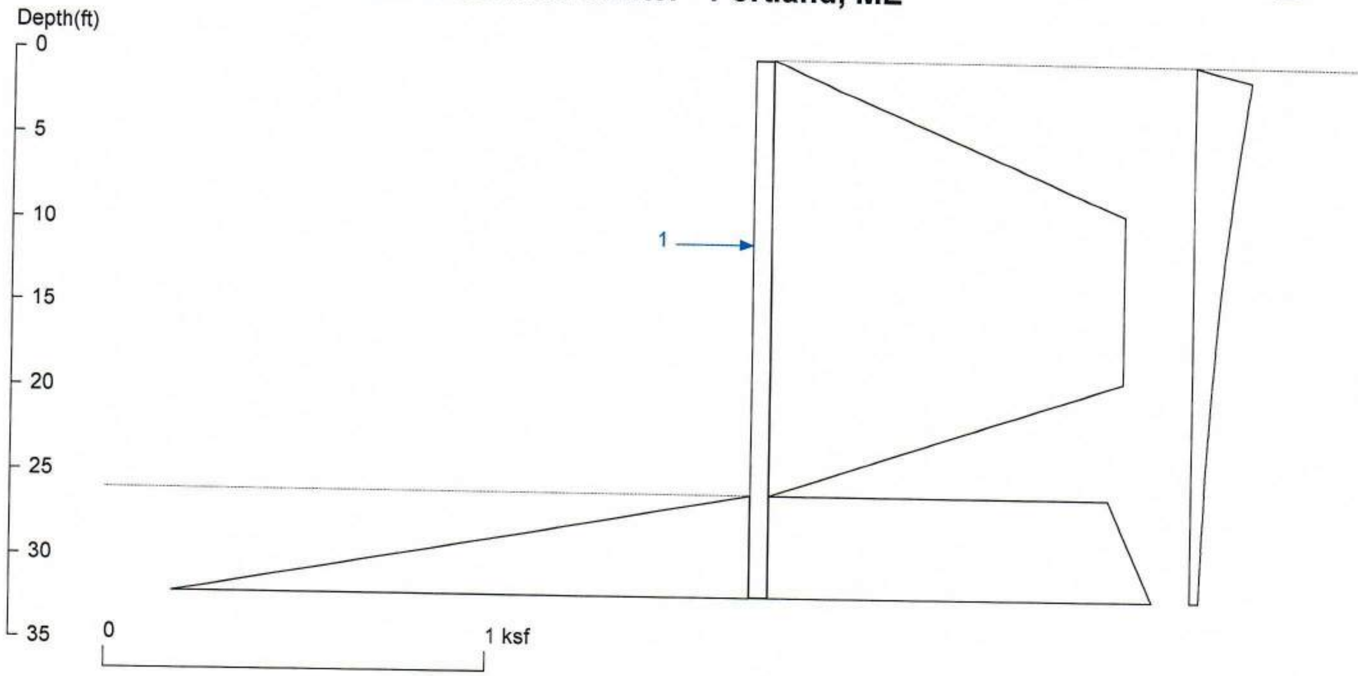
PASSIVE SPACING:

No.	Z depth	Spacing
1	13.00	7.00

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

Southwest Corner SOE
Maine Medical Center - Portland, ME

B5



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Wall Height=26.0 Pile Diameter=3.3 Pile Spacing=7.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=6.16 Min. Pile Length=32.16
MOMENT IN PILE: Max. Moment=206.67 per Pile Spacing=7.0 at Depth=10.98

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

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	11.0	0.0	1.0	16.8	16.8	0.0	0.0	0.0

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
*	Soil	Load	*	
0	0	9	0.923	0.102556
9	0.923	19	0.923	0
19	0.923	26	0	-0.131857
26	0.887	42	1.191	0.019
*	Surch	arge	*	
0.000	0.000	0.850	0.145	0.170108
0.850	0.145	1.700	0.139	-0.00634
1.700	0.139	2.550	0.134	-0.00630
2.550	0.134	3.400	0.129	-0.00624
3.400	0.129	4.250	0.123	-0.00616
4.250	0.123	5.100	0.118	-0.00606
5.100	0.118	5.950	0.113	-0.00595
5.950	0.113	6.800	0.108	-0.00582
6.800	0.108	7.650	0.103	-0.00568
7.650	0.103	8.500	0.099	-0.00553
8.500	0.099	9.350	0.094	-0.00537
9.350	0.094	10.20	0.090	-0.00520

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10.20	0.090	11.05	0.085	-0.00502
11.05	0.085	11.90	0.081	-0.00484
11.90	0.081	12.75	0.077	-0.00466
12.75	0.077	13.60	0.073	-0.00447
13.60	0.073	14.45	0.070	-0.00428
14.45	0.070	15.30	0.066	-0.00410
15.30	0.066	16.15	0.063	-0.00391
16.15	0.063	17.00	0.060	-0.00373
17.00	0.060	18.70	0.054	-0.00347
18.70	0.054	20.40	0.049	-0.00313
20.40	0.049	22.10	0.044	-0.00282
22.10	0.044	23.80	0.039	-0.00253
23.80	0.039	25.50	0.036	-0.00227
25.50	0.036	27.20	0.032	-0.00203
27.20	0.032	28.90	0.029	-0.00181
28.90	0.029	30.60	0.026	-0.00161
30.60	0.026	32.30	0.024	-0.00144

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
26	0	42	3.936	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	7.00
2	26.00	3.25

PASSIVE SPACING:

No.	Z depth	Spacing
1	26.00	7.00

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

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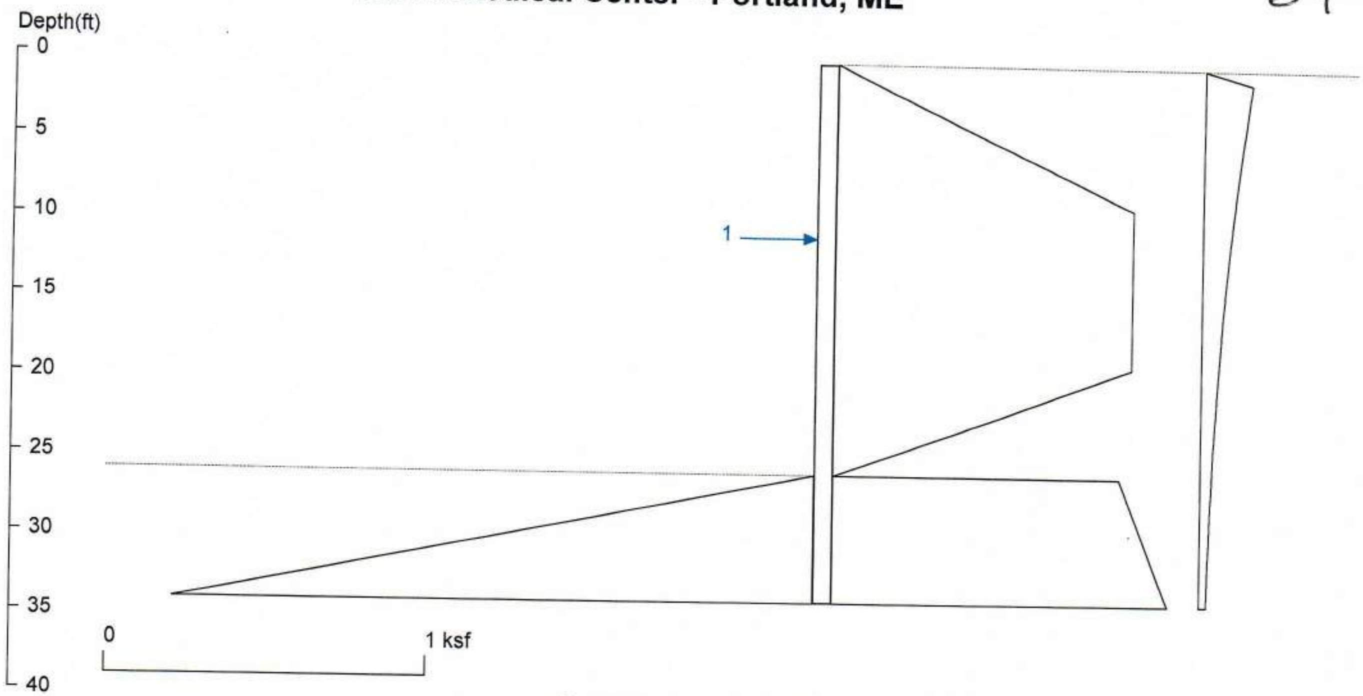
B7



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Wall Height=26.0 Pile Diameter=3.3 Pile Spacing=7.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=8.12 Min. Pile Length=34.12
MOMENT IN PILE: Max. Moment=206.95 per Pile Spacing=7.0 at Depth=11.01

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

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	11.0	0.0	1.0	17.0	17.0	0.0	0.0	0.0

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
*	Soil	Load	*	
0	0	9	0.923	0.102556
9	0.923	19	0.923	0
19	0.923	26	0	-0.131857
26	0.887	42	1.191	0.019
*	Surch	arge	*	
0.000	0.000	0.850	0.145	0.170108
0.850	0.145	1.700	0.139	-0.00634
1.700	0.139	2.550	0.134	-0.00630
2.550	0.134	3.400	0.129	-0.00624
3.400	0.129	4.250	0.123	-0.00616
4.250	0.123	5.100	0.118	-0.00606
5.100	0.118	5.950	0.113	-0.00595
5.950	0.113	6.800	0.108	-0.00582
6.800	0.108	7.650	0.103	-0.00568
7.650	0.103	8.500	0.099	-0.00553
8.500	0.099	9.350	0.094	-0.00537
9.350	0.094	10.20	0.090	-0.00520

B8

10.20	0.090	11.05	0.085	-0.00502
11.05	0.085	11.90	0.081	-0.00484
11.90	0.081	12.75	0.077	-0.00466
12.75	0.077	13.60	0.073	-0.00447
13.60	0.073	14.45	0.070	-0.00428
14.45	0.070	15.30	0.066	-0.00410
15.30	0.066	16.15	0.063	-0.00391
16.15	0.063	17.00	0.060	-0.00373
17.00	0.060	18.70	0.054	-0.00347
18.70	0.054	20.40	0.049	-0.00313
20.40	0.049	22.10	0.044	-0.00282
22.10	0.044	23.80	0.039	-0.00253
23.80	0.039	25.50	0.036	-0.00227
25.50	0.036	27.20	0.032	-0.00203
27.20	0.032	28.90	0.029	-0.00181
28.90	0.029	30.60	0.026	-0.00161
30.60	0.026	32.30	0.024	-0.00144
32.30	0.024	34.00	0.022	-0.00129
34.00	0.022	37.40	0.018	-0.00109

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
26	0	42	3.936	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	7.00
2	26.00	3.25

PASSIVE SPACING:

No.	Z depth	Spacing
1	26.00	7.00

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

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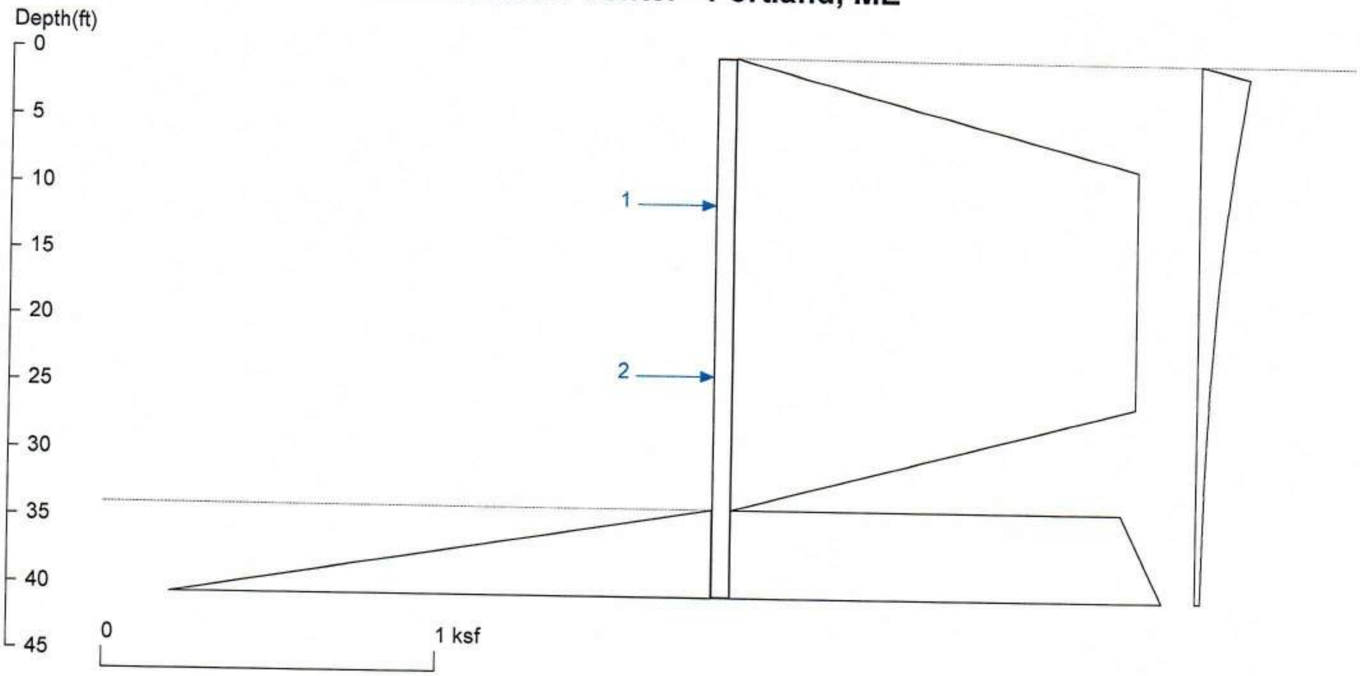
B9



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Wall Height=34.0 Pile Diameter=3.3 Pile Spacing=7.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=6.61 Min. Pile Length=40.61
MOMENT IN PILE: Max. Moment=277.20 per Pile Spacing=7.0 at Depth=10.98

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

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	11.0	0.0	1.0	21.0	21.0	0.0	0.0	0.0
2. Strut	24.0	0.0	1.0	11.1	11.1	0.0	0.0	0.0

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
*	Soil	Load	*	
0	0	8	1.207	0.150875
8	1.207	26	1.207	0.000000
26	1.207	34	0	-0.15087
34	1.167	42	1.319	0.019
*	Surch	arge	*	
0.000	0.000	0.850	0.145	0.170108
0.850	0.145	1.700	0.139	-0.00634
1.700	0.139	2.550	0.134	-0.00630
2.550	0.134	3.400	0.129	-0.00624
3.400	0.129	4.250	0.123	-0.00616
4.250	0.123	5.100	0.118	-0.00606
5.100	0.118	5.950	0.113	-0.00595
5.950	0.113	6.800	0.108	-0.00582
6.800	0.108	7.650	0.103	-0.00568
7.650	0.103	8.500	0.099	-0.00553
8.500	0.099	9.350	0.094	-0.00537

B10

9.350	0.094	10.20	0.090	-0.00520
10.20	0.090	11.05	0.085	-0.00502
11.05	0.085	11.90	0.081	-0.00484
11.90	0.081	12.75	0.077	-0.00466
12.75	0.077	13.60	0.073	-0.00447
13.60	0.073	14.45	0.070	-0.00428
14.45	0.070	15.30	0.066	-0.00410
15.30	0.066	16.15	0.063	-0.00391
16.15	0.063	17.00	0.060	-0.00373
17.00	0.060	18.70	0.054	-0.00347
18.70	0.054	20.40	0.049	-0.00313
20.40	0.049	22.10	0.044	-0.00282
22.10	0.044	23.80	0.039	-0.00253
23.80	0.039	25.50	0.036	-0.00227
25.50	0.036	27.20	0.032	-0.00203
27.20	0.032	28.90	0.029	-0.00181
28.90	0.029	30.60	0.026	-0.00161
30.60	0.026	32.30	0.024	-0.00144
32.30	0.024	34.00	0.022	-0.00129
34.00	0.022	37.40	0.018	-0.00109
37.40	0.018	40.80	0.015	-0.00087

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
34	0	42	1.968	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	7.00
2	34.00	3.25

PASSIVE SPACING:

No.	Z depth	Spacing
1	34.00	7.00

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

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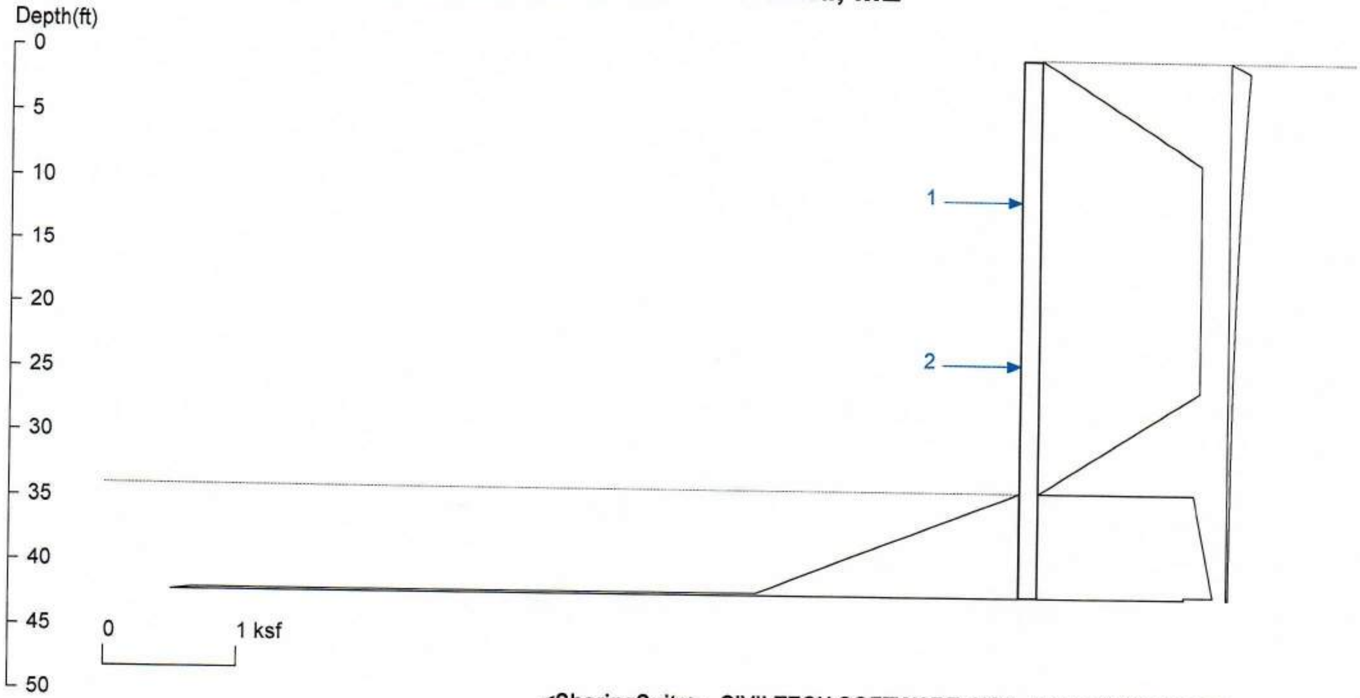
Maine Medical Center - Portland, ME

B11



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Wall Height=34.0 Pile Diameter=3.3 Pile Spacing=7.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=8.18 Min. Pile Length=42.18

MOMENT IN PILE: Max. Moment=277.26 per Pile Spacing=7.0 at Depth=10.98

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

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	11.0	0.0	1.0	21.0	21.0	0.0	0.0	0.0
2. Strut	24.0	0.0	1.0	11.4	11.4	0.0	0.0	0.0

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
*	Soil	Load	*	
0	0	8	1.207	0.150875
8	1.207	26	1.207	0.000000
26	1.207	34	0	-0.15087
34	1.167	42	1.319	0.019
42	1.098	50	1.242	0.018
*	Surch	arge	*	
0.000	0.000	0.850	0.145	0.170108
0.850	0.145	1.700	0.139	-0.00634
1.700	0.139	2.550	0.134	-0.00630
2.550	0.134	3.400	0.129	-0.00624
3.400	0.129	4.250	0.123	-0.00616
4.250	0.123	5.100	0.118	-0.00606
5.100	0.118	5.950	0.113	-0.00595
5.950	0.113	6.800	0.108	-0.00582
6.800	0.108	7.650	0.103	-0.00568
7.650	0.103	8.500	0.099	-0.00553

B12

8.500	0.099	9.350	0.094	-0.00537
9.350	0.094	10.20	0.090	-0.00520
10.20	0.090	11.05	0.085	-0.00502
11.05	0.085	11.90	0.081	-0.00484
11.90	0.081	12.75	0.077	-0.00466
12.75	0.077	13.60	0.073	-0.00447
13.60	0.073	14.45	0.070	-0.00428
14.45	0.070	15.30	0.066	-0.00410
15.30	0.066	16.15	0.063	-0.00391
16.15	0.063	17.00	0.060	-0.00373
17.00	0.060	18.70	0.054	-0.00347
18.70	0.054	20.40	0.049	-0.00313
20.40	0.049	22.10	0.044	-0.00282
22.10	0.044	23.80	0.039	-0.00253
23.80	0.039	25.50	0.036	-0.00227
25.50	0.036	27.20	0.032	-0.00203
27.20	0.032	28.90	0.029	-0.00181
28.90	0.029	30.60	0.026	-0.00161
30.60	0.026	32.30	0.024	-0.00144
32.30	0.024	34.00	0.022	-0.00129
34.00	0.022	37.40	0.018	-0.00109
37.40	0.018	40.80	0.015	-0.00087
40.80	0.015	44.20	0.013	-0.00070

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
34	0	42	1.968	0.246
42	6.215	50	13.28	0.884

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	7.00
2	34.00	3.25

PASSIVE SPACING:

No.	Z depth	Spacing
1	34.00	7.00

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

Southwest Corner SOE
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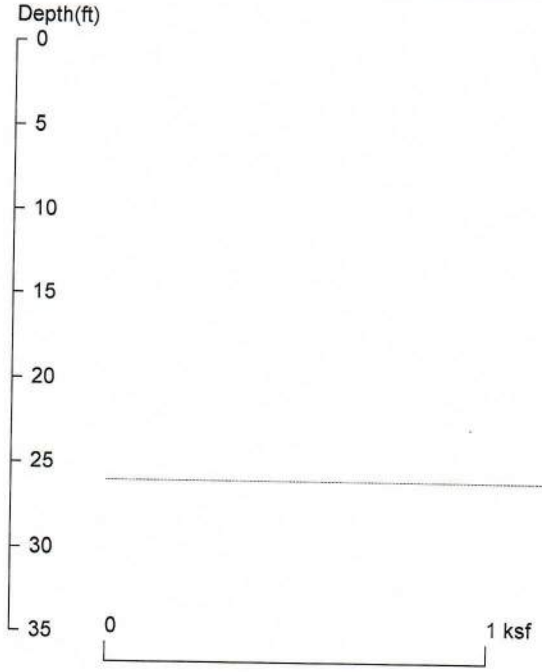
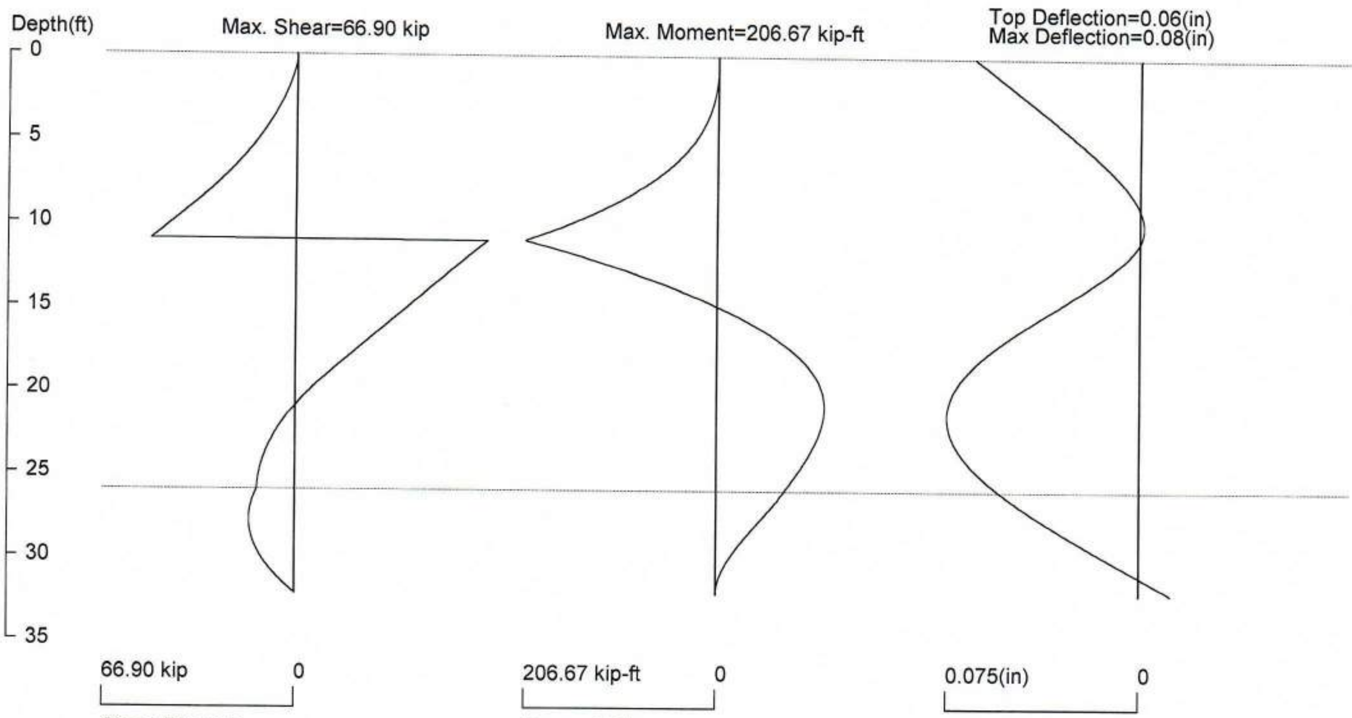
B14



Net Pressure Diagram



Shear Diagram

Moment Diagram

Deflection Diagram

PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 7.0 foot or meter

User Input Pile, W24x104: E (ksi)=29000.0, I (in4)/pile=3100.0

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Gilman Street Parking Garage

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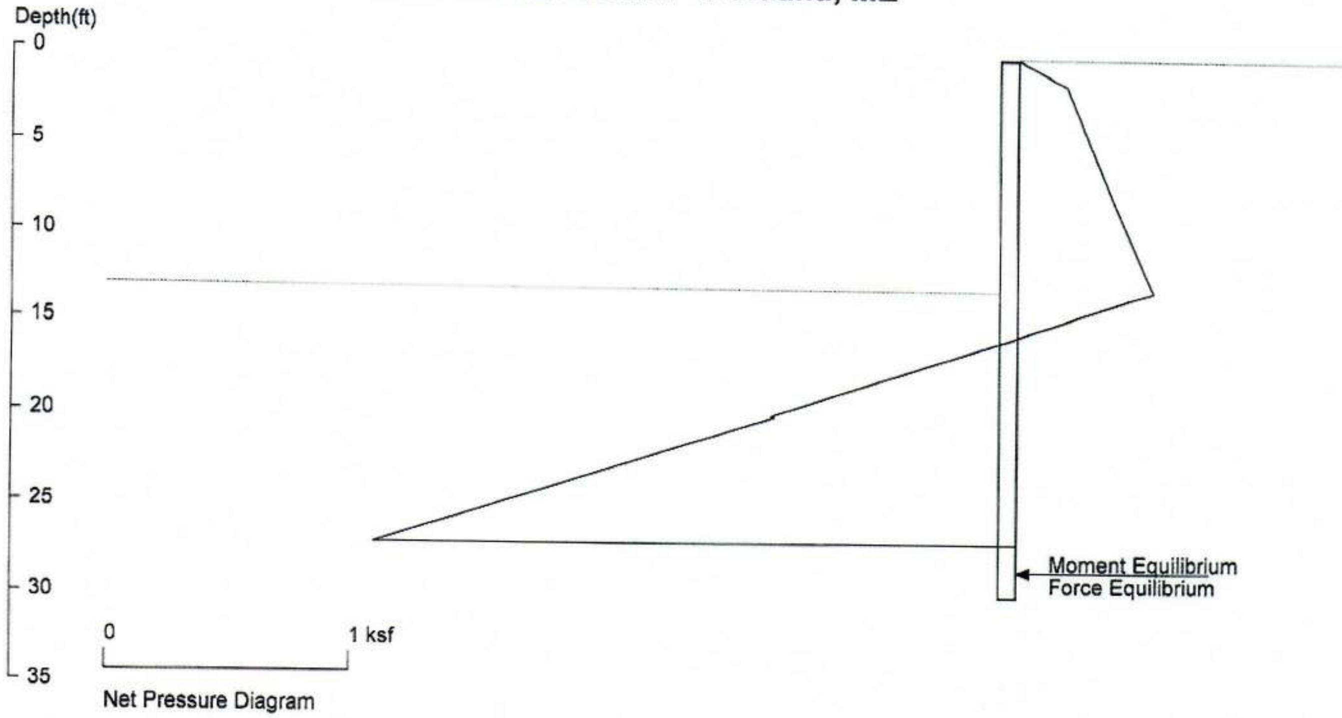
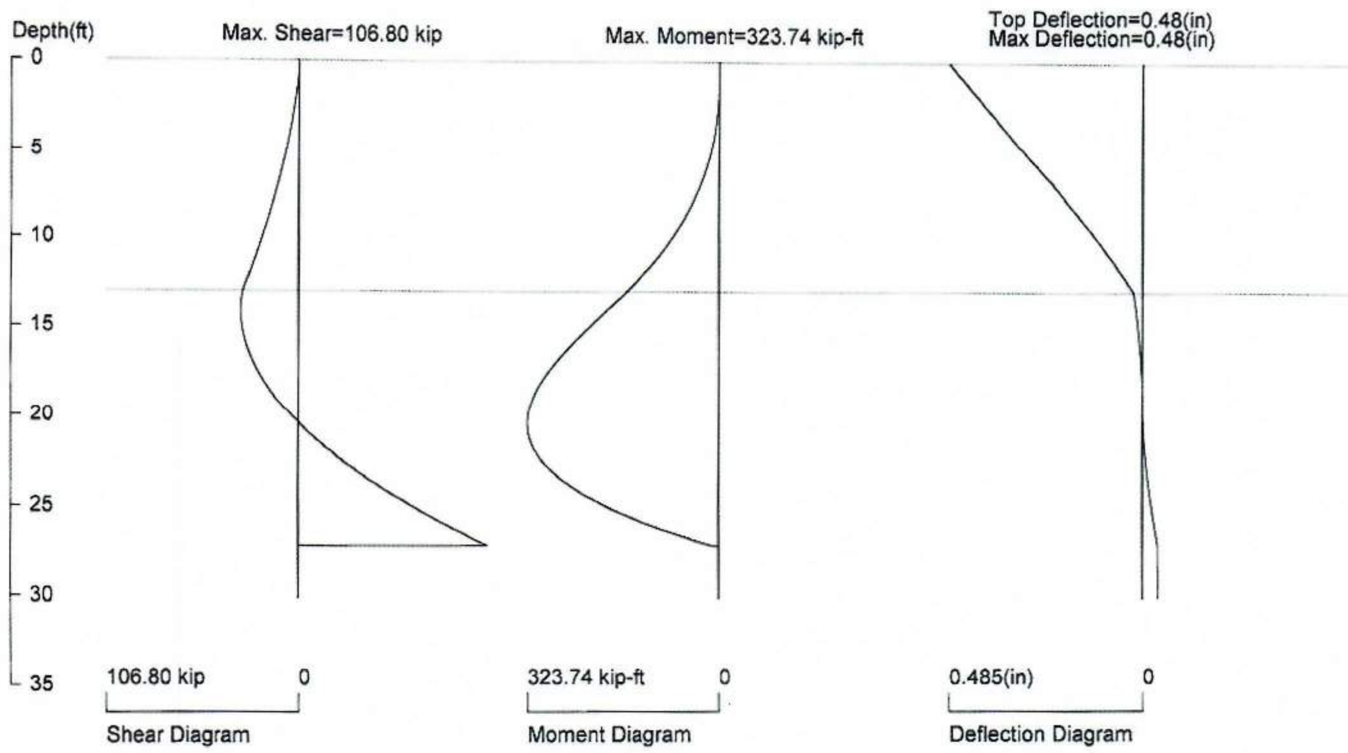
B13





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 7.0 foot or meter

User Input Pile, W24x104: E (ksi)=29000.0, I (in4)/pile=3100.0

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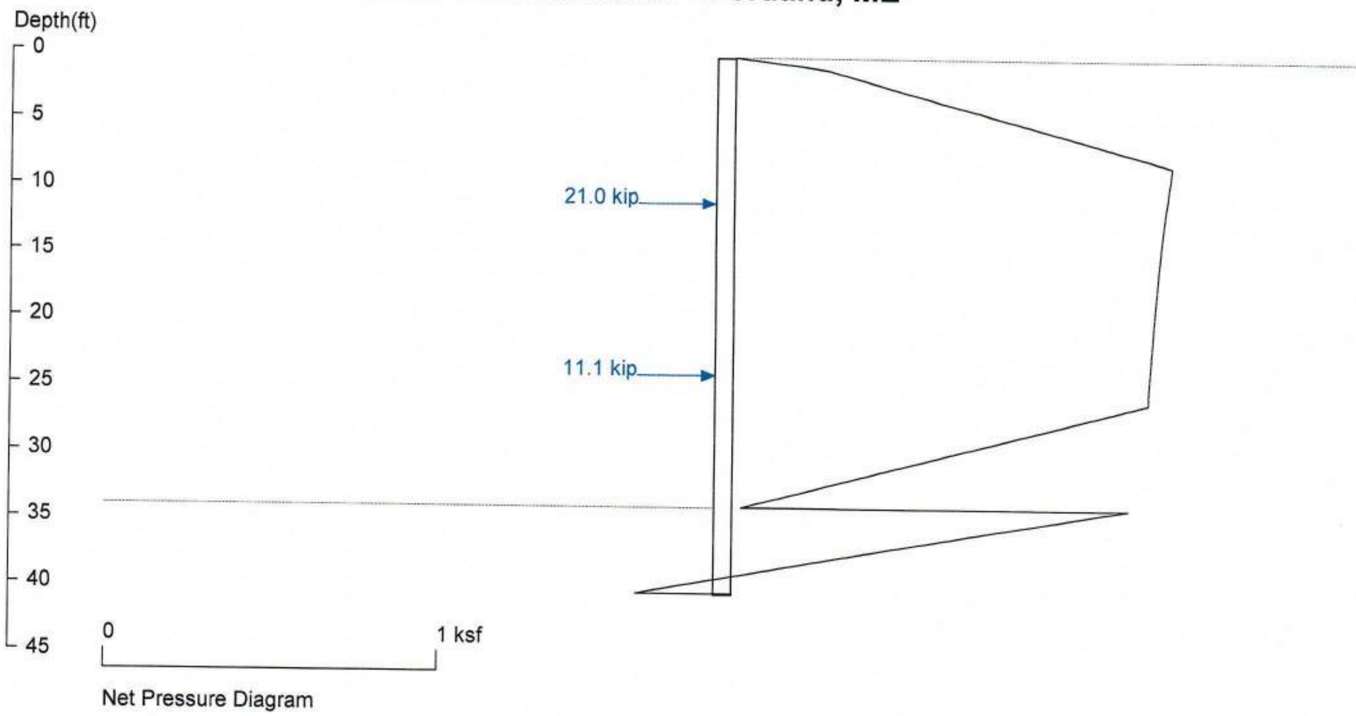
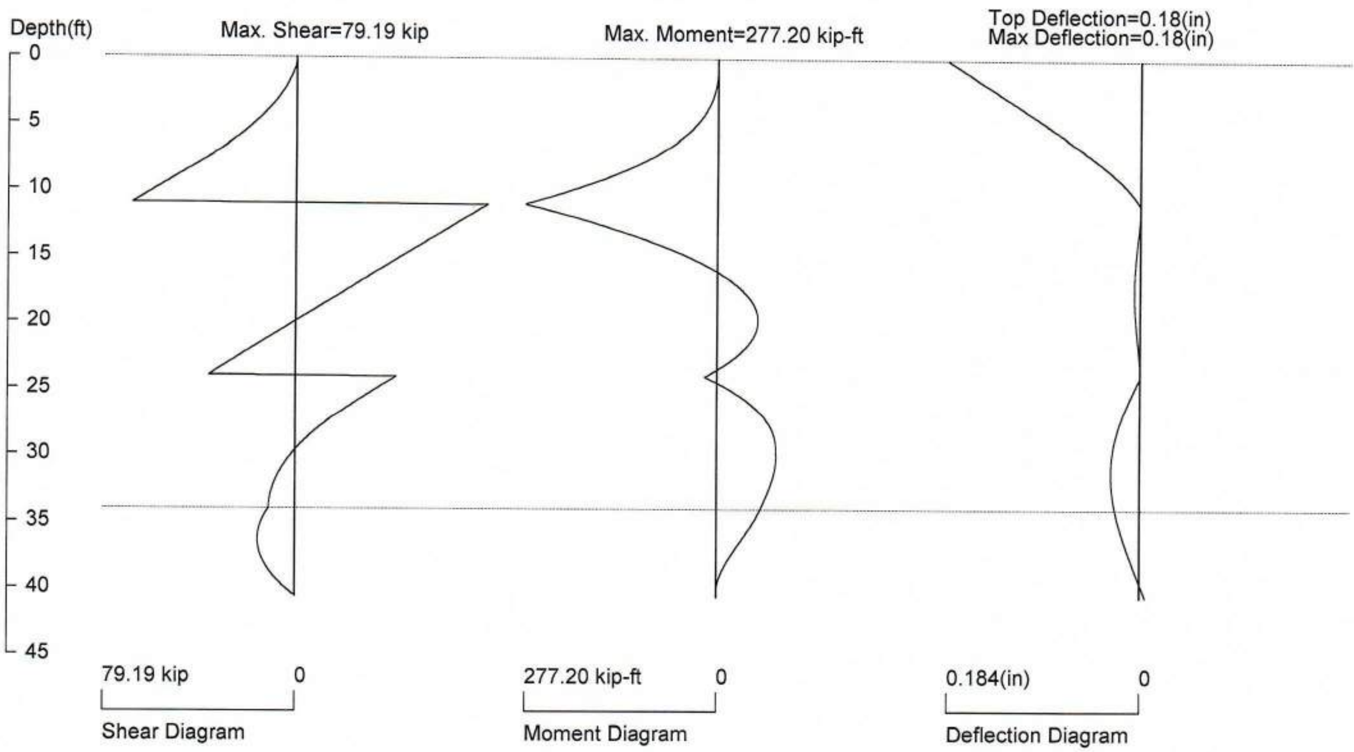
B15





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 7.0 foot or meter

User Input Pile, W24x104: E (ksi)=29000.0, I (in4)/pile=3100.0

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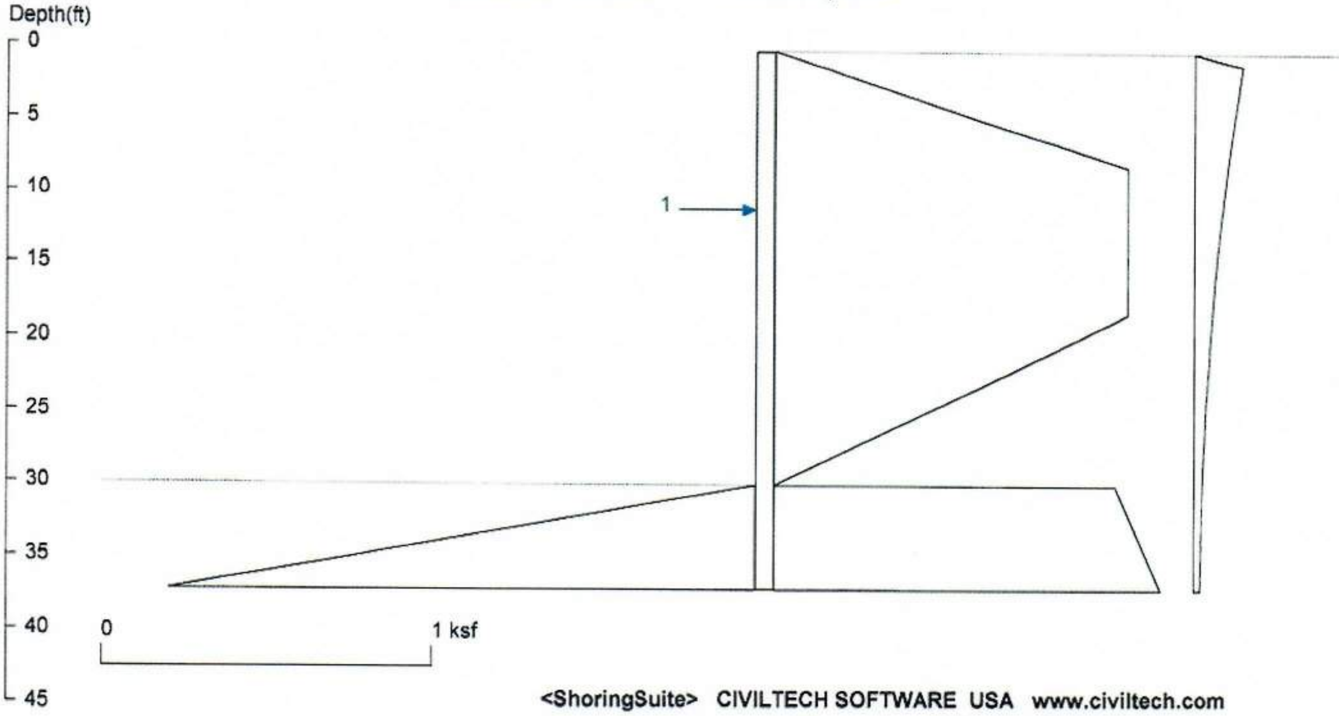
Southwest Corner SOE

Maine Medical Center - Portland, ME

C1



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Wall Height=30.0 Pile Diameter=3.3 Pile Spacing=7.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=7.23 Min. Pile Length=37.23

MOMENT IN PILE: Max. Moment=250.26 per Pile Spacing=7.0 at Depth=11.02

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

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	11.0	0.0	1.0	20.8	20.8	0.0	0.0	0.0

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
*	Soil	Load	*	
0	0	8	1.065	0.133125
8	1.065	18	1.065	0.000000
18	1.065	30	0	-0.08875
30	1.027	42	1.255	0.019
*	Surch	arge	*	
0.000	0.000	0.850	0.145	0.170108
0.850	0.145	1.700	0.139	-0.00634
1.700	0.139	2.550	0.134	-0.00630
2.550	0.134	3.400	0.129	-0.00624
3.400	0.129	4.250	0.123	-0.00616
4.250	0.123	5.100	0.118	-0.00606
5.100	0.118	5.950	0.113	-0.00595
5.950	0.113	6.800	0.108	-0.00582
6.800	0.108	7.650	0.103	-0.00568
7.650	0.103	8.500	0.099	-0.00553
8.500	0.099	9.350	0.094	-0.00537
9.350	0.094	10.20	0.090	-0.00520

C2

10.20	0.090	11.05	0.085	-0.00502
11.05	0.085	11.90	0.081	-0.00484
11.90	0.081	12.75	0.077	-0.00466
12.75	0.077	13.60	0.073	-0.00447
13.60	0.073	14.45	0.070	-0.00428
14.45	0.070	15.30	0.066	-0.00410
15.30	0.066	16.15	0.063	-0.00391
16.15	0.063	17.00	0.060	-0.00373
17.00	0.060	18.70	0.054	-0.00347
18.70	0.054	20.40	0.049	-0.00313
20.40	0.049	22.10	0.044	-0.00282
22.10	0.044	23.80	0.039	-0.00253
23.80	0.039	25.50	0.036	-0.00227
25.50	0.036	27.20	0.032	-0.00203
27.20	0.032	28.90	0.029	-0.00181
28.90	0.029	30.60	0.026	-0.00161
30.60	0.026	32.30	0.024	-0.00144
32.30	0.024	34.00	0.022	-0.00129
34.00	0.022	37.40	0.018	-0.00109

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
30	0	42	2.952	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	7.00
2	30.00	3.25

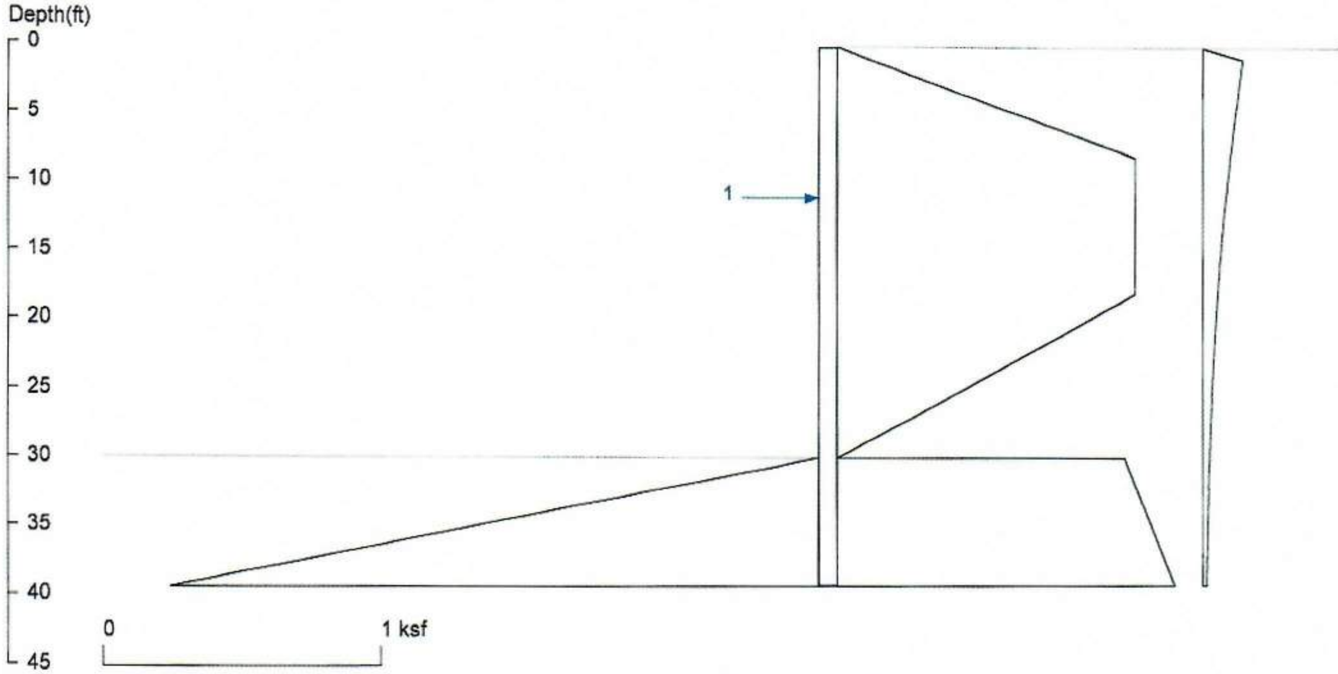
PASSIVE SPACING:

No.	Z depth	Spacing
1	30.00	7.00

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

Southwest Corner SOE
Maine Medical Center - Portland, ME

C3



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Wall Height=30.0 Pile Diameter=3.3 Pile Spacing=7.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=9.51 Min. Pile Length=39.51
MOMENT IN PILE: Max. Moment=250.97 per Pile Spacing=7.0 at Depth=10.99

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

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	11.0	0.0	1.0	21.1	21.1	0.0	0.0	0.0

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
*	Soil	Load	*	
0	0	8	1.065	0.133125
8	1.065	18	1.065	0.000000
18	1.065	30	0	-0.08875
30	1.027	42	1.255	0.019
*	Surch	arge	*	
0.000	0.000	0.850	0.145	0.170108
0.850	0.145	1.700	0.139	-0.00634
1.700	0.139	2.550	0.134	-0.00630
2.550	0.134	3.400	0.129	-0.00624
3.400	0.129	4.250	0.123	-0.00616
4.250	0.123	5.100	0.118	-0.00606
5.100	0.118	5.950	0.113	-0.00595
5.950	0.113	6.800	0.108	-0.00582
6.800	0.108	7.650	0.103	-0.00568
7.650	0.103	8.500	0.099	-0.00553
8.500	0.099	9.350	0.094	-0.00537
9.350	0.094	10.20	0.090	-0.00520

C4

10.20	0.090	11.05	0.085	-0.00502
11.05	0.085	11.90	0.081	-0.00484
11.90	0.081	12.75	0.077	-0.00466
12.75	0.077	13.60	0.073	-0.00447
13.60	0.073	14.45	0.070	-0.00428
14.45	0.070	15.30	0.066	-0.00410
15.30	0.066	16.15	0.063	-0.00391
16.15	0.063	17.00	0.060	-0.00373
17.00	0.060	18.70	0.054	-0.00347
18.70	0.054	20.40	0.049	-0.00313
20.40	0.049	22.10	0.044	-0.00282
22.10	0.044	23.80	0.039	-0.00253
23.80	0.039	25.50	0.036	-0.00227
25.50	0.036	27.20	0.032	-0.00203
27.20	0.032	28.90	0.029	-0.00181
28.90	0.029	30.60	0.026	-0.00161
30.60	0.026	32.30	0.024	-0.00144
32.30	0.024	34.00	0.022	-0.00129
34.00	0.022	37.40	0.018	-0.00109
37.40	0.018	40.80	0.015	-0.00087

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
30	0	42	2.952	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	7.00
2	30.00	3.25

PASSIVE SPACING:

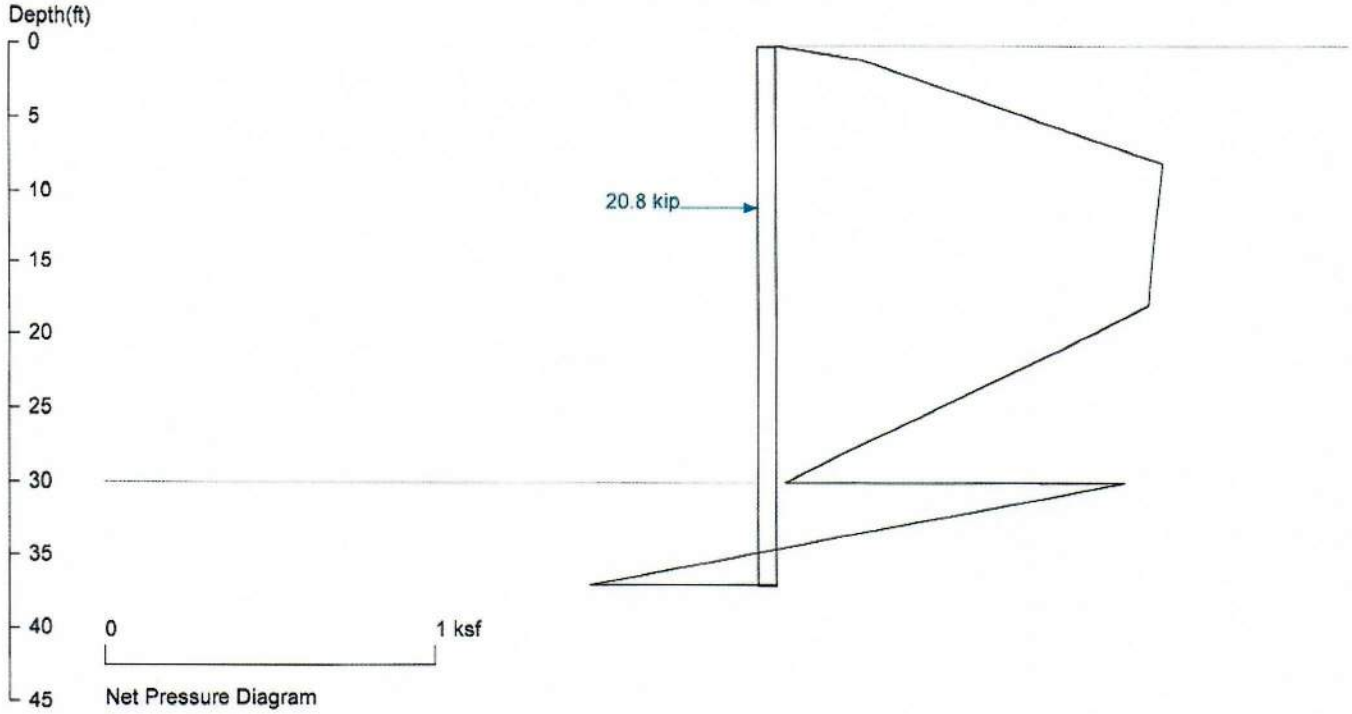
No.	Z depth	Spacing
1	30.00	7.00

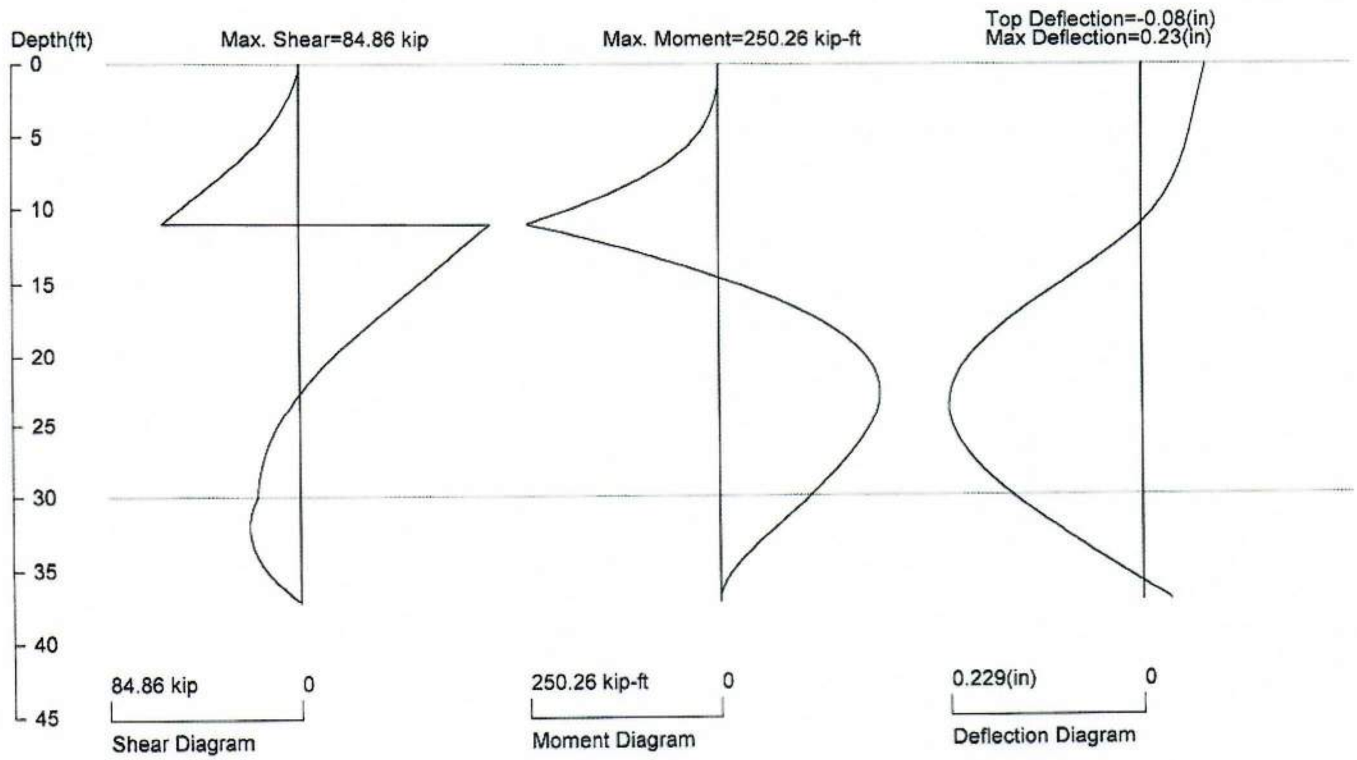
UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Southwest Corner SOE

Maine Medical Center - Portland, ME

C5





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 7.0 foot or meter

User Input Pile, W24x104: E (ksi)=29000.0, I (in4)/pile=3100.0

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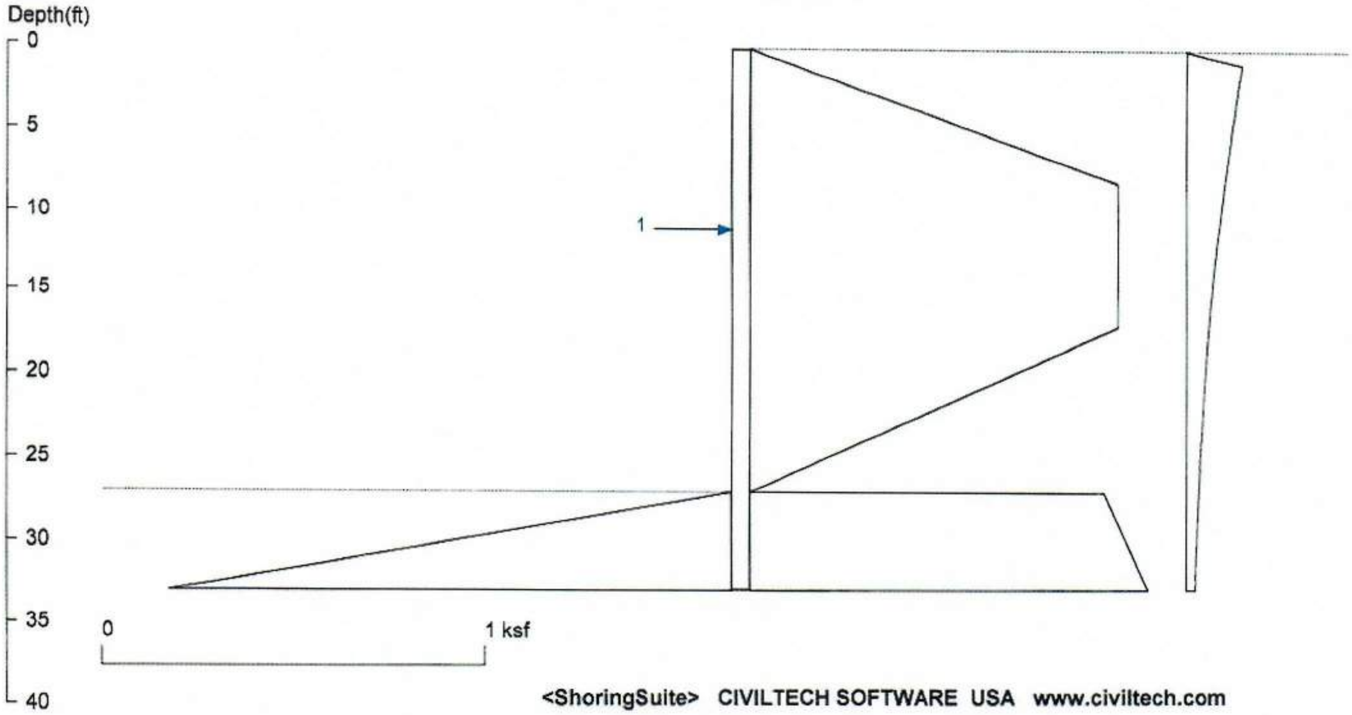
01



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Wall Height=27.0 Pile Diameter=3.3 Pile Spacing=7.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=5.99 (5~10ft is recommended!!!) Min. Pile Length=32.99
MOMENT IN PILE: Max. Moment=230.70 per Pile Spacing=7.0 at Depth=11.01

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

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	11.0	0.0	1.0	17.7	17.7	0.0	0.0	0.0

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
*	Soil	Load	*	
0	0	8	0.958	0.119750
8	0.958	17	0.958	0.000000
17	0.958	27	0	-0.09580
27	0.922	42	1.207	0.019
*	Surch	arge	*	
0.000	0.000	0.850	0.145	0.170108
0.850	0.145	1.700	0.139	-0.00634
1.700	0.139	2.550	0.134	-0.00630
2.550	0.134	3.400	0.129	-0.00624
3.400	0.129	4.250	0.123	-0.00616
4.250	0.123	5.100	0.118	-0.00606
5.100	0.118	5.950	0.113	-0.00595
5.950	0.113	6.800	0.108	-0.00582
6.800	0.108	7.650	0.103	-0.00568
7.650	0.103	8.500	0.099	-0.00553
8.500	0.099	9.350	0.094	-0.00537
9.350	0.094	10.20	0.090	-0.00520

D2

10.20	0.090	11.05	0.085	-0.00502
11.05	0.085	11.90	0.081	-0.00484
11.90	0.081	12.75	0.077	-0.00466
12.75	0.077	13.60	0.073	-0.00447
13.60	0.073	14.45	0.070	-0.00428
14.45	0.070	15.30	0.066	-0.00410
15.30	0.066	16.15	0.063	-0.00391
16.15	0.063	17.00	0.060	-0.00373
17.00	0.060	18.70	0.054	-0.00347
18.70	0.054	20.40	0.049	-0.00313
20.40	0.049	22.10	0.044	-0.00282
22.10	0.044	23.80	0.039	-0.00253
23.80	0.039	25.50	0.036	-0.00227
25.50	0.036	27.20	0.032	-0.00203
27.20	0.032	28.90	0.029	-0.00181
28.90	0.029	30.60	0.026	-0.00161
30.60	0.026	32.30	0.024	-0.00144
32.30	0.024	34.00	0.022	-0.00129

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
27	0	42	3.690	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	7.00
2	27.00	3.25

PASSIVE SPACING:

No.	Z depth	Spacing
1	27.00	7.00

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

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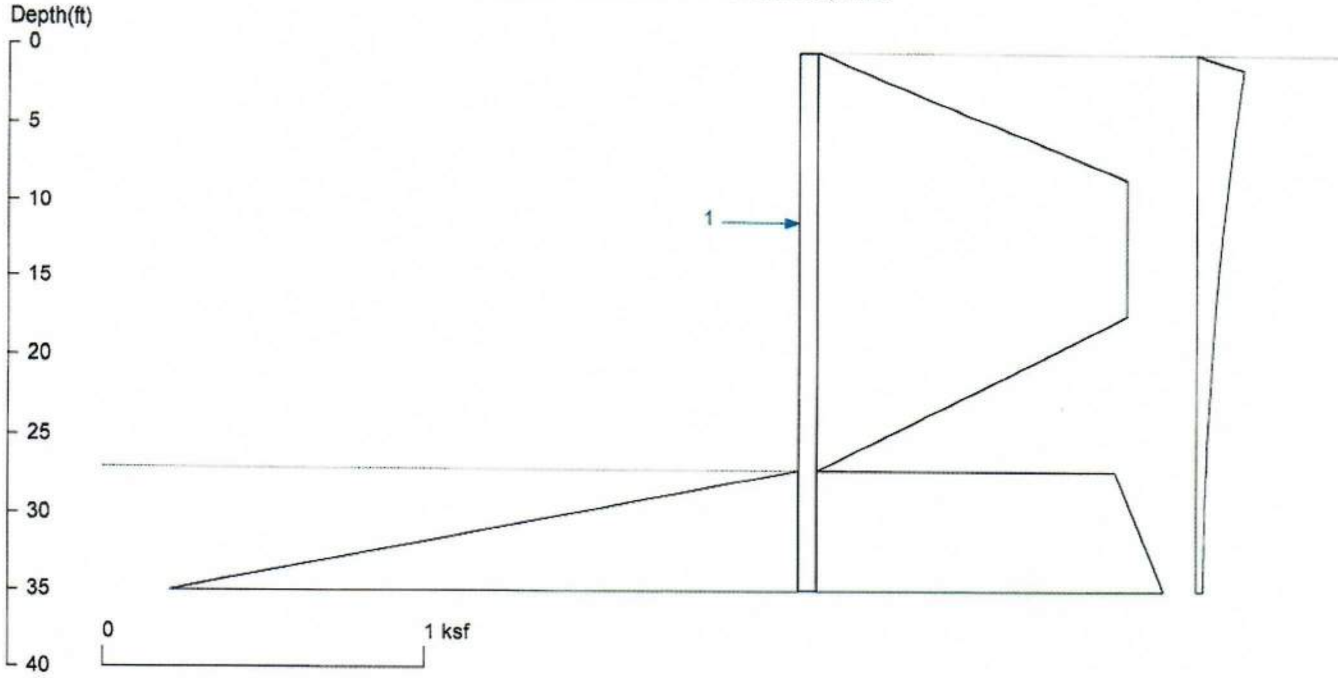
D3



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Wall Height=27.0 Pile Diameter=3.3 Pile Spacing=7.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=7.96 Min. Pile Length=34.96
MOMENT IN PILE: Max. Moment=230.77 per Pile Spacing=7.0 at Depth=11.01

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

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	11.0	0.0	1.0	17.9	17.9	0.0	0.0	0.0

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
*	Soil	Load	*	
0	0	8	0.958	0.119750
8	0.958	17	0.958	0.000000
17	0.958	27	0	-0.09580
27	0.922	42	1.207	0.019
*	Surch	arge	*	
0.000	0.000	0.850	0.145	0.170108
0.850	0.145	1.700	0.139	-0.00634
1.700	0.139	2.550	0.134	-0.00630
2.550	0.134	3.400	0.129	-0.00624
3.400	0.129	4.250	0.123	-0.00616
4.250	0.123	5.100	0.118	-0.00606
5.100	0.118	5.950	0.113	-0.00595
5.950	0.113	6.800	0.108	-0.00582
6.800	0.108	7.650	0.103	-0.00568
7.650	0.103	8.500	0.099	-0.00553
8.500	0.099	9.350	0.094	-0.00537
9.350	0.094	10.20	0.090	-0.00520

P4

10.20	0.090	11.05	0.085	-0.00502
11.05	0.085	11.90	0.081	-0.00484
11.90	0.081	12.75	0.077	-0.00466
12.75	0.077	13.60	0.073	-0.00447
13.60	0.073	14.45	0.070	-0.00428
14.45	0.070	15.30	0.066	-0.00410
15.30	0.066	16.15	0.063	-0.00391
16.15	0.063	17.00	0.060	-0.00373
17.00	0.060	18.70	0.054	-0.00347
18.70	0.054	20.40	0.049	-0.00313
20.40	0.049	22.10	0.044	-0.00282
22.10	0.044	23.80	0.039	-0.00253
23.80	0.039	25.50	0.036	-0.00227
25.50	0.036	27.20	0.032	-0.00203
27.20	0.032	28.90	0.029	-0.00181
28.90	0.029	30.60	0.026	-0.00161
30.60	0.026	32.30	0.024	-0.00144
32.30	0.024	34.00	0.022	-0.00129
34.00	0.022	37.40	0.018	-0.00109

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
27	0	42	3.690	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	7.00
2	27.00	3.25

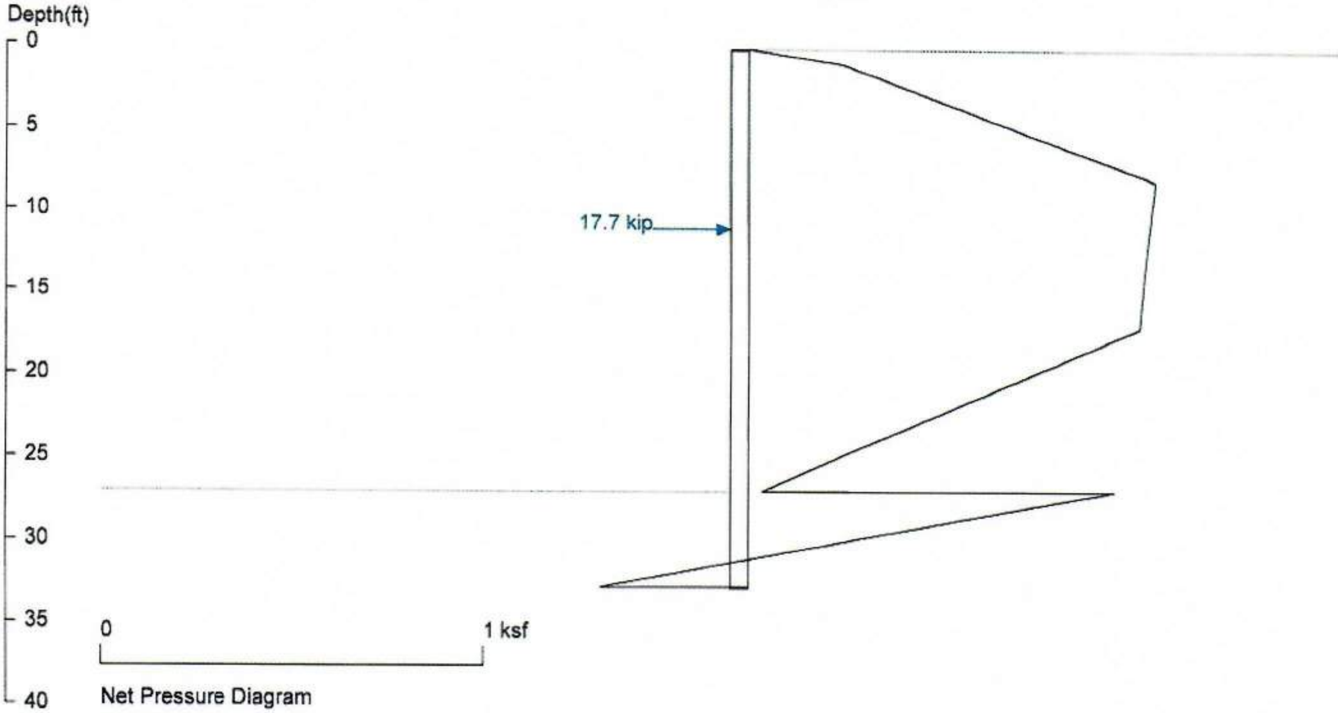
PASSIVE SPACING:

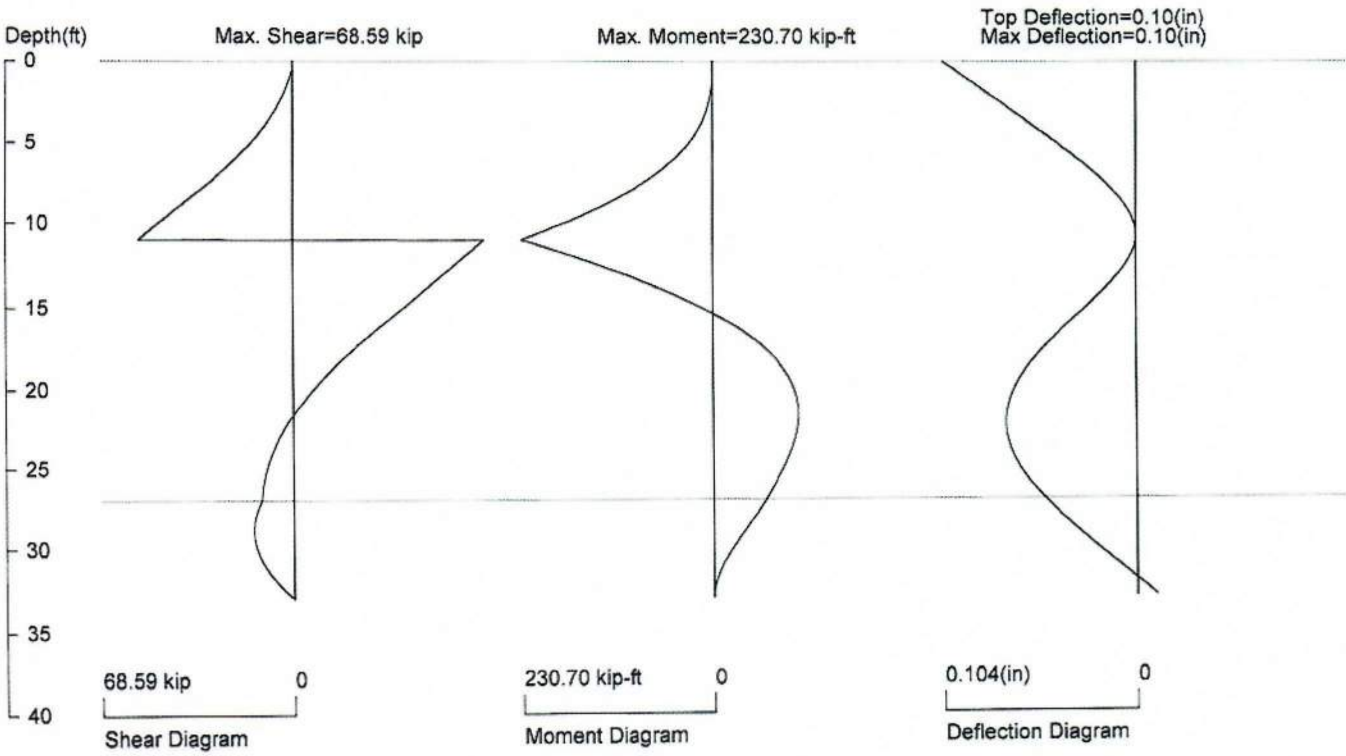
No.	Z depth	Spacing
1	27.00	7.00

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

Southwest Corner SOE
Maine Medical Center - Portland, ME

D5





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 7.0 foot or meter

User Input Pile, W24x104: E (ksi)=29000.0, I (in4)/pile=3100.0

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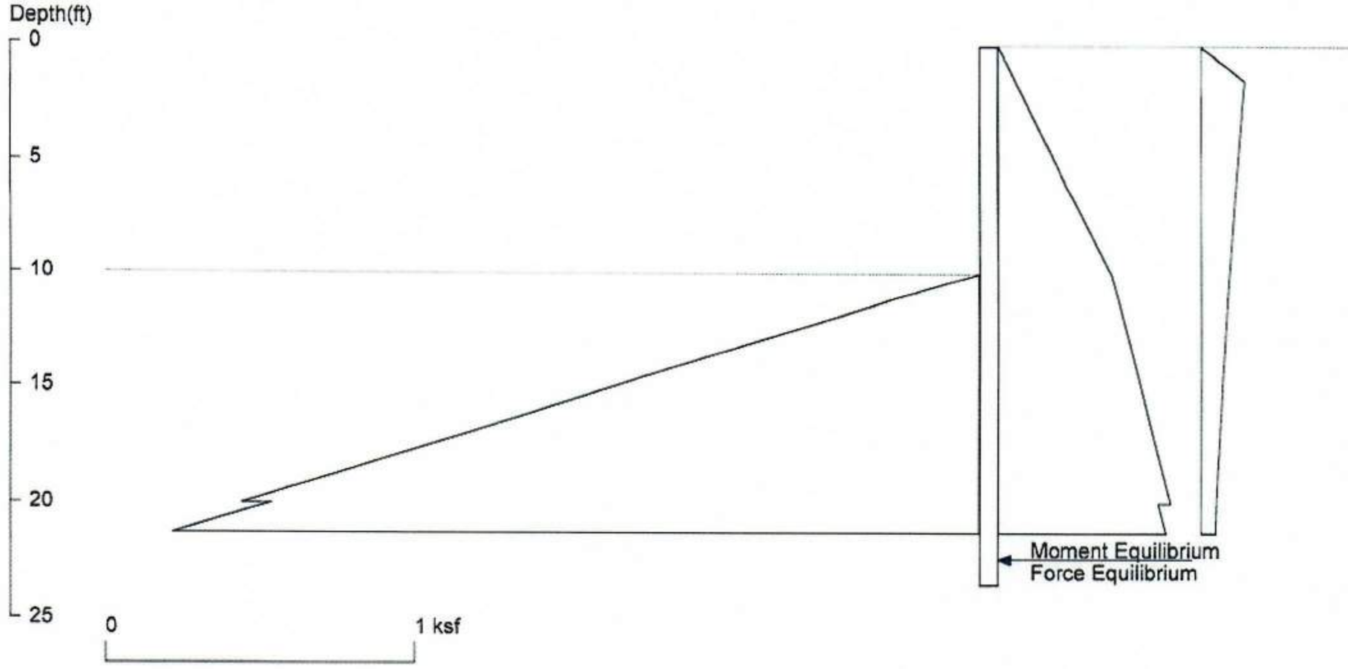
Gilman Street Parking Garage
Maine Medical Center - Portland, ME

E1



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Wall Height=10.0 Pile Diameter=3.3 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=11.30 Min. Pile Length=21.30

MOMENT IN PILE: Max. Moment=190.42 per Pile Spacing=8.0 at Depth=15.83

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
10	0.364	20	0.554	0.019
20	0.514	42	0.932	0.019
*	Sur-	charg	*	
0.000	0.000	1.500	0.140	0.093644
1.500	0.140	3.000	0.131	-0.00629
3.000	0.131	4.500	0.122	-0.00617
4.500	0.122	6.000	0.113	-0.00599
6.000	0.113	7.500	0.104	-0.00576
7.500	0.104	9.000	0.096	-0.00550
9.000	0.096	10.50	0.088	-0.00520
10.50	0.088	12.00	0.081	-0.00489
12.00	0.081	13.50	0.074	-0.00456
13.50	0.074	15.00	0.068	-0.00423
15.00	0.068	16.50	0.062	-0.00391
16.50	0.062	18.00	0.056	-0.00359
18.00	0.056	19.50	0.051	-0.00329
19.50	0.051	21.00	0.047	-0.00300
21.00	0.047	22.50	0.043	-0.00273
22.50	0.043	24.00	0.039	-0.00248

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
10	0	20	2.390	0.239

20	2.293	42	7.705	0.246

E2

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	10.00	3.25

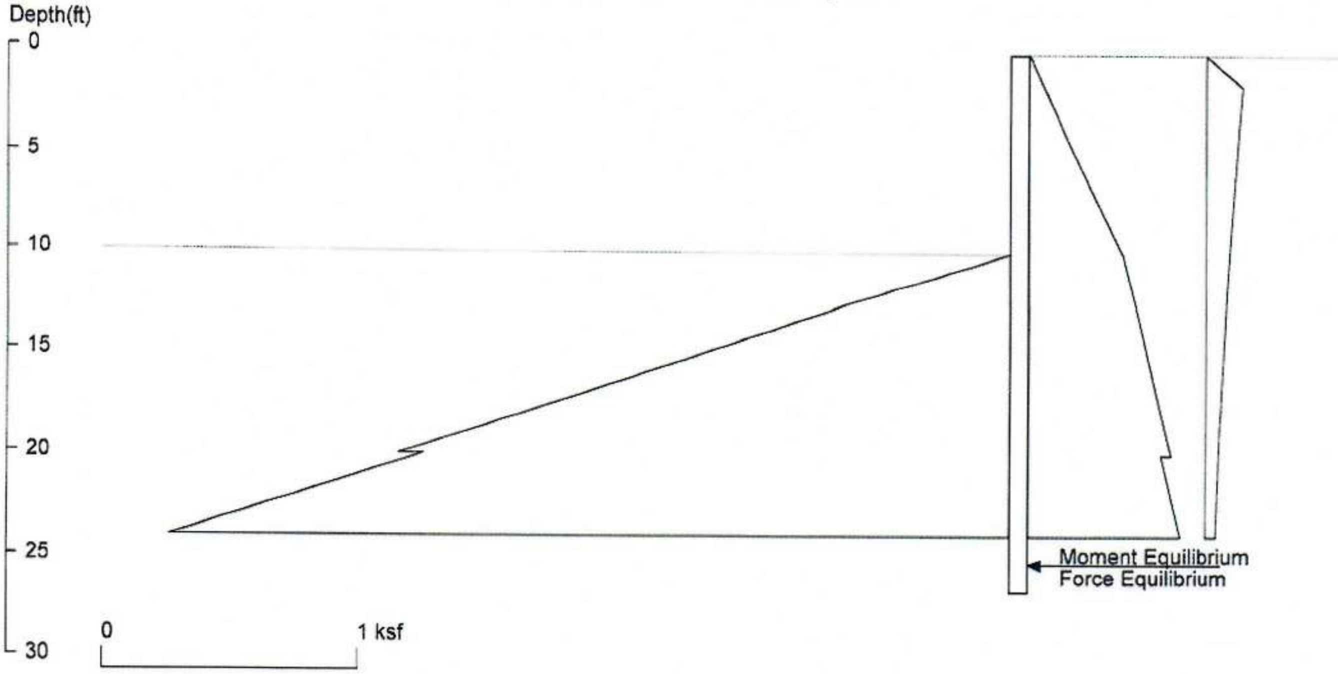
PASSIVE SPACING:

No.	Z depth	Spacing
1	10.00	8.00

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

Gilman Street Parking Garage
Maine Medical Center - Portland, ME

E3



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Wall Height=10.0 Pile Diameter=3.3 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=14.04 Min. Pile Length=24.04
MOMENT IN PILE: Max. Moment=220.88 per Pile Spacing=8.0 at Depth=17.46

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
10	0.364	20	0.554	0.019
20	0.514	42	0.932	0.019
*	Sur-	charg	*	
0.000	0.000	1.500	0.140	0.093644
1.500	0.140	3.000	0.131	-0.00629
3.000	0.131	4.500	0.122	-0.00617
4.500	0.122	6.000	0.113	-0.00599
6.000	0.113	7.500	0.104	-0.00576
7.500	0.104	9.000	0.096	-0.00550
9.000	0.096	10.50	0.088	-0.00520
10.50	0.088	12.00	0.081	-0.00489
12.00	0.081	13.50	0.074	-0.00456
13.50	0.074	15.00	0.068	-0.00423
15.00	0.068	16.50	0.062	-0.00391
16.50	0.062	18.00	0.056	-0.00359
18.00	0.056	19.50	0.051	-0.00329
19.50	0.051	21.00	0.047	-0.00300
21.00	0.047	22.50	0.043	-0.00273
22.50	0.043	24.00	0.039	-0.00248
24.00	0.039	25.50	0.036	-0.00225
25.50	0.036	27.00	0.033	-0.00204

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

E4

Z1	P1	Z2	P2	Slope
10	0	20	2.390	0.239
20	2.293	42	7.705	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	10.00	3.25

PASSIVE SPACING:

No.	Z depth	Spacing
1	10.00	8.00

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

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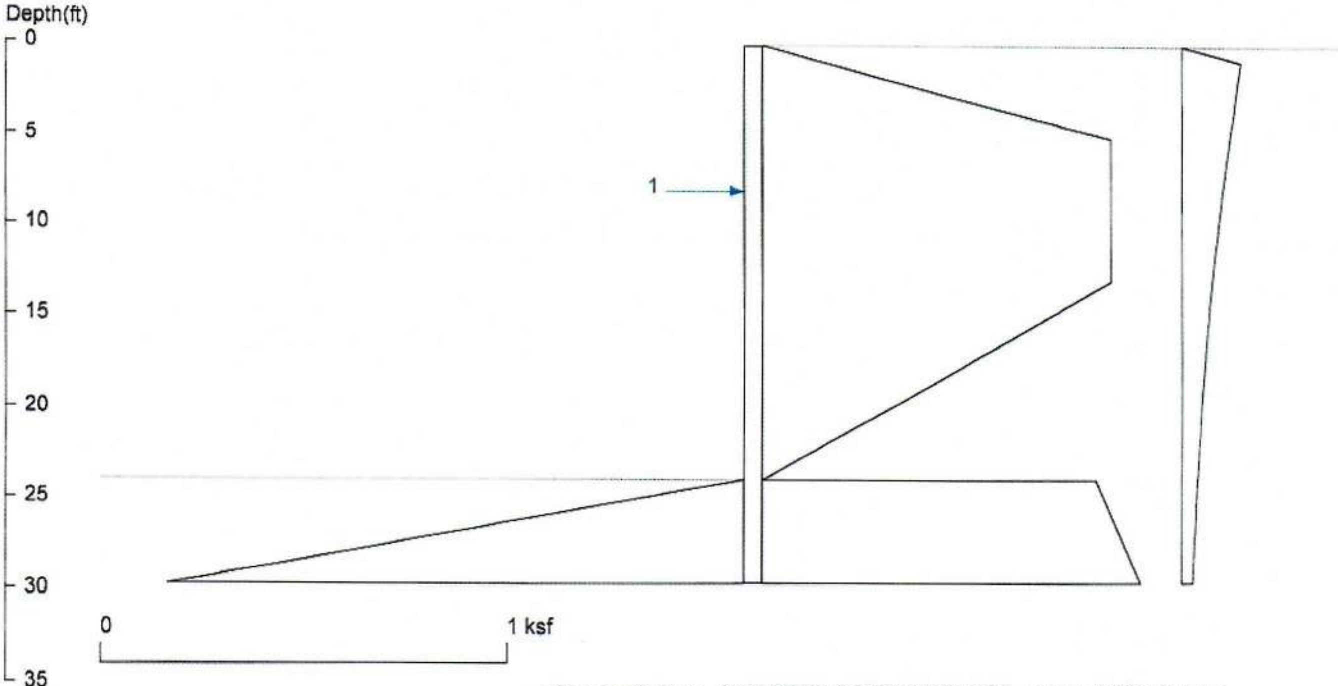
ES



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Wall Height=24.0 Pile Diameter=3.3 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=5.76 (5~10ft is recommended!!!) Min. Pile Length=29.76
MOMENT IN PILE: Max. Moment=141.60 per Pile Spacing=8.0 at Depth=17.48

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

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	8.0	0.0	1.0	13.7	13.7	0.0	0.0	0.0

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
*	Soil	Load	*	
0	0	5	0.852	0.170400
5	0.852	13	0.852	0.000000
13	0.852	24	0	-0.07745
24	0.816	42	1.158	0.019
*	Surch	arge	*	
0.000	0.000	0.850	0.145	0.170108
0.850	0.145	1.700	0.139	-0.00634
1.700	0.139	2.550	0.134	-0.00630
2.550	0.134	3.400	0.129	-0.00624
3.400	0.129	4.250	0.123	-0.00616
4.250	0.123	5.100	0.118	-0.00606
5.100	0.118	5.950	0.113	-0.00595
5.950	0.113	6.800	0.108	-0.00582
6.800	0.108	7.650	0.103	-0.00568
7.650	0.103	8.500	0.099	-0.00553
8.500	0.099	9.350	0.094	-0.00537
9.350	0.094	10.20	0.090	-0.00520

E6

10.20	0.090	11.05	0.085	-0.00502
11.05	0.085	11.90	0.081	-0.00484
11.90	0.081	12.75	0.077	-0.00466
12.75	0.077	13.60	0.073	-0.00447
13.60	0.073	14.45	0.070	-0.00428
14.45	0.070	15.30	0.066	-0.00410
15.30	0.066	16.15	0.063	-0.00391
16.15	0.063	17.00	0.060	-0.00373
17.00	0.060	18.70	0.054	-0.00347
18.70	0.054	20.40	0.049	-0.00313
20.40	0.049	22.10	0.044	-0.00282
22.10	0.044	23.80	0.039	-0.00253
23.80	0.039	25.50	0.036	-0.00227
25.50	0.036	27.20	0.032	-0.00203
27.20	0.032	28.90	0.029	-0.00181
28.90	0.029	30.60	0.026	-0.00161

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
24	0	42	4.428	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	24.00	3.25

PASSIVE SPACING:

No.	Z depth	Spacing
1	24.00	8.00

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

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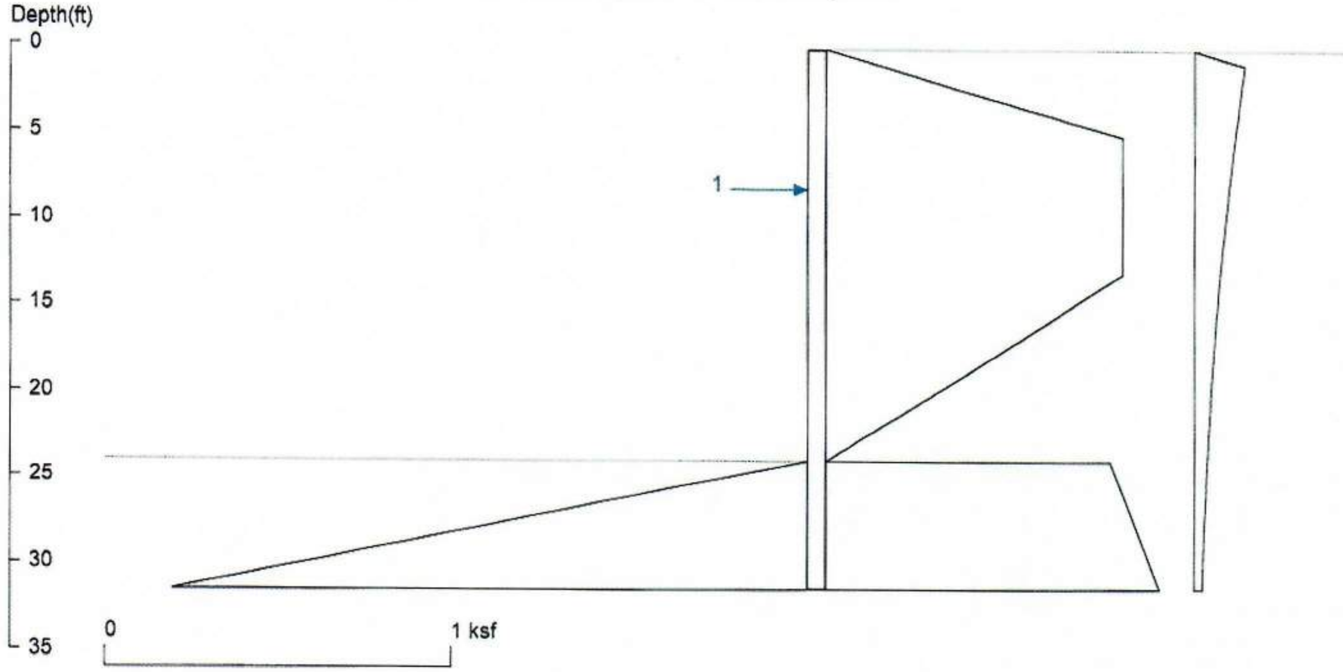
E7



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Wall Height=24.0 Pile Diameter=3.3 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=7.47 Min. Pile Length=31.47
MOMENT IN PILE: Max. Moment=154.68 per Pile Spacing=8.0 at Depth=17.79

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

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	8.0	0.0	1.0	13.8	13.8	0.0	0.0	0.0

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
*	Soil	Load	*	
0	0	5	0.852	0.170400
5	0.852	13	0.852	0.000000
13	0.852	24	0	-0.07745
24	0.816	42	1.158	0.019
*	Surch	arge	*	
0.000	0.000	0.850	0.145	0.170108
0.850	0.145	1.700	0.139	-0.00634
1.700	0.139	2.550	0.134	-0.00630
2.550	0.134	3.400	0.129	-0.00624
3.400	0.129	4.250	0.123	-0.00616
4.250	0.123	5.100	0.118	-0.00606
5.100	0.118	5.950	0.113	-0.00595
5.950	0.113	6.800	0.108	-0.00582
6.800	0.108	7.650	0.103	-0.00568
7.650	0.103	8.500	0.099	-0.00553
8.500	0.099	9.350	0.094	-0.00537
9.350	0.094	10.20	0.090	-0.00520

E8

10.20	0.090	11.05	0.085	-0.00502
11.05	0.085	11.90	0.081	-0.00484
11.90	0.081	12.75	0.077	-0.00466
12.75	0.077	13.60	0.073	-0.00447
13.60	0.073	14.45	0.070	-0.00428
14.45	0.070	15.30	0.066	-0.00410
15.30	0.066	16.15	0.063	-0.00391
16.15	0.063	17.00	0.060	-0.00373
17.00	0.060	18.70	0.054	-0.00347
18.70	0.054	20.40	0.049	-0.00313
20.40	0.049	22.10	0.044	-0.00282
22.10	0.044	23.80	0.039	-0.00253
23.80	0.039	25.50	0.036	-0.00227
25.50	0.036	27.20	0.032	-0.00203
27.20	0.032	28.90	0.029	-0.00181
28.90	0.029	30.60	0.026	-0.00161
30.60	0.026	32.30	0.024	-0.00144

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
24	0	42	4.428	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	24.00	3.25

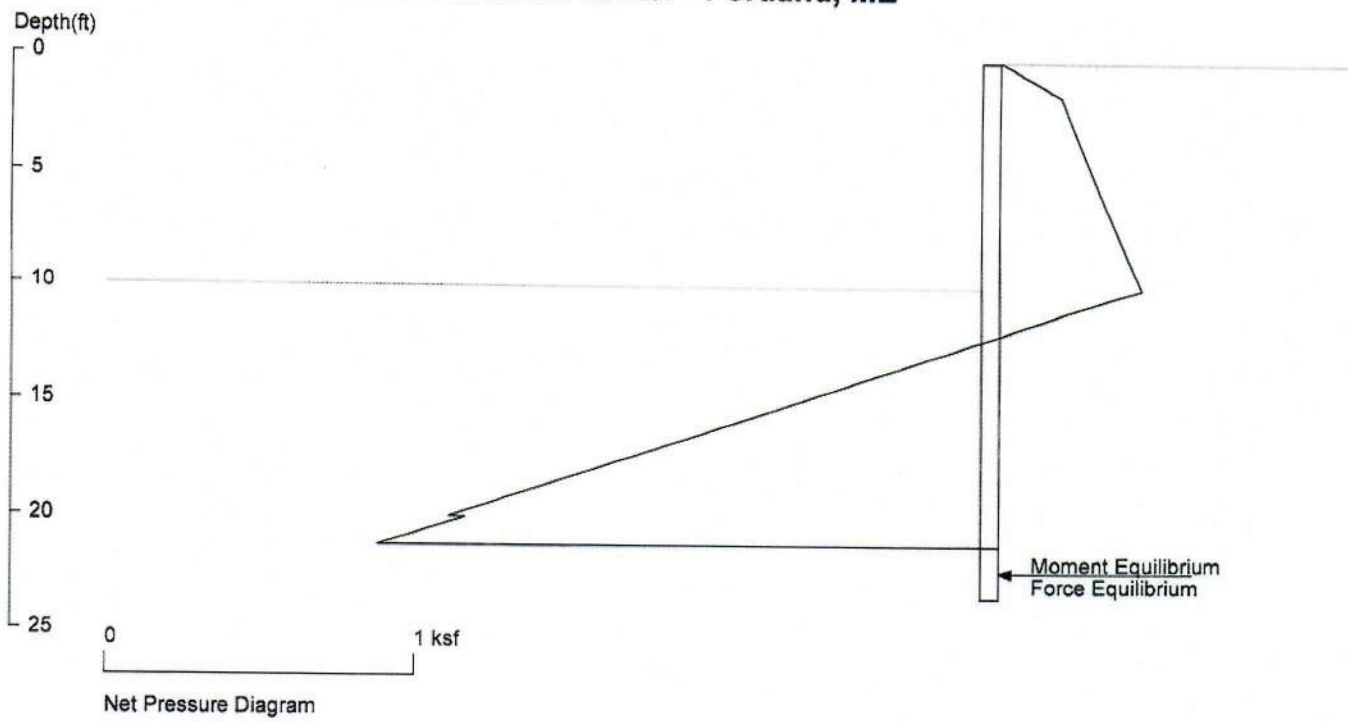
PASSIVE SPACING:

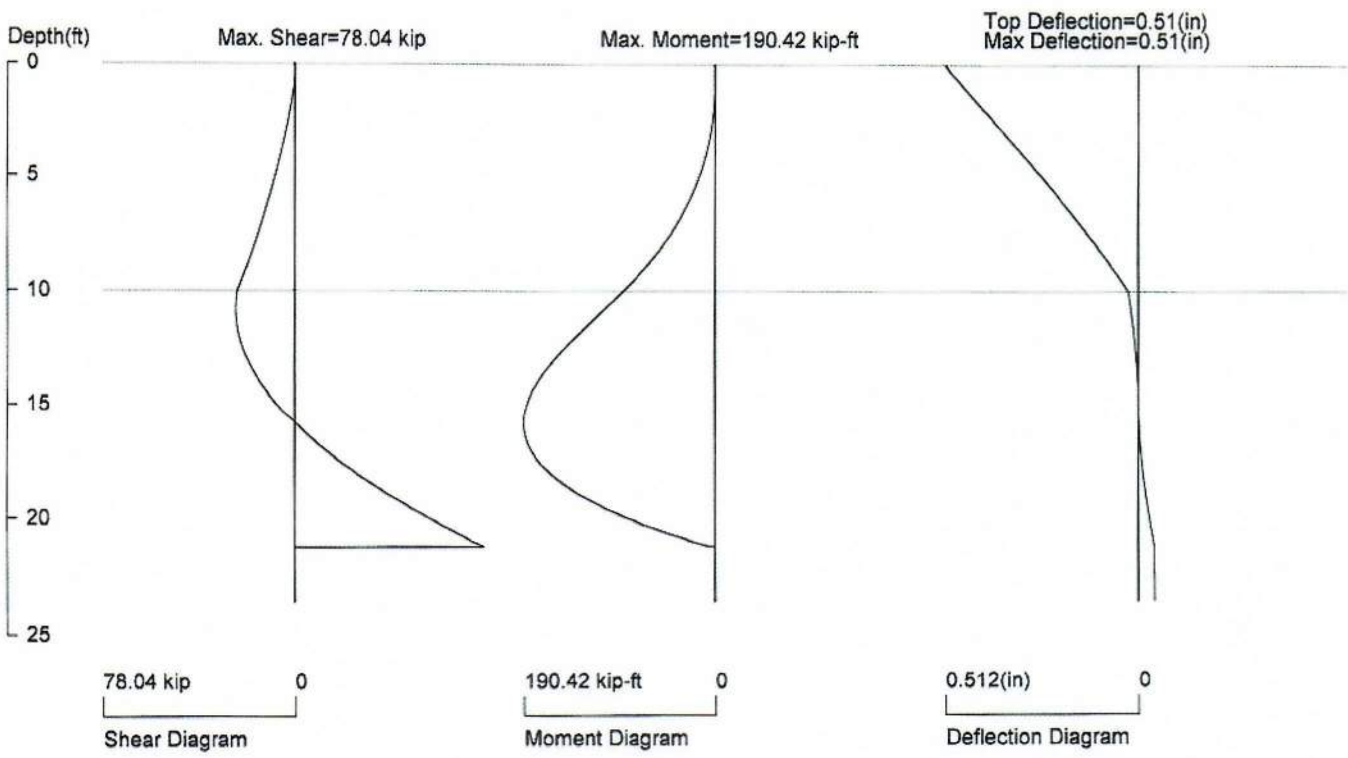
No.	Z depth	Spacing
1	24.00	8.00

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

Gilman Street Parking Garage
Maine Medical Center - Portland, ME

E9





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 8.0 foot or meter

User Input Pile, HP14x102: E (ksi)=29000.0, I (in4)/pile=1050.0

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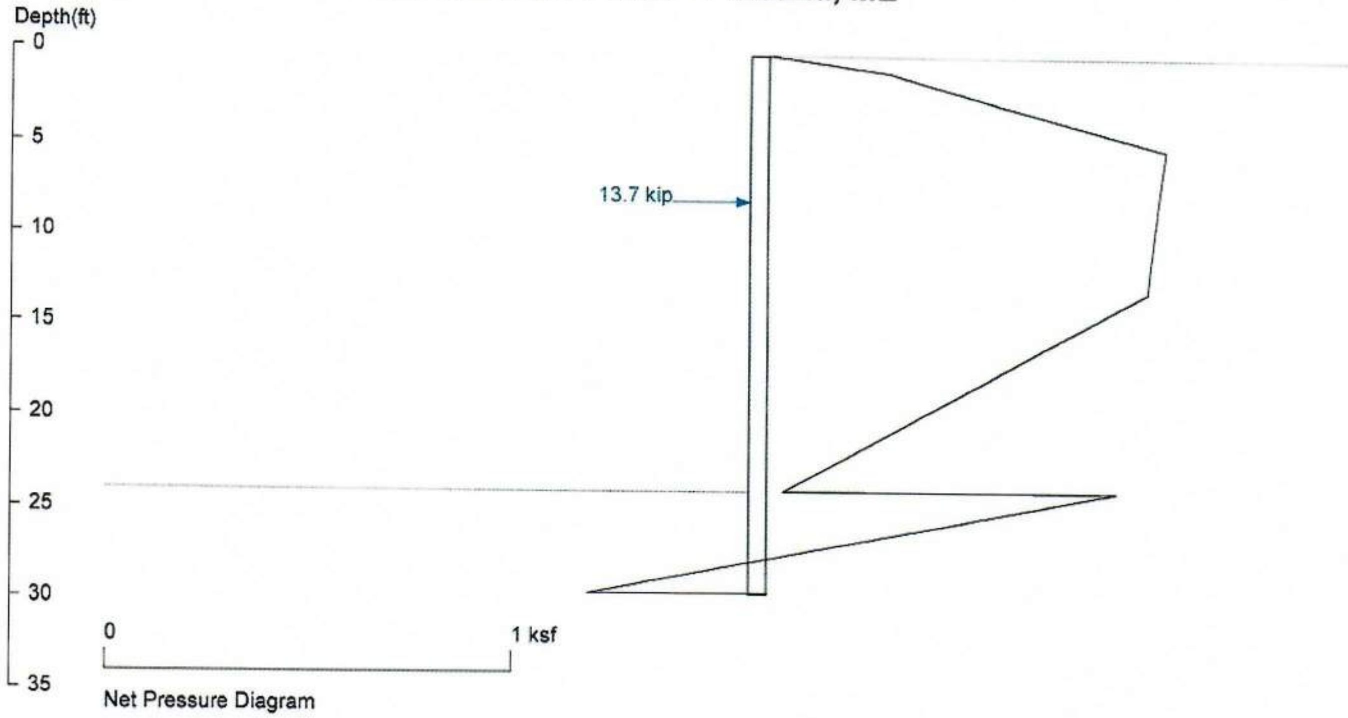

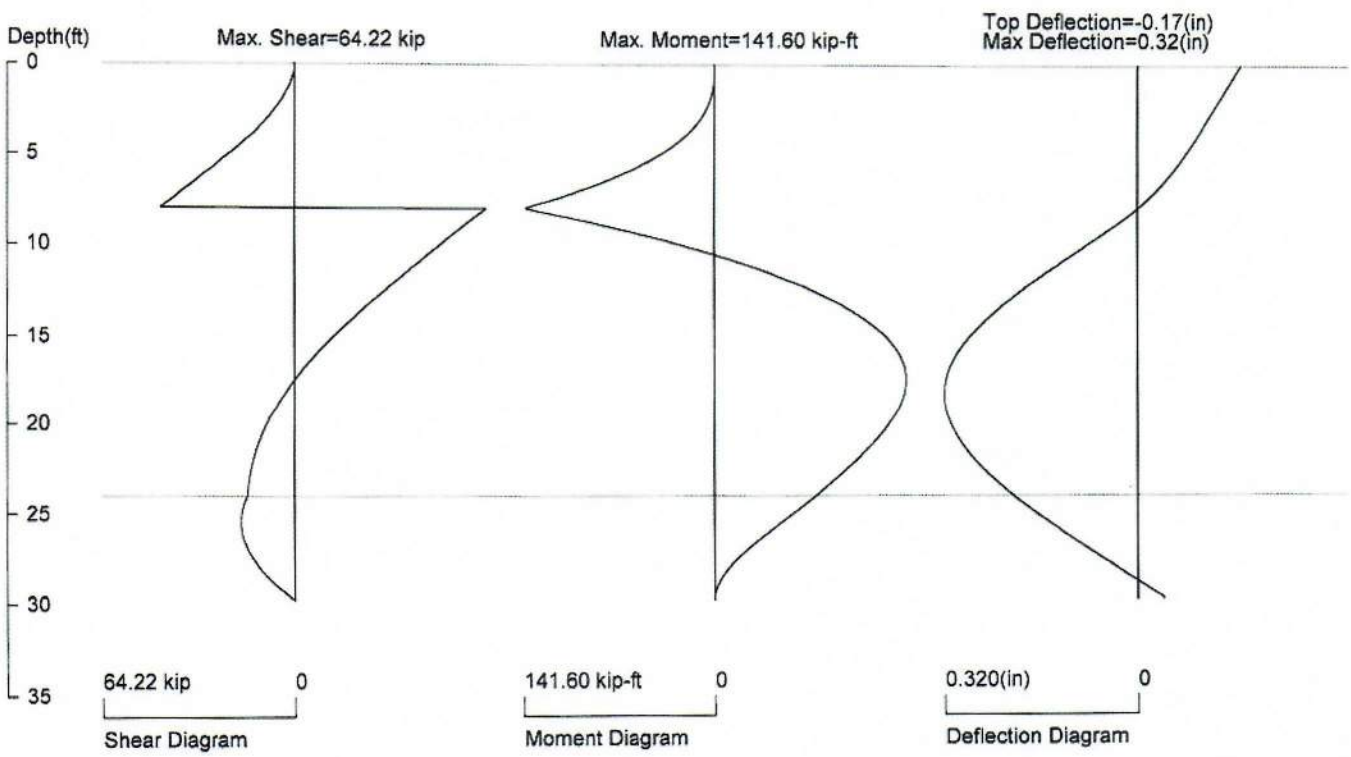

PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 8.0 foot or meter

User Input Pile, HP14x102: E (ksi)=29000.0, I (in4)/pile=1050.0

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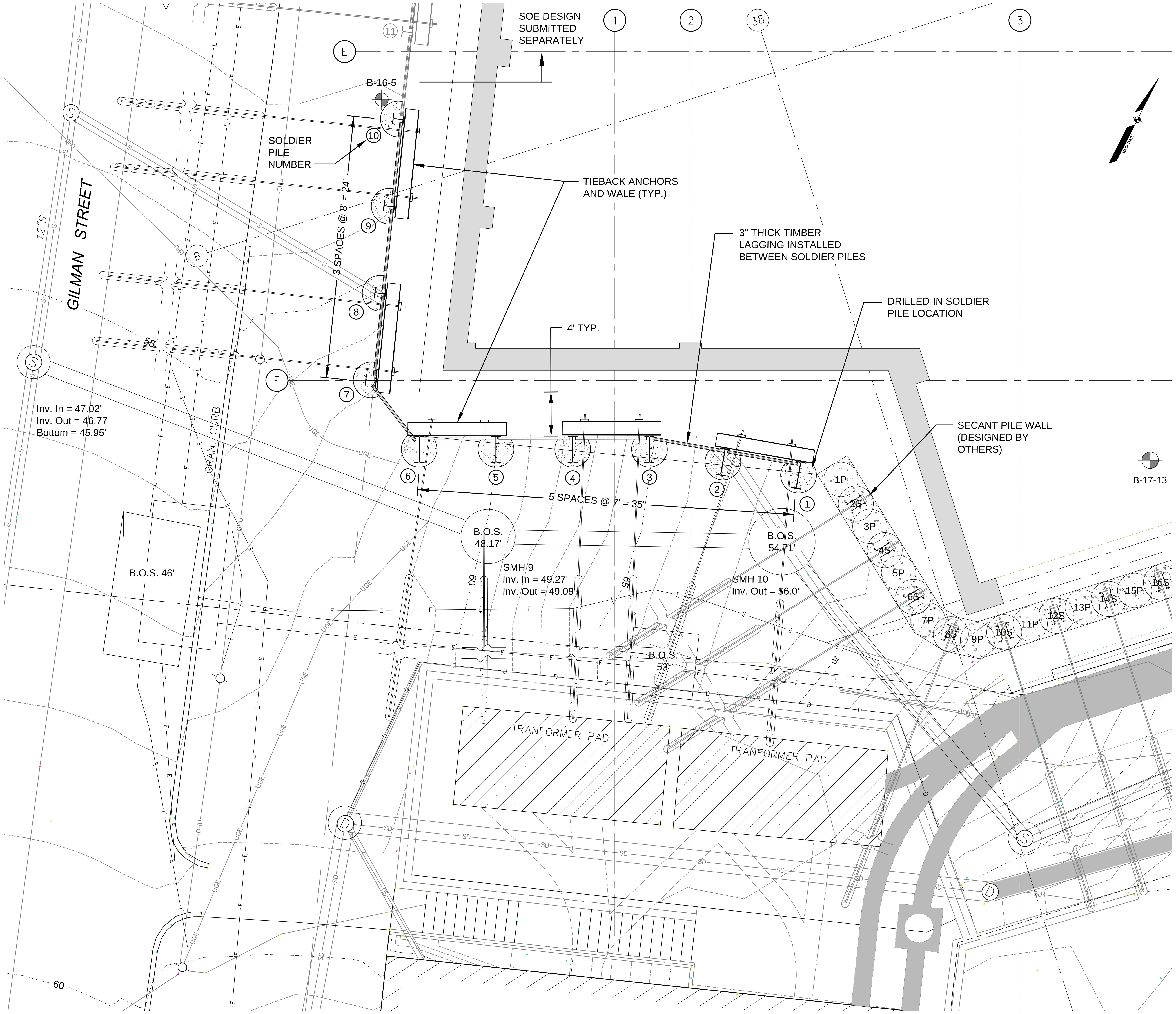


PLAN OF EXCAVATION SUPPORT
SCALE: 1"=5'-0"

GENERAL NOTES

THESE PLANS DETAIL THE TEMPORARY EXCAVATION SUPPORT SYSTEM TO BE INSTALLED AT THE SOUTHWEST CORNER OF THE NEW CONGRESS STREET BUILDINGAT THE MAINE MEDICAL CENTER IN PORTLAND, MAINE. THE EXCAVATION SUPPORT SYSTEM HAS BEEN DESIGNED FOR A MAXIMUM VERTICAL SURCHARGE OF 300 PSF APPLIED AT THE TOP OF THE SUPPORT WALL.

INSTALLATION PROCEDURE

1. THE AREA ALONG THE SOLDIER PILE ALIGNMENT SHALL BE CLEARED OF ALL EXISTING UTILITIES AND OTHER OBSTRUCTIONS PRIOR TO PILE INSTALLATION. THE AREA AT PILE 1 TO BE GRADED TO ELEV. +65 AND SLOPED DOWN TO PILE 6 AT ELEV. 57.
2. THE SOLDIER PILES SHALL THEN BE INSTALLED AT THE LOCATIONS SHOWN IN PLAN. THE PILES SHALL BE INSTALLED WITHIN PREDRILLED CASED HOLES WHICH SHALL BE ADVANCED DOWN TO THE LENGTH GIVEN IN THE SOLDIER PILE SCHEDULE. THE PILES SHALL BE SET WITHIN THE DRILLED SHAFT IN THE CORRECT ORIENTATION AND THEN BACKFILLED WITH FLO FILL CONCRETE UP TO EXISTING GRADE.
3. AFTER THE SOLDIER PILES HAVE BEEN INSTALLED MAKE THE INITIAL EXCAVATION ALONG THE SOLDIER PILE WALL TO 5 FEET BELOW GRADE FOR INSTALLATION OF TIMBER LAGGING BETWEEN PILES. THE HEIGHT OF UNSUPPORTED SOIL FACE MAY NEED TO BE REDUCED FROM 5 FEET BASED ON ACTUAL SOIL CONDITIONS TO MAINTAIN A STABLE SOIL FACE. TIMBER LAGGING WILL BE EITHER TUCKED BEHIND THE PILE FLANGES OR ATTACHED TO THE FLANGES WITH WELDED THREADED ROD (SEE DETAIL ON DRWG. 2 OF 3). LAGGING WILL BE SPACED WITH LOUVERS TO PERMIT FREE DRAINAGE. ALL VOIDS BEHIND THE LAGGING WILL BE TIGHTLY BACK PACKED WITH ON-SITE GRANULAR MATERIAL. TIMBER LAGGING TO BE INSTALLED IMMEDIATELY AFTER EXCAVATION IS MADE.
4. THE GENERAL EXCAVATION SHALL CONTINUE IN LIFTS WITH LAGGING INSTALLED BETWEEN THE PILES AS DESCRIBED ABOVE DOWN TO TWO FEET BELOW EACH BRACING LEVEL FOR INSTALLATION OF THE TIEBACK ANCHORS AND WALES, AS DETAILED. TIEBACKS SHALL BE INSTALLED AT THE DEPTH AND ANGLE GIVEN IN THE SOLDIER PILE SCHEDULE. THE TIEBACK TENDON AND REGROUT TUBE SHALL BE INSTALLED THE FULL LENGTH WITHOUT DIFFICULTY. PLACE GROUT BY TREMIE METHODS TO THE FACE OF EXCAVATION. TIEBACKS SHALL BE REGROUTED AT LEAST ONCE. AFTER THE TIEBACKS HAVE BEEN INSTALLED THEY SHALL BE TESTED FOLLOWING THE *"TIEBACK TESTING PROCEDURE"* GIVEN ON DRAWING 2 OF 3. TIEBACK TEST REPORTS TO BE PROVIDED TO EARTHWORK ENGINEERING FOR REVIEW.
5. .AFTER THE STRUCTURE IS INSTALLED AND BACKFILL HAS BEEN PLACED UP TO WITHIN 2 FEET OF THE BRACING LEVEL THE WALE AND BRACING CAN BE REMOVED. IN ADDITION, THE TIEBACKS SHALL BE DETENTIONED AND THE DOUBLE CHANNLE WALES REMOVED.

THE LATERAL MOVEMENT OF THE SYSTEM SHALL BE MONITORED DURING CONSTRUCTION. MONITORING POINTS SHALL BE LOCATED EVERY 16 FEET ALONG THE EXCAVATION SUPPORT (MAX.) AND READINGS TAKEN 2 TO 3 TIMES PER WEEK DURING ACTIVE EXCAVATION WORK. AFTER THE EXCAVATION REACHES SUBGRADE THE READINGS SHALL BE TAKEN WEEKLY. MONITORING DATA SHALL BE PROVIDED TO EARTHWORK ENGINEERING FOR REVIEW AS IT IS OBTAINED.

MATERIAL SCHEDULE

ITEM	MATERIAL	GRADE
SOLDIER PILES	SEE SCHDULE	ASTM A572 (Fy=50 ksi)
FLO FILL	LEAN CONCRETE	fc = 150 psi (min.)
TIMBER LAGGING	3-INCH THICK (NOM.)	Fb = 875 psi
TIEBACK WALES	2 - C15x33.9 CHANNEL 2 - C15x50 CHANNEL	ASTM A572 (Fy=50 ksi) ASTM A572 (Fy=50 ksi)
TIEBACK TENDONS	0.6"Ø 7 WIRE STRAND	ASTM A-416 (Fu=270 ksi)
TIEBACK PLATES	12"x12"x1.5" PLATE	ASTM A572 (Fy=50 ksi)
SUPPORT BRACKET	HP12x53 SECTION	ASTM A572 (Fy=50 ksi)
WELDS	E70XX	Fy=70 ksi

MATERIALS OF EQUAL OR GREATER STRENGTH MAY BE SUBSTITUTED FOR THOSE LISTED ABOVE WRITTEN UPON APPROVAL BY THE EARTHWORK ENGINEERING.

TURNER CONSTRUCTION COMPANY
Reviewed for General Acceptance only. This review does not relieve the Subcontractor of the responsibility for making the work conform to the requirements of the contract. The Subcontractor is responsible for all dimensions, correct fabrication and accurate fit with the work of other trades.
SUBJECT TO ARCHITECTS APPROVAL
Signed [signature] Date Mar 02, 2021
Submittal No. CS-315001-SOE-0002-3

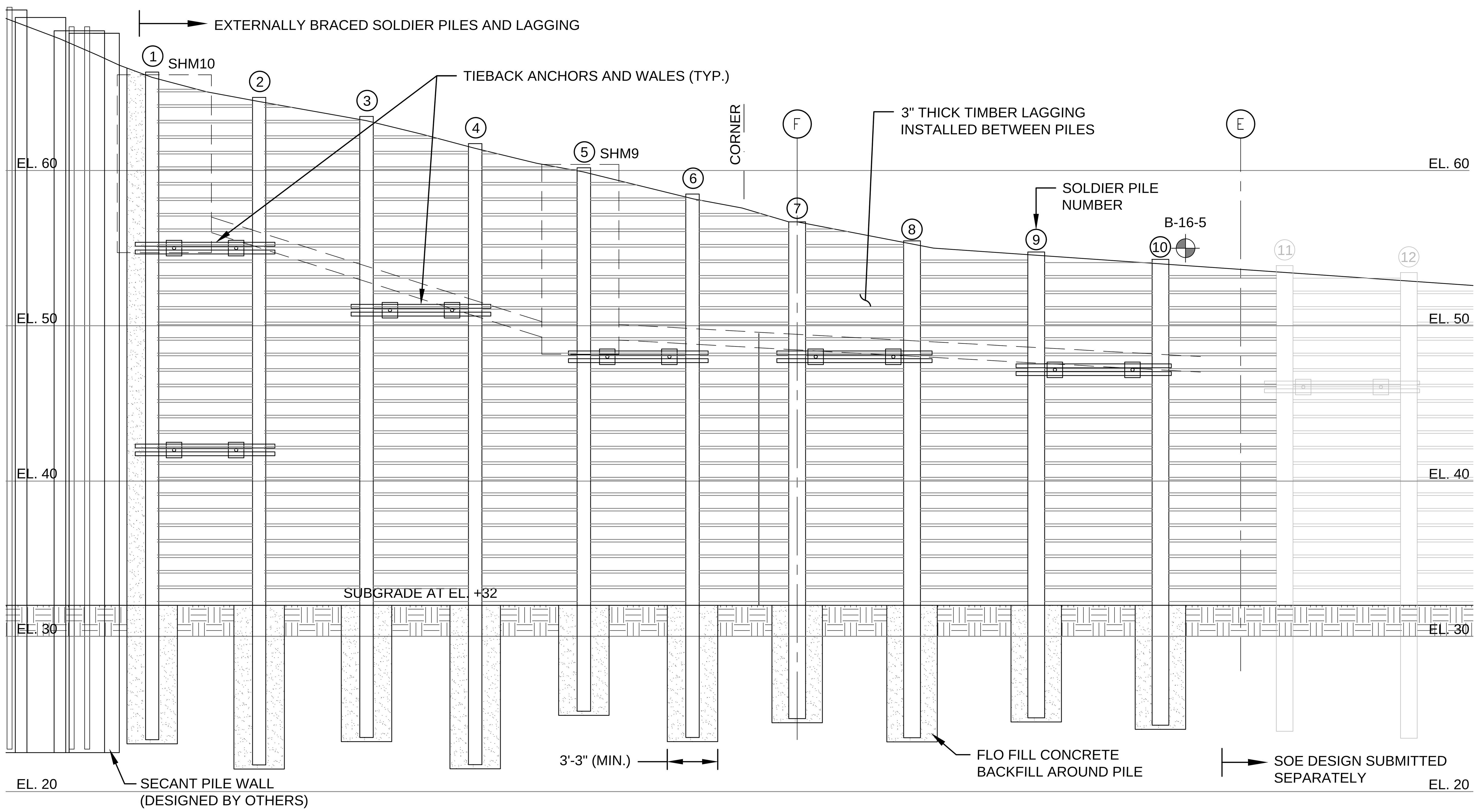
DESIGN AND DRAWING PREPARED BASED IN PART ON UNVERIFIED INFORMATION PROVIDED BY OTHERS. IF ACTUAL SITE AND/OR SOIL CONDITIONS VARY FROM THOSE SHOWN NOTIFY THE DESIGN ENGINEER TO REVIEW PRIOR TO THE START OF WORK.

NO.	DATE	REVISIONS
3	3/1/21	Revised tieback alignment at piles 1 to 6 and wale section at pile 3 to 4.
2	12/31/20	Revised to address review comments.
1	12/11/20	Revised to address review comments.

STATE OF MAINE — PAUL A. DETERLING — No. 5506 — REGISTERED PROFESSIONAL ENGINEER

DESIGN ENGINEER	CONTRACTOR	PROJECT	DRAWING TITLE
EARTHWORK ENGINEERING, INC. 175 Ridge Road - Hollis, NH 03049 Tel. (603) 465-9500 - Fax (603) 465-9650	KELLER - NORTH AMERICA 30 Martin - Cumberland, RI 02864 Tel. (401) 334-2565 - Fax (401) 334-3337	CONGRESS STREET BUILDING MAINE MEDICAL CENTER FACILITY PORTLAND, MAINE	SOLDIER PILE AND LAGGING WITH TIEBACK ANCHORS PLAN AND GENERAL NOTES

DESIGN BY: PAD
DATE: 10/14/20
PROJECT: 20092
SHEET: 1 of 3



ELEVATION VIEW OF EXCAVATION SUPPORT SYSTEM AT DRILLED IN SOLDIER PILES 1 TO 10

SCALE: 1"=5'-0"

TIEBACK ANCHOR TESTING PROCEDURES

AFTER THE TIEBACK ANCHORS HAVE BEEN INSTALLED THEY SHALL BE TESTED USING THE FOLLOWING PROCEDURES. THE TIEBACK DESIGN LOAD WILL BE AS GIVEN IN THE SOLDIER PILE AND TIEBACK SCHEDULE.

TESTING PROCEDURE

THE FIRST ANCHOR INSTALLED SHALL BE PERFORMANCE TESTED AND ALL OTHER TIEBACK ANCHORS SHALL BE PROOF TESTED. PERFORMANCE AND PROOF TESTS SHALL FOLLOW THE LOADING SCHEDULE GIVEN HERE. LOAD AND MOVEMENT MEASUREMENTS SHALL BE RECORDED AND PLOTTED. A RECENTLY CALIBRATED HYDRAULIC TEST JACK SHALL BE USED TO APPLY THE TEST LOADS AND A DIAL GAUGE MOUNTED ON AN INDEPENDENT REFERENCE SHALL BE USED TO RECORD MOVEMENTS TO AN ACCURACY OF 0.001 INCHES.

PERFORMANCE TESTING LOAD SCHEDULE (DL=DESIGN LOAD)

5 KIPS, 25%DL
5 KIPS, 25%DL, 50%DL
5 KIPS, 25%DL, 50%DL, 75%DL
5 KIPS, 25%DL, 50%DL, 75%DL, 100%DL
5 KIPS, 25%DL, 50%DL, 75%DL, 100%DL, 125%DL
5 KIPS, 25%DL, 50%DL, 75%DL, 100%DL, 125%DL, 133%DL (CREEP TEST),
125%DL, 100%DL, 5 KIPS, 100%DL (LOCK-OFF).

PROOF TESTING LOAD SCHEDULE (DL=DESIGN LOAD)

5 KIPS, 25%DL, 50%DL, 75%DL, 100%DL, 120%DL, 133%DL, 100%DL (LOCK-OFF)

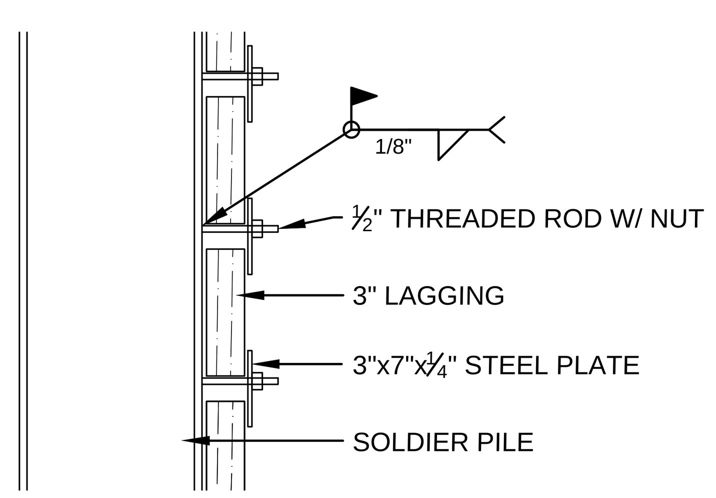
DURING TESTING THE MOVEMENT OF THE TENDON SHALL BE MEASURED TO THE NEAREST 0.001 INCHES AND RECORDED. THE LOAD SHALL BE HELD AT EACH LOAD INCREMENT UNTIL THE MOVEMENT STABILIZES. THE MAXIMUM TEST LOAD FOR THE PROOF AND PERFORMANCE TESTS SHALL BE HELD FOR 10 MINUTES AND MOVEMENT READINGS TAKEN AT 1 MINUTE INTERVALS. IF THE MOVEMENT BETWEEN 1 AND 10 MINUTES EXCEEDS 0.04 INCHES THE TEST LOAD SHALL BE HELD AND ADDITIONAL 50 MINUTES AND MOVEMENT READINGS TAKEN AT 10 MINUTE INTERVALS.

AFTER THE ANCHOR HAS BEEN LOAD TESTED AND DETERMINED TO BE ACCEPTABLE IT SHALL BE LOCKED-OFF AT THE DESIGN LOAD. THE ANCHORS WILL BE DETERMINED ACCEPTABLE USING THE FOLLOWING ACCEPTANCE CRITERIA:

a.) CREEP RATE STABILIZED TO A RATE OF LESS THAN 0.040 INCHES BETWEEN 1 AND 10 MINUTES OR, FOR LOADS HELD 60 MINUTES, THE CREEP RATE SHALL BE LESS THAN 0.080 INCHES BETWEEN 6 AND 60 MINUTES.

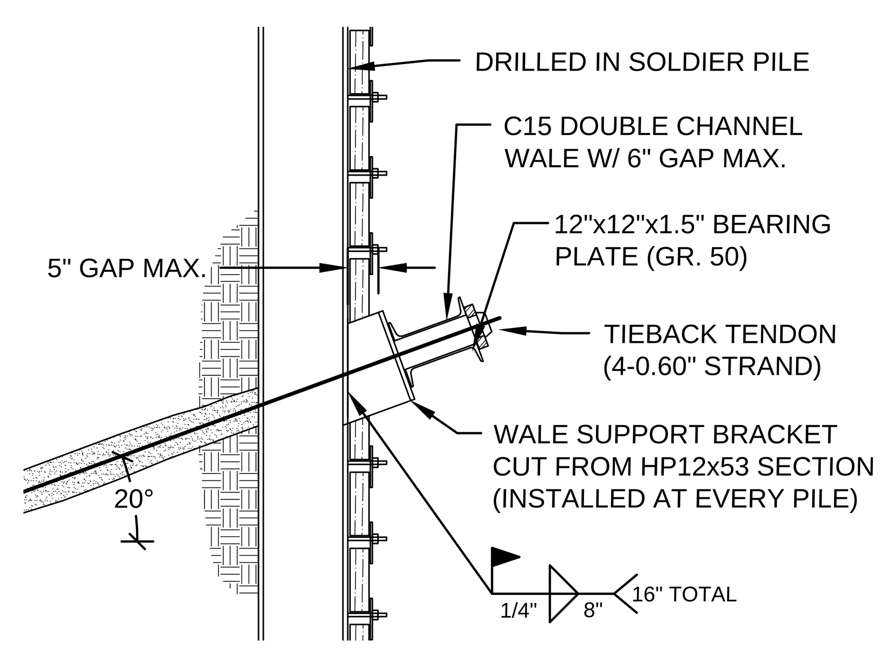
b.) THE MEASURED TIEBACK ELONGATION IS GREATER THAN THE THEORETICAL ELASTIC ELONGATION BASED ON 80% OF THE FREE LENGTH AND LESS THAN THE THEORETICAL ELASTIC ELONGATION OF THE FREE LENGTH PLUS 50% OF THE BONDED LENGTH.

TIEBACKS WHICH FAIL TO MEET THE ACCEPTANCE CRITERIA MAY BE REGROUTED AND RETESTED. A TIEBACK WHICH CANNOT MEET THE ACCEPTANCE CRITERIA MAY BE INCORPORATED INTO THE SYSTEM AT 67% OF THE STABILIZED LOAD. THE STABILIZED LOAD SHALL BE DETERMINED BASED ON THE STABILIZED HYDRAULIC JACK PRESSURE AFTER 10 MINUTES. EARTHWORK ENGINEERING SHALL BE NOTIFIED IF ANY ANCHORS FAILS TO HOLD THE FULL DESIGN LOAD IMMEDIATELY TO DETERMINE WHAT ADDITIONAL ANCHORS MAY BE REQUIRED. ALL TEST REPORTS TO BE PROVIDED TO EARTHWORK ENGINEERING FOR REVIEW.



LAGGING CONNECTION DETAIL

SCALE: ½"=1'-0"



WALE TO PILE CONNECTION DETAIL

SCALE: ½"=1'-0"

SOLDIER PILE AND TIEBACK SCHEDULE

PILE	SECTION	LENGTH	TIEBACK ELEV.	TIEBACK DL	STRANDS	VERT. ANGLE	HORIZ. ANGLE*	FREE LENGTH	BOND LENGTH	WALE SECTION
1 & 2	W24x104	43 ft.	EL. 55	152 kips	5	13 Degrees	-6 Degrees	20 ft.	65 ft.	2 - C15x33.9
			EL. 42	86 kips	3	25 Degrees	8 Degrees	15 ft.	25 ft.	2 - C15x33.9
3 & 4	W24x104	40 ft.	EL. 51	162 kips	5	26 Degrees	2 Degrees	20 ft.	48 ft.	2 - C15x50
5	W24x104	35 ft.	EL. 48	142 kips	5	24 Degrees	0 Degrees	15 ft.	40 ft.	2 - C15x33.9
6	W24x104	35 ft.	EL. 48	142 kips	4	28 Degrees	8 Degrees	15 ft.	40 ft.	2 - C15x33.9
7 & 8	HP14x102	32 ft.	EL. 48	117 kips	4	20 Degrees	0 Degrees	15 ft.	50 ft.	2 - C15x33.9
9 & 10	HP14x102	30 ft.	EL. 47	117 kips	4	20 Degrees	0 Degrees	15 ft.	50 ft.	2 - C15x33.9

* HORIZONTAL ANGLES GIVEN BASED ON CLOCKWISE ROTATION = POSITIVE ANGLE.

TURNER CONSTRUCTION COMPANY

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SUBJECT TO ARCHITECTS APPROVAL

Signed [signature] Date Mar 02, 2021

Submittal No. CS-315001-SOE-0002-3

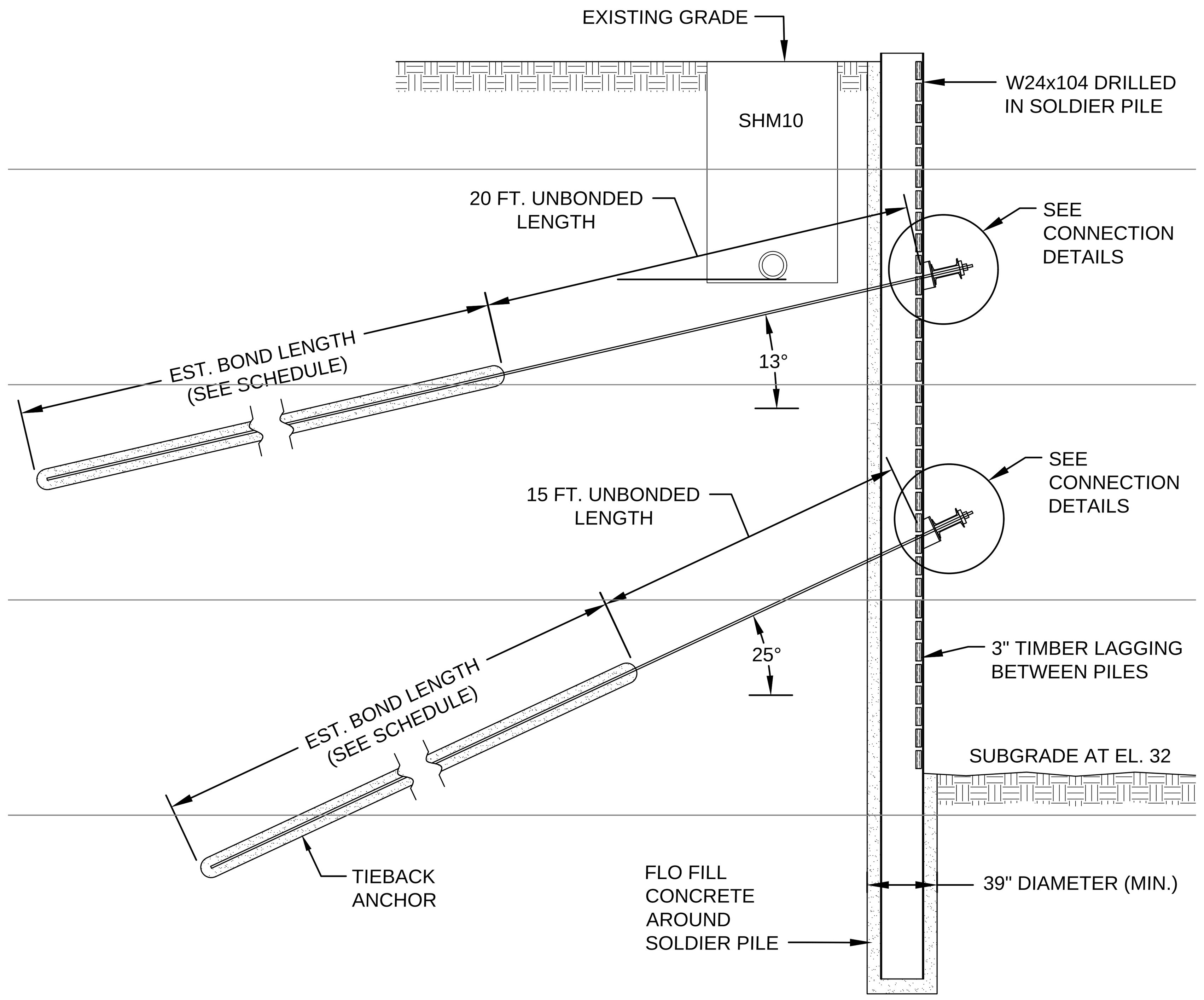
DESIGN AND DRAWING PREPARED BASED IN PART ON UNVERIFIED INFORMATION PROVIDED BY OTHERS. IF ACTUAL SITE AND/OR SOIL CONDITIONS VARY FROM THOSE SHOWN NOTIFY THE DESIGN ENGINEER TO REVIEW PRIOR TO THE START OF WORK.

NO.	DATE	REVISIONS
3	3/1/21	Revised to address review comments.
2	12/31/20	Revised to address review comments.
1	12/11/20	Revised to address review comments.

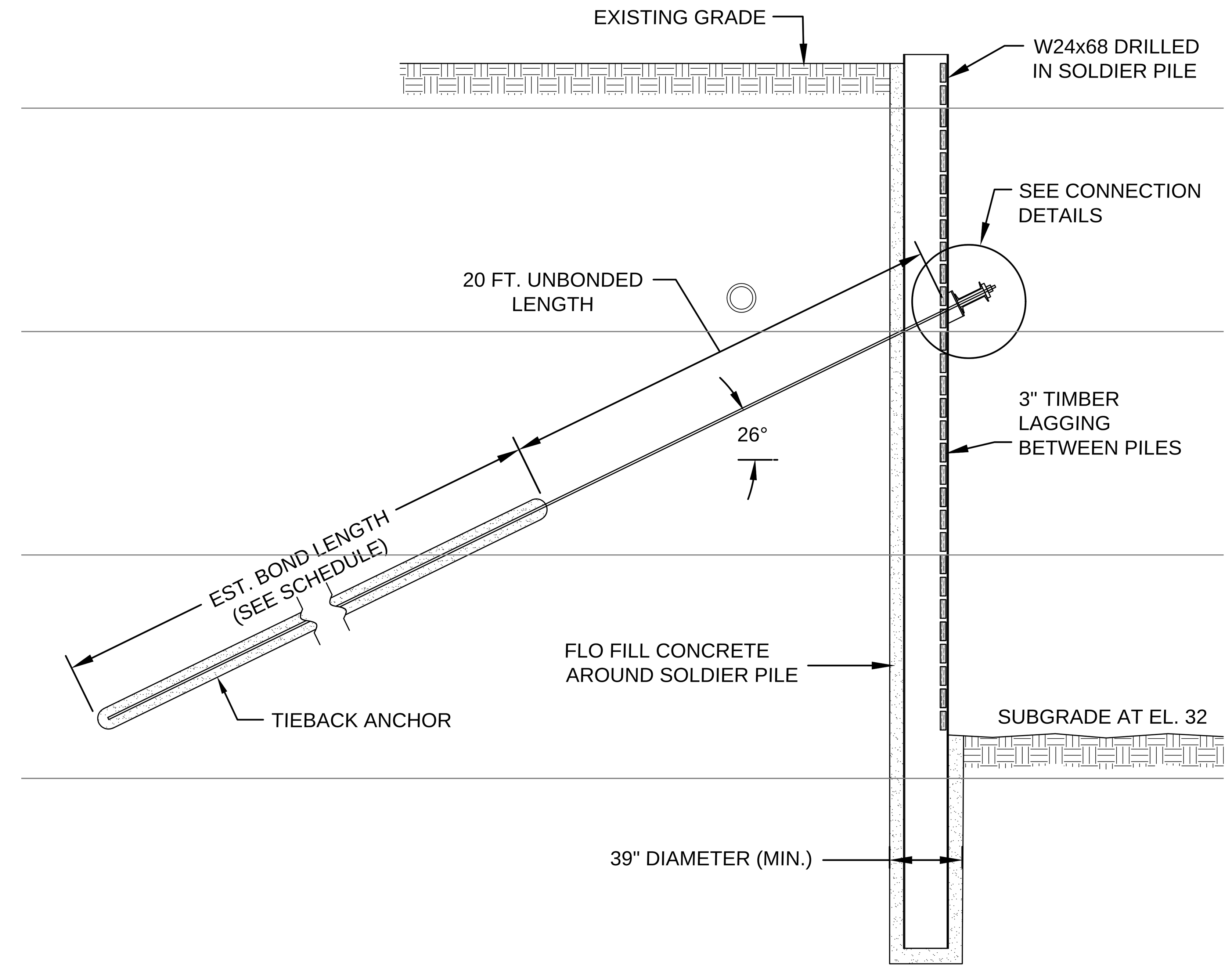
STATE OF MAINE · PAUL A. DETERLING · No. 5506 · REGISTERED PROFESSIONAL ENGINEER

DESIGN ENGINEER	CONTRACTOR	PROJECT	DRAWING TITLE
EARTHWORK ENGINEERING, INC. 175 Ridge Road - Hollis, NH 03049 Tel. (603) 465-9500 - Fax (603) 465-9650	KELLER - NORTH AMERICA 30 Martin Street - Cumberland, RI 02864 Tel. (401) 334-2565 - Fax (401) 334-3337	CONGRESS STREET BUILDING MAINE MEDICAL CENTER FACILITY PORTLAND, MAINE	SOLDIER PILE AND LAGGING WITH TIEBACK ANCHORS ELEVATION, DETAILS AND TESTING

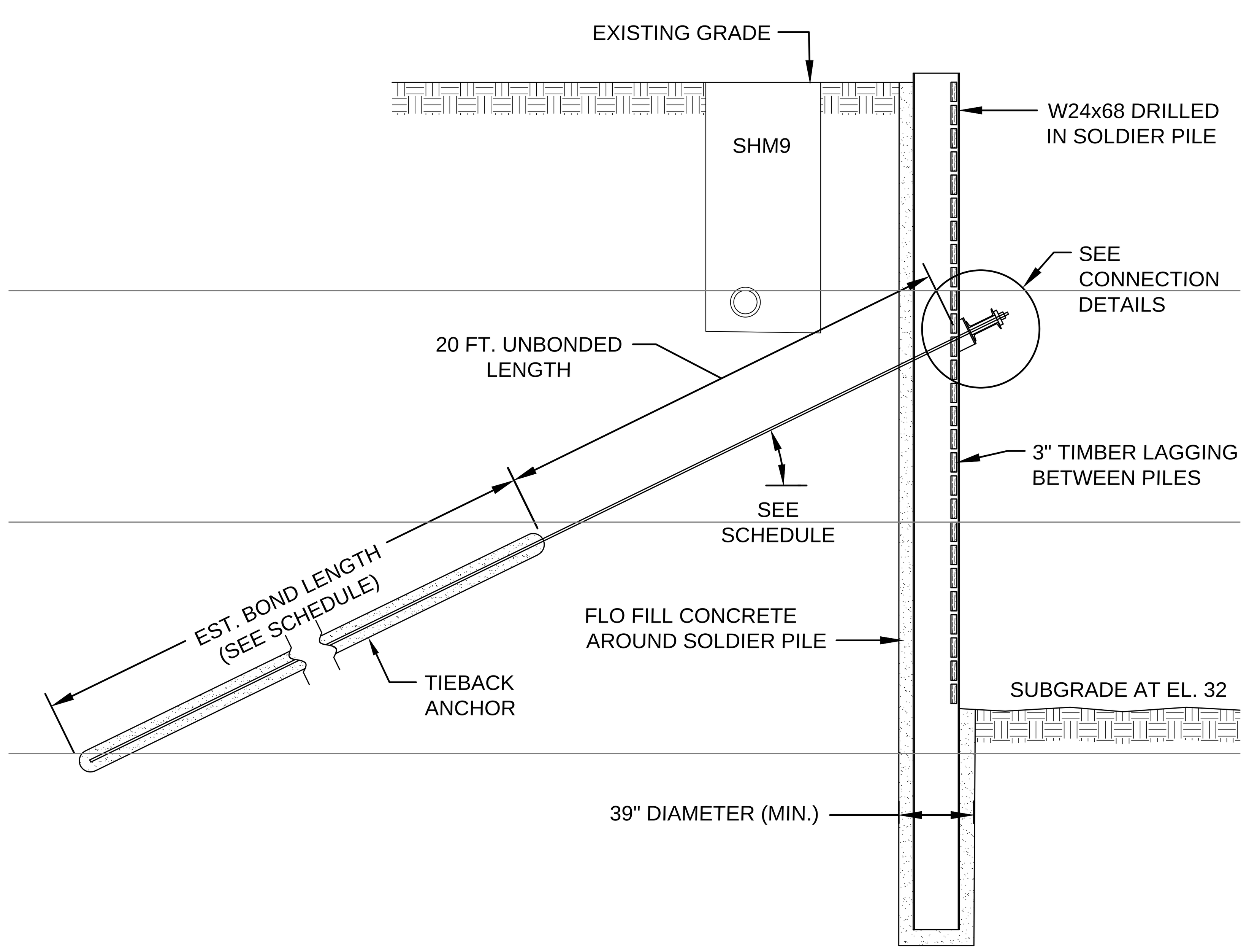
DESIGN BY: PAD
DATE: 10/14/20
PROJECT: 20092
SHEET: 2 of 3



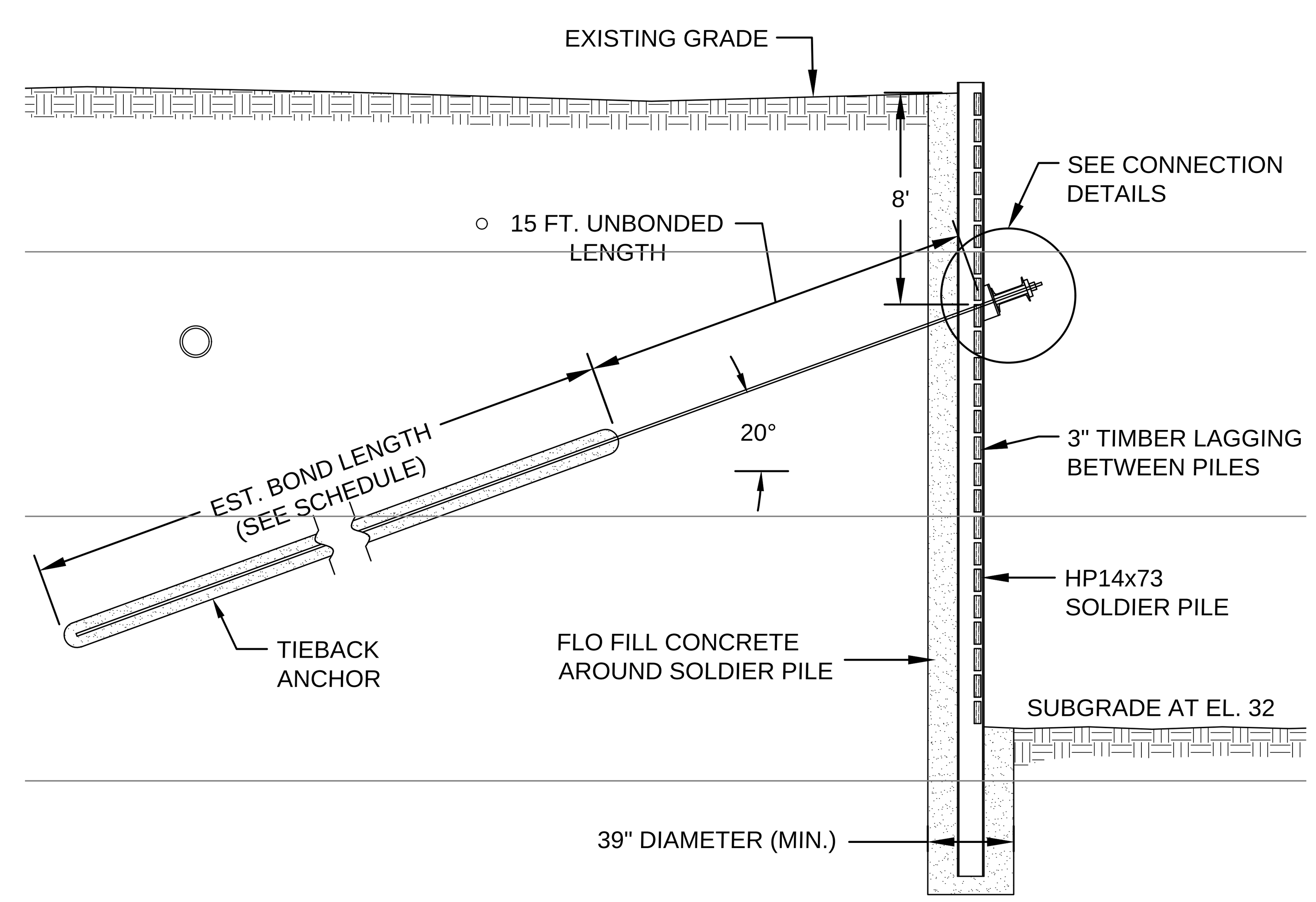
SECTION OF EXCAVATION SUPPORT AT PILES 1 AND 2
SCALE: 1"=5'-0"



SECTION OF EXCAVATION SUPPORT AT PILES 3 AND 4
SCALE: 1"=5'-0"



SECTION OF EXCAVATION SUPPORT AT PILES 5 AND 6
SCALE: 1"=5'-0"



SECTION OF EXCAVATION SUPPORT AT PILES 7 TO 10
SCALE: 1"=5'-0"

TURNER CONSTRUCTION COMPANY
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SUBJECT TO ARCHITECTS APPROVAL
Signed ___ Date Mar 02, 2021
Submittal No. CS-315001-SOE-0002-3

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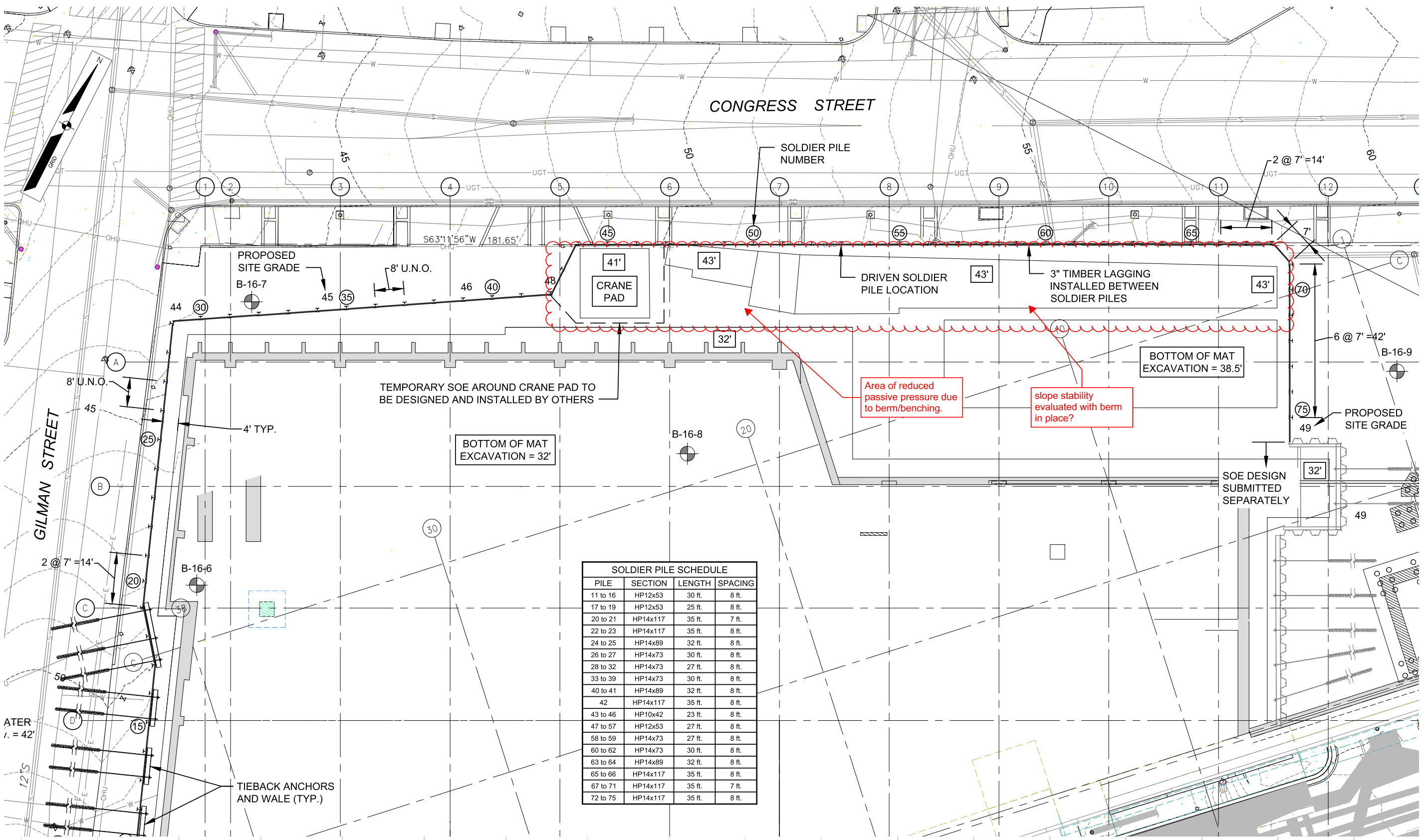
NO.	DATE	REVISIONS
3	3/1/21	Revised tieback alignment at piles 1 to 6 and wale section at pile 3 to 4.
2	12/31/20	Revised to address review comments.
1	12/11/20	Revised to address review comments.

STATE OF MAINE
PAUL A. DETERLING
No. 5506
REGISTERED PROFESSIONAL ENGINEER

DESIGN ENGINEER	CONTRACTOR	PROJECT	DRAWING TITLE
EARTHWORK ENGINEERING, INC. 175 Ridge Road - Hollis, NH 03049 Tel. (603) 465-9500 - Fax (603) 465-9650	HAYWARD BAKER, INC. 9 Whipple Street - Cumberland, RI 02864 Tel. (401) 334-2565 - Fax (401) 334-3337	GILMAN STREET PARKING GARAGE MAINE MEDICAL CENTER FACILITY PORTLAND, MAINE	SOLDIER PILE AND LAGGING WITH TIEBACK ANCHORS DESIGN SECTIONS

DESIGN BY: PAD
DATE: 10/14/20
PROJECT: 20092
SHEET: 3 of 3



SOLDIER PILE SCHEDULE			
PILE	SECTION	LENGTH	SPACING
11 to 16	HP12x53	30 ft.	8 ft.
17 to 19	HP12x53	25 ft.	8 ft.
20 to 21	HP14x117	35 ft.	7 ft.
22 to 23	HP14x117	35 ft.	8 ft.
24 to 25	HP14x89	32 ft.	8 ft.
26 to 27	HP14x73	30 ft.	8 ft.
28 to 32	HP14x73	27 ft.	8 ft.
33 to 39	HP14x73	30 ft.	8 ft.
40 to 41	HP14x89	32 ft.	8 ft.
42	HP14x117	35 ft.	8 ft.
43 to 46	HP10x42	23 ft.	8 ft.
47 to 57	HP12x53	27 ft.	8 ft.
58 to 59	HP14x73	27 ft.	8 ft.
60 to 62	HP14x73	30 ft.	8 ft.
63 to 64	HP14x89	32 ft.	8 ft.
65 to 66	HP14x117	35 ft.	8 ft.
67 to 71	HP14x117	35 ft.	7 ft.
72 to 75	HP14x117	35 ft.	8 ft.

GENERAL NOTES

THESE PLANS DETAIL THE TEMPORARY EXCAVATION SUPPORT SYSTEM TO BE INSTALLED ALONG GILMAN AND CONGRESS STREETS AS PART OF THE NEW CONGRESS STREET BUILDING AT THE MAINE MEDICAL CENTER IN PORTLAND, MAINE. THE EXCAVATION SUPPORT SYSTEM HAS BEEN DESIGNED FOR A MAXIMUM VERTICAL SURCHARGE OF 300 PSF APPLIED AT THE TOP OF THE SUPPORT WALL.

INSTALLATION PROCEDURE

1. THE AREA ALONG THE SOLDIER PILE ALIGNMENT SHALL BE CLEARED OF ALL EXISTING UTILITIES AND OTHER OBSTRUCTIONS PRIOR TO PILE INSTALLATION.
2. THE SOLDIER PILES SHALL THEN BE INSTALLED AT THE LOCATIONS SHOWN IN PLAN. THE PILES SHALL BE DRIVEN IN PLACE USING EITHER A VIBRATORY OR IMPACT PILE DRIVING HAMMER.
3. AFTER THE SOLDIER PILES HAVE BEEN INSTALLED MAKE THE INITIAL EXCAVATION ALONG THE SOLDIER PILE WALL TO 5 FEET BELOW GRADE FOR INSTALLATION OF TIMBER LAGGING BETWEEN PILES. THE HEIGHT OF UNSUPPORTED SOIL FACE MAY NEED TO BE REDUCED FROM 5 FEET BASED ON ACTUAL SOIL CONDITIONS TO MAINTAIN A STABLE SOIL FACE. TIMBER LAGGING WILL BE EITHER TUCKED BEHIND THE PILE FLANGES OR ATTACHED TO THE FLANGES WITH WELDED THREADED ROD (SEE DETAIL ON DRWG. 3 OF 3). LAGGING WILL BE SPACED WITH LOUVERS TO PERMIT FREE DRAINAGE. ALL VOIDS BEHIND THE LAGGING WILL BE TIGHTLY BACK PACKED WITH ON-SITE GRANULAR MATERIAL. TIMBER LAGGING TO BE INSTALLED IMMEDIATELY AFTER EXCAVATION IS MADE.
4. THE GENERAL EXCAVATION SHALL CONTINUE IN LIFTS WITH LAGGING INSTALLED BETWEEN THE PILES AS DESCRIBED ABOVE DOWN TO TWO FEET BELOW EACH BRACING LEVEL FOR INSTALLATION OF THE TIEBACK ANCHORS AND WALES, AS DETAILED. TIEBACKS SHALL BE INSTALLED AT THE DEPTH AND ANGLE GIVEN IN THE SOLDIER PILE SCHEDULE. THE TIEBACK TENDON AND REGROUT TUBE SHALL BE INSTALLED THE FULL LENGTH WITHOUT DIFFICULTY. PLACE GROUT BY TREMIE METHODS TO THE FACE OF EXCAVATION. TIEBACKS SHALL BE REGROUTED AT LEAST ONCE. AFTER THE TIEBACKS HAVE BEEN INSTALLED THEY SHALL BE TESTED FOLLOWING THE *"TIEBACK TESTING PROCEDURE"* GIVEN ON DRAWING 3 OF 3. TIEBACK TEST REPORTS TO BE PROVIDED TO EARTHWORK ENGINEERING FOR REVIEW.
5. EXCAVATION SHALL CONTINUE IN LIFTS WITH LAGGING INSTALLED AS DECRIBED ABOVE DOWN TO REQUIRED SUBGRADE.
6. AFTER THE STRUCTURE IS INSTALLED AND BACKFILL HAS BEEN PLACED UP TO WITHIN 2 FEET OF THE BRACING LOCATIONS THE TIEBACKS WILL BE DETENTIONED AND THE WALE REMOVED.

THE LATERAL MOVEMENT OF THE SYSTEM SHALL BE MONITORED DURING CONSTRUCTION. MONITORING POINTS SHALL BE LOCATED EVERY 16 FEET ALONG THE EXCAVATION SUPPORT (MAX.) AND READINGS TAKEN 2 TO 3 TIMES PER WEEK DURING ACTIVE EXCAVATION WORK. AFTER THE EXCAVATION REACHES SUBGRADE THE READINGS SHALL BE TAKEN WEEKLY. MONITORING DATA SHALL BE PROVIDED TO EARTHWORK ENGINEERING FOR REVIEW AS IT IS OBTAINED.

MATERIAL SCHEDULE	
MATERIAL	GRADE
;CHDULE	ASTM A572 (Fy=50 ksi)
H THICK (NOM.)	Fb = 875 psi
5x33.9 CHANNEL	ASTM A36 (Fy=36 ksi)
7 WIRE STRAND	ASTM A-416 (Fu=270 ksi)
2"x1.25" PLATE	ASTM A572 (Fy=50 ksi)
x42 SECTION	ASTM A572 (Fy=50 ksi)
K	Fy=70 ksi

'ER STRENGTH MAY BE SUBSTITUTED FOR THOSE
'PROVAL BY THE EARTHWORK ENGINEERING.

	B-17-1		B-17-2		B-17-3		B-17-4		B-17-5		B-17-6		B-17-7		B-17-8		B-17-9		B-17-10	
GSE	56.5		58		57.5		54		53.5		50.5		49		47		54		56	
Stratum	Thickness	TOP EL	Thickness	TOP EL	Thickness	TOP EL	Thickness	TOP EL	Thickness	TOP EL	Thickness	TOP EL	Thickness	TOP EL	Thickness	TOP EL	Thickness	TOP EL	Thickness	TOP EL
Fill	2	57	4	58	5	58	5	54	8	54	2	51	4	49	4	47	3	54	3	56
Upper SS	13	55	6	54	5	53	0	49	2	46	6	49	0	45	2	43	2	51	3	53
Silty Clay	4	42	10	48	10	48	11	49	12	44	13	43	10	45	11	41	10	50	16	50
Lower SS	17	38	9	38	15	38	26	38	25	32	20	30	27	35	17	31	14	40	9	35
Glacial Till		21		29		23		12		8		10		8		14		26		26

	B-17-11		B-16-5		B-16-6		B-16-8		
GSE	58		53		50		59		
Stratum	Thickness	TOP EL	Thickness	TOP EL	Thickness	TOP EL	Thickness	TOP EL	Average
Fill	3	58	4	53	8	50	13	59	5
Upper SS	0	55	0	49	0	42	0	46	3
Silty Clay	8	55	12	49	5	42	5	46	10
Lower SS	23	47	21	38	28	37	12	41	19
Glacial Till		24		17		9		29	

Average Stratum Thickness

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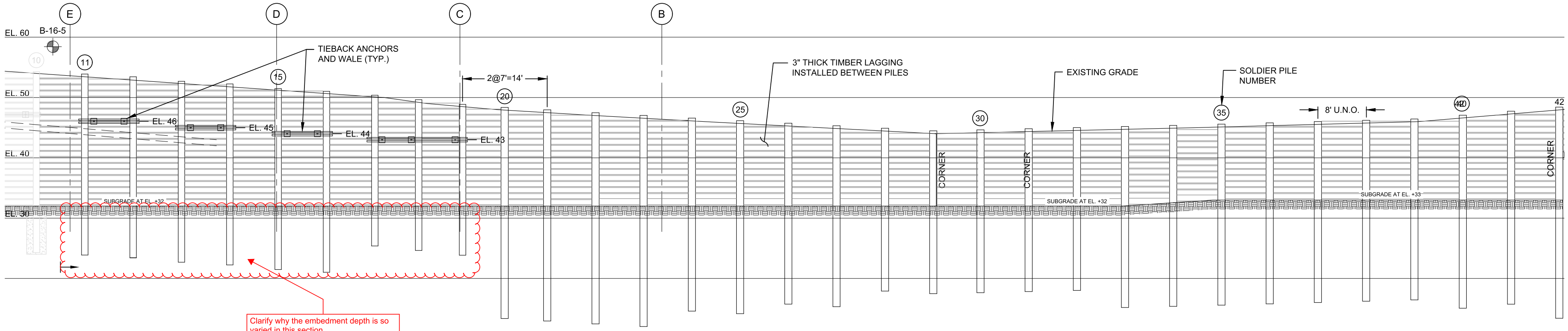
NO.	DATE	REVISIONS

STATE OF MAINE — PAUL A. DETERLING — No. 5508 — PROFESSIONAL ENGINEER

DESIGN ENGINEER	CONTRACTOR	PROJECT	DRAWING TITLE	
EARTHWORK ENGINEERING, INC. 175 Ridge Road - Hollis, NH 03049 Tel. (603) 465-9500 - Fax (603) 465-9650	KELLER - NORTH AMERICA 30 Martin - Cumberland, RI 02864 Tel. (401) 334-2565 - Fax (401) 334-3337	CONGRESS STREET BUILDING MAINE MEDICAL CENTER FACILITY PORTLAND, MAINE	SOLDIER PILE AND LAGGING WALL AT GILMAN AND CONGRESS STREEETS PLAN AND GENERAL NOTES	DESIGN BY: PAD DATE: 12/18/20 PROJECT: 20090 SHEET: 1 of 3



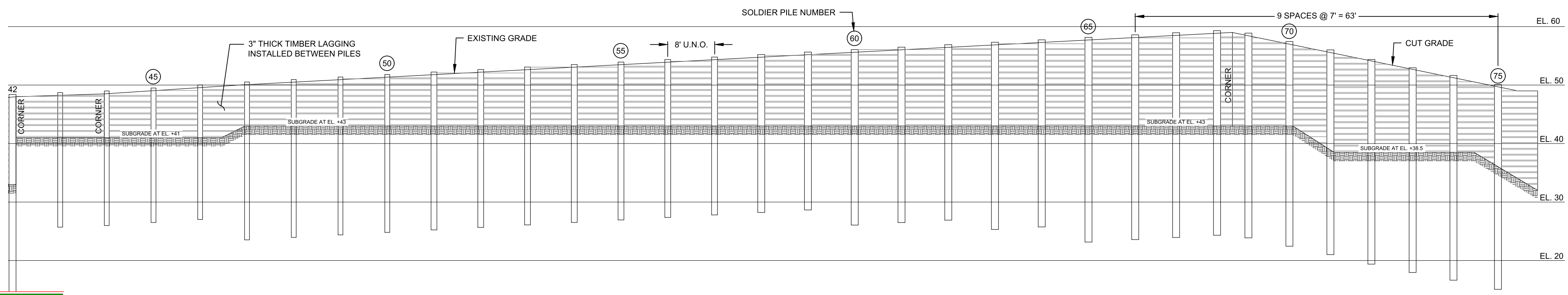
ELEVATION VIEW OF EXCAVATION SUPPORT SYSTEM AT SOLDIER PILES 11 TO 42

SCALE: 1/8"=1'-0"

TIEBACK SCHEDULE					
PILE	TIEBACK DL	STRANDS	FREE LENGTH	BOND LENGTH	ELEV.
11 & 12	93 kips	3	15 ft.	35 ft.	EL. 46
13 & 14	93 kips	3	15 ft.	35 ft.	EL. 45
15 & 16	93 kips	3	15 ft.	35 ft.	EL. 44
17 to 19	74 kips	3	15 ft.	30 ft.	EL. 43

SOLDIER PILE SCHEDULE			
PILE	SECTION	LENGTH	SPACING
11 to 16	HP12x53	30 ft.	8 ft.
17 to 19	HP12x53	25 ft.	8 ft.
20 to 21	HP14x117	35 ft.	7 ft.
22 to 23	HP14x117	35 ft.	8 ft.
24 to 25	HP14x89	32 ft.	8 ft.
26 to 27	HP14x73	30 ft.	8 ft.
28 to 32	HP14x73	27 ft.	8 ft.
33 to 39	HP14x73	30 ft.	8 ft.
40 to 41	HP14x89	32 ft.	8 ft.

SOLDIER PILE SCHEDULE			
PILE	SECTION	LENGTH	SPACING
42	HP14x117	35 ft.	8 ft.
43 to 46	HP10x42	23 ft.	8 ft.
47 to 57	HP12x53	27 ft.	8 ft.
58 to 59	HP14x73	27 ft.	8 ft.
60 to 62	HP14x73	30 ft.	8 ft.
63 to 64	HP14x89	32 ft.	8 ft.
65 to 66	HP14x117	35 ft.	8 ft.
67 to 75	HP14x117	35 ft.	7 ft.



ELEVATION VIEW OF EXCAVATION SUPPORT SYSTEM AT SOLDIER PILES 42 TO 75

SCALE: 1/8"=1'-0"

Subm. CS-315001-0003-0 previously submitted for HP Steel Soldier material release only, this package is for full submittal review

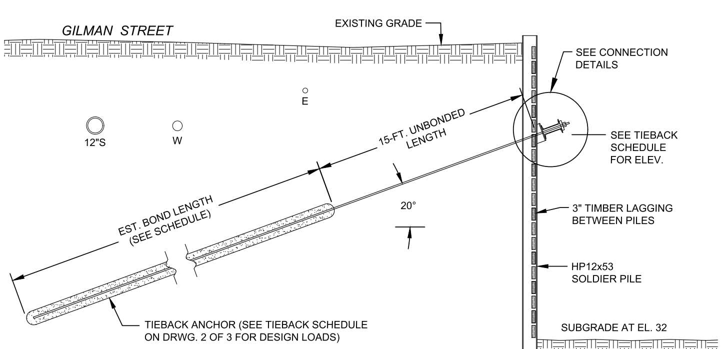
DESIGN AND DRAWING PREPARED BASED IN PART ON UNVERIFIED INFORMATION PROVIDED BY OTHERS. IF ACTUAL SITE AND/OR SOIL CONDITIONS VARY FROM THOSE SHOWN NOTIFY THE DESIGN ENGINEER TO REVIEW PRIOR TO THE START OF WORK.

NO.	DATE	REVISIONS

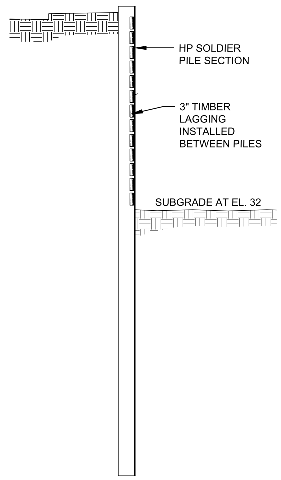
STATE OF MAINE — PAUL A. DETERLING — No. 5506 — REGISTERED PROFESSIONAL ENGINEER

DESIGN ENGINEER	CONTRACTOR	PROJECT	DRAWING TITLE
EARTHWORK ENGINEERING, INC. 175 Ridge Road - Hollis, NH 03049 Tel. (603) 465-9500 - Fax (603) 465-9650	KELLER - NORTH AMERICA 30 Martin Street - Cumberland, RI 02864 Tel. (401) 334-2565 - Fax (401) 334-3337	CONGRESS STREET BUILDING MAINE MEDICAL CENTER FACILITY PORTLAND, MAINE	SOLDIER PILE AND LAGGING WALL AT GILMAN AND CONGRESS STREETS ELEVATIONS AND SCHEDULES

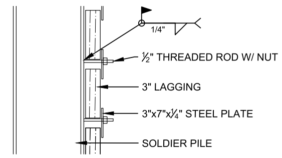
DESIGN BY: PAD
DATE: 12/18/20
PROJECT: 20090
SHEET: 2 of 3



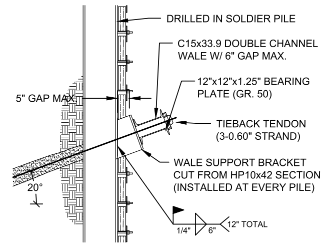
SECTION OF EXCAVATION SUPPORT AT PILES 11 TO 19
SCALE: ¼"=1'-0"



SECTION OF CANTILEVER EXCAVATION SUPPORT AT GILMAN STREET
SCALE: ¼"=1'-0"



LAGGING CONNECTION DETAIL
SCALE: ½"=1'-0"



WALE TO PILE CONNECTION DETAIL
SCALE: ½"=1'-0"

TIEBACK ANCHOR TESTING PROCEDURES

AFTER THE TIEBACK ANCHORS HAVE BEEN INSTALLED THEY SHALL BE TESTED USING THE FOLLOWING PROCEDURES. THE TIEBACK DESIGN LOAD WILL BE AS GIVEN IN THE TIEBACK SCHEDULE.

TESTING PROCEDURE

THE FIRST ANCHOR INSTALLED SHALL BE PERFORMANCE TESTED AND ALL OTHER TIEBACK ANCHORS SHALL BE PROOF TESTED. PERFORMANCE AND PROOF TESTS SHALL FOLLOW THE LOADING SCHEDULE GIVEN HERE. LOAD AND MOVEMENT MEASUREMENTS SHALL BE RECORDED AND PLOTTED. A RECENTLY CALIBRATED HYDRAULIC TEST JACK SHALL BE USED TO APPLY THE TEST LOADS AND A DIAL GAUGE MOUNTED ON AN INDEPENDENT REFERENCE SHALL BE USED TO RECORD MOVEMENTS TO AN ACCURACY OF 0.001 INCHES.

PERFORMANCE TESTING LOAD SCHEDULE (DL=DESIGN LOAD)
5 KIPS, 25%DL
5 KIPS, 25%DL, 50%DL
5 KIPS, 25%DL, 50%DL, 75%DL
5 KIPS, 25%DL, 50%DL, 75%DL, 100%DL
5 KIPS, 25%DL, 50%DL, 75%DL, 100%DL, 125%DL
5 KIPS, 25%DL, 50%DL, 75%DL, 100%DL, 125%DL, 133%DL (CREEP TEST), 125%DL, 100%DL, 5 KIPS, 100%DL (LOCK-OFF).

PROOF TESTING LOAD SCHEDULE (DL=DESIGN LOAD)
5 KIPS, 25%DL, 50%DL, 75%DL, 100%DL, 120%DL, 133%DL, 100%DL (LOCK-OFF)

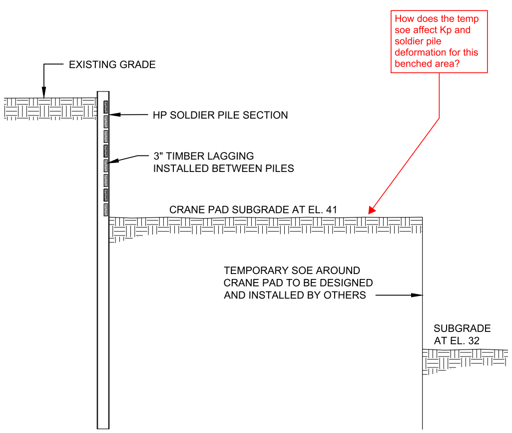
DURING TESTING THE MOVEMENT OF THE TENDON SHALL BE MEASURED TO THE NEAREST 0.001 INCHES AND RECORDED. THE LOAD SHALL BE HELD AT EACH LOAD INCREMENT UNTIL THE MOVEMENT STABILIZES. THE MAXIMUM TEST LOAD FOR THE PROOF AND PERFORMANCE TESTS SHALL BE HELD FOR 10 MINUTES AND MOVEMENT READINGS TAKEN AT 1 MINUTE INTERVALS. IF THE MOVEMENT BETWEEN 1 AND 10 MINUTES EXCEEDS 0.04 INCHES THE TEST LOAD SHALL BE HELD AND ADDITIONAL 50 MINUTES AND MOVEMENT READINGS TAKEN AT 10 MINUTE INTERVALS.

AFTER THE ANCHOR HAS BEEN LOAD TESTED AND DETERMINED TO BE ACCEPTABLE IT SHALL BE LOCKED-OFF AT THE DESIGN LOAD. THE ANCHORS WILL BE DETERMINED ACCEPTABLE USING THE FOLLOWING ACCEPTANCE CRITERIA:

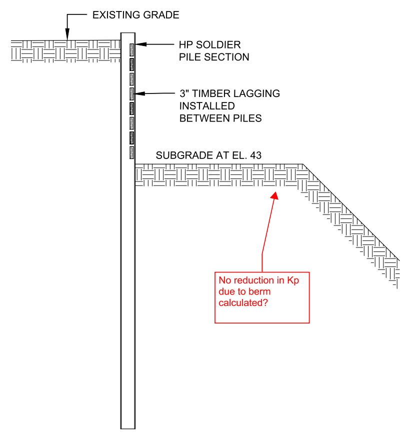
a.) CREEP RATE STABILIZED TO A RATE OF LESS THAN 0.040 INCHES BETWEEN 1 AND 10 MINUTES OR, FOR LOADS HELD 60 MINUTES, THE CREEP RATE SHALL BE LESS THAN 0.080 INCHES BETWEEN 6 AND 60 MINUTES.

b.) THE MEASURED TIEBACK ELONGATION IS GREATER THAN THE THEORETICAL ELASTIC ELONGATION BASED ON 80% OF THE FREE LENGTH AND LESS THAN THE THEORETICAL ELASTIC ELONGATION OF THE FULL FREE LENGTH PLUS 50% OF THE BONDED LENGTH.

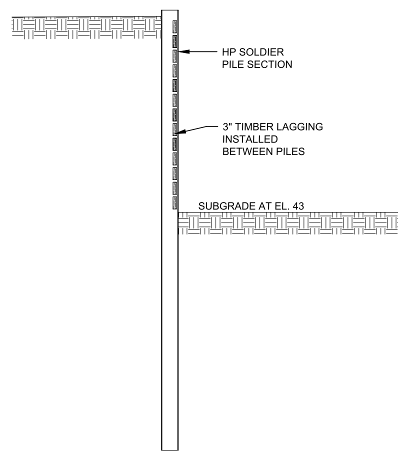
TIEBACKS WHICH FAIL TO MEET THE ACCEPTANCE CRITERIA MAY BE REGROUTED AND RETESTED. A TIEBACK WHICH CANNOT MEET THE ACCEPTANCE CRITERIA MAY BE INCORPORATED INTO THE SYSTEM AT 67% OF THE STABILIZED LOAD. THE STABILIZED LOAD SHALL BE DETERMINED BASED ON THE STABILIZED HYDRAULIC JACK PRESSURE AFTER 10 MINUTES. EARTHWORK ENGINEERING SHALL BE NOTIFIED IF ANY ANCHORS FAILS TO HOLD THE FULL DESIGN LOAD IMMEDIATELY TO DETERMINE WHAT ADDITIONAL ANCHORS MAY BE REQUIRED. ALL TEST REPORTS TO BE PROVIDED TO EARTHWORK ENGINEERING FOR REVIEW.



SECTION OF EXCAVATION SUPPORT AT PILES 43 TO 46
SCALE: ¼"=1'-0"



SECTION OF EXCAVATION SUPPORT AT PILES 47 TO 55
SCALE: 1"=5'-0"



SECTION OF EXCAVATION SUPPORT AT PILES 56 TO 68
SCALE: 1"=5'-0"

Stratum	Average EL
Fill	54
Upper SS	49
Silty Clay	46
Lower SS	37
Glacial Til	18

SGH Avg. Stratum EL

Subm. CS-315001-0003-0 previously submitted for HP Steel Soldier material release only, this package is for full submittal review

TURNER CONSTRUCTION COMPANY
SUBJECT TO ARCHITECTS APPROVAL
Richard Martineau Dec 21, 2020
CS-315001-0004-0

DESIGN AND DRAWING PREPARED BASED IN PART ON UNVERIFIED INFORMATION PROVIDED BY OTHERS. IF ACTUAL SITE AND/OR SOIL CONDITIONS VARY FROM THOSE SHOWN NOTIFY THE DESIGN ENGINEER TO REVIEW PRIOR TO THE START OF WORK.

NO.	DATE	REVISIONS

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DESIGN ENGINEER	CONTRACTOR	PROJECT	DRAWING TITLE
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DESIGN BY: PAD
DATE: 12/11/20
PROJECT: 20092
SHEET: 3 of 3

Design Calculations for Temporary Excavation Support Along Gilman and Congress Streets

Congress Street Building

Maine Medical Center

Portland, Maine

Prepared For:

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December 18, 2020

Subm. CS-315001-0003-0 previously submitted for HP Steel Soldier material release only, this package is for full submittal review

TURNER CONSTRUCTION COMPANY

Reviewed for General Acceptance only. This review does not relieve the Subcontractor of the responsibility for making the work conform to the requirements of the contract. The Subcontractor is responsible for all dimensions, correct fabrication and accurate fit with the work of other trades.

SUBJECT TO ARCHITECTS APPROVAL

Signed Richard Martineau Date Dec 21, 2020

Submittal No. CS-315001-0004-0

Design of Excavation Support Along Gilman and Congress Street
Congress Street Building
Maine Medical Center
Portland, Maine

1.0 Design Procedure and Assumptions

For construction of the new Congress Street Building a temporary excavation support system will be installed along Gilman Street and Congress Street. The system will consist of driven soldier piles with timber lagging. A level of external bracing will be installed at Gilman Street where the height of support is greater than 16 feet. The system will be designed to resist lateral pressures due to soil and construction surcharge loadings.

For the cantilever conditions the lateral soil pressures on the system will be triangular based on rankine earth pressures. For the braced condition the lateral soil loading will be modeled as a trapezoidal loading based on apparent earth pressures. The apparent earth pressure diagram will be based on the recommended loading diagram detailed in Figure 24 from FHWA Geotechnical Engineering Circular No. 4, *"Ground Anchors and Anchored Systems"* (see page A1). The construction surcharge loading on the system will be modeled as a vertical loading of 300 psf, as per note 5C on Contract Drawing SE00-01. The resulting lateral loading will be determined using the LPRES program.

The total lateral loadings on the excavation support system will be modeled and the resulting forces on the system will be determined using the CT-Shoring Computer Program. The lateral loads on the excavation support system will be analyzed for each stage of excavation to determine the maximum loading on each member for design. From the calculated forces the soldier piles and bracing will be designed based on allowable stress design.

2.0 Design Parameters and Variables

The soil conditions along the SOE alignment are taken from borings B16-5 to B16-9. Based on the boring information the soil profile will consist of approximately 10 feet of loose to medium dense granular fill over 8 feet of silty clay. Below the clay layer is approximately17 feet of medium dense silty sand over a medium dense to very dense glacial till. The design parameters for these soils will be taken from Note 5A on Contract Drawing SE00-01. The design groundwater table will be set Elev. +53, as per Note 5C on Drawing SE00-01.

Soil Design Parameters

o Granular Fill (0' to 10')

Unit Weight = $\gamma_{fill} := 130 \cdot pcf$

Buoyant Unit Weight = $\gamma_{bf} := \gamma_{fill} - \gamma_w$

$$\gamma_{bf} = 68 \cdot pcf$$

Friction Angle = $\phi_f := 34 \cdot deg$

Active Pressure Coefficient = $K_{af} := 0.28$

Passive Pressure Coefficient = $K_{pf} := \tan\left(45 \cdot deg + \frac{\phi_f}{2}\right)^2$

$K_{pf} = 3.54$

o Clay
(10' to 18')

Analyze for drained and undrained conditions

Unit Weight = $\gamma_{clay} := 125 \cdot pcf$

Buoyant Unit Weight = $\gamma_{bc} := \gamma_{clay} - \gamma_w$

$\gamma_{bc} = 63 \cdot pcf$

Shear Strength = $S_u := 1000 \cdot psf$

Active Pressure Coefficient = $K_{ac} := 1.00$

Passive Pressure Coefficient = $K_{pc} := 1.00$

o Sand
(18' to 35')

Unit Weight = $\gamma_{sand} := 135 \cdot pcf$

Buoyant Unit Weight = $\gamma_{bs} := \gamma_{sand} - \gamma_w$

$\gamma_{bs} = 73 \cdot pcf$

Friction Angle = $\phi_s := 33 \cdot deg$

Active Pressure Coefficient = $K_{as} := 0.26$

Passive Pressure Coefficient = $K_{ps} := \tan\left(45 \cdot deg + \frac{\phi_s}{2}\right)^2$

$K_{ps} = 3.39$

o Glacial Till
(Below 35')

Unit Weight = $\gamma_{till} := 145 \cdot pcf$

Buoyant Unit Weight = $\gamma_{bt} := \gamma_{till} - \gamma_w$

$\gamma_{bt} = 83 \cdot pcf$

Friction Angle = $\phi_t := 38 \cdot deg$

Active Pressure Coefficient = $K_{at} := 0.22$

Passive Pressure Coefficient = $K_{pt} := 10.7$

Where embedment is in clay, this should only be 2xdia.

3.0 Design of Excavation Support System

The design height of the excavation support will be up to 21 feet. The soil loading will be modeled as a triangular loading for the cantilever condition and trapezoidal loading for the braced condition, as described in section 1.0. The active and passive soil pressures below subgrade will be based on the soil properties given above. The passive pressures below subgrade will be mobilized over 3 pile diameter width, as per Brom's Theory. The water table will be set at elev. 53 or subgrade, whichever is lower. An analysis will be run for each stage of excavation and the final condition in each design case. The allowable lateral deflection of the system along Gilman Street and Congress Street is 2 inches.

Surcharge Loading

The construction surcharge loading on the system will be modeled as a 30-foot wide vertical strip loading of 300 psf. The resulting lateral loading on the system will be determined using the LPRES program which utilizes Bousinesq equations. The results are exported to the CT-Shoring analyses and are given on page A2 of these calculations.

Design of Soldier Pile and Lagging System

The cantilever excavation support areas will be analyzed for the loads given in Section 1.0 For areas with bracing the initial cantilever excavation for bracing installation will extend down to 2 feet below the bracing level.

Design Case 1 - Braced Height of Support of 21 Feet on Gilman Street

The design height of support will be 21 feet with a levels of bracing. To avoid existing utilities the level of bracing will be installed at a depth of 7 feet. The piles will be installed at an 8-foot spacing for this area.

Design Case 1a - Cantilever Height of Support of 9 Feet

The design cantilever height of support will be 9 feet for installation of tiebacks at 7 feet. Ground water level will be set at subgrade.

Height of Excavation = $H := 9 \cdot ft$

Active Pressure

Active Pressure at Bottom of Subgrade = $P_{a1} := K_{af} \cdot (9 \cdot ft \cdot \gamma_{fill})$

$$P_{a1} = 328 \cdot psf$$

Slope of Active in Fill = $S_{a1} := K_{af} \cdot \gamma_{bf}$

$$S_{a1} = 19 \cdot \frac{psf}{ft}$$

Active Pressure at Clay = $P_{a2} := (9\cdot ft\cdot\gamma_{fill} + 1\cdot ft\cdot\gamma_{bf}) - 2\cdot S_u$

$P_{a2} = -762\cdot psf$ ≤ 0 psf *Use P_a=0 psf*

Depth in Clay to Positive Active Pressure = $h_c := \frac{P_{a2}}{\gamma_{clay}} = -6.1\,ft$ Use 6 ft.

Slope of Active in Clay Below Water = $S_{a2} := \gamma_{bc}$

$S_{a2} = 63\cdot\frac{psf}{ft}$

Active Pressure at Sand = $P_{a3} := K_{as}\cdot(9\cdot ft\cdot\gamma_{fill} + 1\cdot ft\cdot\gamma_{bf} + 8\cdot ft\cdot\gamma_{bc})$

$P_{a3} = 452\cdot psf$

Slope of Active in Sand Below Water = $S_{a3} := K_{as}\cdot\gamma_{bs}$

$S_{a3} = 19\cdot\frac{psf}{ft}$

Active Pressure at Till = $P_{a4} := K_{at}\cdot(9\cdot ft\cdot\gamma_{fill} + 1\cdot ft\cdot\gamma_{bf} + 8\cdot ft\cdot\gamma_{bc} + 17\cdot ft\cdot\gamma_{bs})$

$P_{a4} = 654\cdot psf$

Slope of Active in Till = $S_{a4} := K_{at}\cdot\gamma_{bt}$

$S_{a4} = 18\cdot\frac{psf}{ft}$

Passive Earth Pressures

Slope of Passive in Fill = $S_p := K_{pf}\cdot\gamma_{bf}$

$S_p = 239\cdot\frac{psf}{ft}$

Passive Pressure at Clay = $P_{p1} := K_{pc}\cdot(1\cdot ft\cdot\gamma_{bf}) + 2\cdot S_u$

$P_{p1} = 2068\cdot psf$

Slope of Passive in Clay = $S_{p1} := \gamma_{bc}$

$S_{p1} = 63\cdot\frac{psf}{ft}$

Passive Pressure at Sand = $P_{p2} := K_{ps} \cdot (1 \cdot ft \cdot \gamma_{bf} + 8 \cdot ft \cdot \gamma_{bc})$

$$P_{p2} = 1928 \cdot psf$$

Slope of Passive in Sand Below Water = $S_{p2} := K_{ps} \cdot \gamma_{bs}$

$$S_{p2} = 246 \cdot \frac{psf}{ft}$$

Passive Pressure at Till = $P_{p3} := K_{pt} \cdot (1 \cdot ft \cdot \gamma_{bf} + 8 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs})$

$$P_{p3} = 19288 \cdot psf$$

Slope of Passive in Till = $S_{p3} := K_{pt} \cdot \gamma_{bt}$

$$S_{p3} = 884 \cdot \frac{psf}{ft}$$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages B1 to B4 of these calculations.

Maximum Bending Moment = $M_{1a} := 126.18 \cdot kft$

Minimum Soldier Pile Length = $L_{1a} := 22.56 \cdot ft$

Design Case 1b - Braced Height of Support of 21 Feet

The braced design height of support will be 21 feet with a level of bracing at 7 feet. Ground water will be set at subgrade.

Height of Excavation = $H := 21 \cdot ft$

Apparent Earth Pressure = $P_a := 0.65 \cdot K_{af} \cdot \gamma_{fill} \cdot H$

$$P_a = 24 \cdot H \cdot pcf$$

$$P_a = 497 \cdot psf$$

Total Apparent Soil Load = $TL_{soil} := P_a \cdot H$

$$TL_{soil} = 10.4 \cdot klf$$

Maximum Apparent Soil Pressure = $p := \frac{TL_{soil}}{\frac{2}{3} \cdot H}$

$$p = 745 \cdot psf$$

Active Pressure

Active Pressure at Subgrade = $P_{a1} := K_{as} \cdot (10 \cdot ft \cdot \gamma_{fill} + 8 \cdot ft \cdot \gamma_{clay} + 3 \cdot ft \cdot \gamma_{sand})$

$$P_{a1} = 703 \cdot psf$$

Slope of Active in Sand = $S_{a1} := K_{as} \cdot \gamma_{bs}$

$$S_{a1} = 19 \cdot \frac{psf}{ft}$$

Active Pressure at Till = $P_{a2} := K_{at} \cdot (10 \cdot ft \cdot \gamma_{fill} + 8 \cdot ft \cdot \gamma_{clay} + 3 \cdot ft \cdot \gamma_{sand} + 14 \cdot ft \cdot \gamma_{bs})$

$$P_{a2} = 819 \cdot psf$$

Slope of Active in Till = $S_{a2} := K_{at} \cdot \gamma_{bt}$

$$S_{a2} = 18 \cdot \frac{psf}{ft}$$

Passive Earth Pressures

Slope of Passive in Sand Below Water = $S_{p1} := K_{ps} \cdot \gamma_{bs}$

$$S_{p1} = 246 \cdot \frac{psf}{ft}$$

Passive Pressure at Till = $P_{p2} := K_{pt} \cdot (14 \cdot ft \cdot \gamma_{bs})$

$$P_{p2} = 10875 \cdot psf$$

Slope of Passive in Till = $S_{p2} := K_{pt} \cdot \gamma_{bt}$

$$S_{p2} = 884 \cdot \frac{psf}{ft}$$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages B5 to B8 of these calculations.

Maximum Bending Moment = $M_{1b} := 101.43 \cdot kft$

Lateral Brace Loading = $B_{1b} := 10.9 \cdot klf$

Minimum Soldier Pile Length = $L_{1b} := 29.40 \cdot ft$

Design Loads for Excavation Support System

Maximum Bending Moment = $M_{max} := \max(M_{1a}, M_{1b})$

$M_{max} = 126.2 \cdot kft$

Bracing Loads = $B := B_{1b}$

$B = 10.9 \cdot klf$

Minimum Soldier Pile Length = $L_{min} := \max(L_{1a}, L_{1b})$

$L_{min} = 29.4\,ft$

Soldier Pile Design

The soldier pile design will determine the required pile section and length based on the analysis above along with determining the estimated maximum deflection.

Soldier Pile Section

The required soldier pile section will be determined based on AISC allowable bending stresses for design of the temporary excavation support system.

Yield Strength = $F_y := 50 \cdot ksi$ (ASTM A572 Steel)

Maximum Bending Moment = $M_b := M_{max}$

$M_b = 126.18 \cdot kft$

Required Section Modulus = $S_x := \dfrac{M_b}{0.667 \cdot F_y}$

$S_x = 45.40 \cdot in^3$

Use HP12x53 Section with S_x = 66.7 in^3

(see page A3 for specification sheet)

Soldier Pile Length

The required soldier pile length is determined by the CT-Shoring Program. The results of this analysis are given above.

Minimum Soldier Pile Length = $L_{min} = 29.4\,ft$

Provide 30-Foot Long Soldier Piles

Estimated Lateral Deflection of Soldier Pile Wall

Lateral deflection of soldier pile wall will be estimated using the CT-Shoring program. The moment of inertia for the HP12x53 soldier pile section is input (S_x = 393 in^4) and the program generates an estimated lateral deflections for the cantilever and braced conditions. The results are on pages B9 and B10 of these calculations.

Estimated Cantilever Deflection = $\delta_{1a} := 0.86\cdot in$

Estimated Maximum Final Braced Deflection = $\delta_{1b} := 0.50\cdot in$

Based on this result the estimated maximum lateral of the soldier pile wall will be approximately 1 inch. This is only an estimate and the actual deflection may vary based on specific soil and surcharge conditions.

Use HP12x53 with 30-Foot Length

Design of Tieback Anchors

The tiebacks will be installed at a depth of 7 feet and at 8-foot spacing. The design of the tieback anchors will be done based on the bracing design load determined above.

Bracing Design Load = $B = 10.9\cdot klf$

Spacing of Tiebacks = $S_{tb} := 8\cdot ft$

Installation Angle of Tiebacks = $\alpha := 20\cdot deg$

Design Load per Tieback = $DL := \dfrac{B\cdot S_{tb}}{\cos(\alpha)}$

$DL = 93\cdot kips$

The tieback tendons will consist of 7-wire strand (f_u=270 ksi). The specification sheet for these tendons is on page A4 of these calculations. For the given design load a 3-strand tendon will be used which has an allowable design tensile load of up to 105.5 kips (60% GUTS).

Tieback Design Load = 93 kips

Estimate of Tieback Free Length

The tiebacks will be installed at 14 feet above subgrade. The active soil wedge failure plane will extend up from subgrade at approximately 30 degrees from vertical. The minimum required free length will be calculated here per PTI Section 6.8.1.

Height Above Subgrade to Tieback = $H_{tb} := 14 \cdot ft$

Angle of Failure Plane to Vertical = $\omega := 30 \cdot deg$

Minimum of Free Length = $L_{u.min} := \dfrac{\tan(\omega) \cdot H_{tb}}{\cos(\alpha)} + 5 \cdot ft$

$$L_{u.min} = 13.6\,ft$$

The minimum required free length, as per Section 6.8 of PTI *"Recommendations for Prestressed Rock and Soil Anchors"*, is 15 feet for strand anchors. Therefore the free length for the tiebacks shall be 15 feet.

<u>Tieback Free Length = 15 feet</u>

<u>Estimate of Tieback Bond Length</u>

The above tieback loads are to be achieved with regrouted tiebacks drilled into the clay and sand layers. The estimated bond length will be determined based on the allowable grout to soil bond stress. The estimated bond stress will be taken from Table 5.3 of FHWA NHI-05-039 *"Micropile Design and Construction"* for anchors with one phase of secondary grouting, i.e. regrouted (Type C, see page A4).

Maximum Tieback Load = $DL = 93 \cdot kips$

Tieback Diameter = $d_{bond} := 4.5 \cdot in$

Estimated Bond Stress = $\beta := 25 \cdot psi$ (Tiebacks in Clay, Type C Grouting)

Factor of Safety = $FS := 1.50$

Allowable Bond Stress = $\varepsilon := \dfrac{\beta}{FS}$

$$\varepsilon = 17 \cdot psi$$

Estimated Capacity Per Foot of Anchor = $\lambda := \varepsilon \cdot (\pi \cdot d_{bond})$

$$\lambda = 2.83 \cdot klf$$

Estimated Bond Length for Tiebacks = $L_{bond} := \dfrac{DL}{\lambda}$

$$L_{bond} = 33 \cdot ft$$

The estimated bond length of 33 feet for the 93 kip tiebacks is given for informational purposes. All tiebacks will be tested in the field to verify that they can provide the required tieback reaction. For construction a bond length of 35 feet will be recommend.

<u>Estimated Tieback Bond Length = 35 feet</u>

Wale Design

The wale will span between the soldier piles to transfer the lateral bracing loads. The tiebacks will be located 1-foot from the soldier pile centerline. The wale will be designed for the resulting bending moment. The bending moment in the wale is calculated based on a simple beam with two equal concentrated loads symmetrically placed. The allowable bending stress in the wale will be 0.60 x F_y.

Distance from Tieback to Piles = $a := 1 \cdot ft$

Applied Bending Moment = $M_b := DL \cdot a$

$M_b = 93 \cdot kft$

Safety Factor For Flexure = $\Omega_b := 1.67$

Trial Section: 2 - C15x33.9 Channel

Yield Strength of Wale = $F_y := 36 \cdot ksi$

Modulus of Elasticity = $E := 29000 \cdot ksi$

Depth of Section = $d := 15.0 \cdot in$

Web Thickness = $t_w := 0.400 \cdot in$

Flange Width = $b_f := 3.40 \cdot in$

Flange Thickness = $t_f := 0.650 \cdot in$

Major Axis Elastic Section Modulus = $S_x := 42.0 \cdot in^3$

Major Axis Elastic Section Modulus = $Z_x := 50.8 \cdot in^3$

Minor Axis Radius of Gyration = $r_y := 0.901 \cdot in$

Minor Axis Moment of Inertia = $I_y := 8.07 \cdot in^4$

Distance Between Flange Centroids = $h_o := d - t_f = 14.35 \cdot in$

Torsional Stiffness Constant = $J := 1.01 \cdot in^4$

Torsional Shear Constant = $C_w := 358 \cdot in^6$

Lateral Torsional Buckling Modification Factor = $C_b := 1.0$

Effective Radius of Gyration = $r_{ts} := \sqrt{\frac{\sqrt{I_y \cdot C_w}}{S_x}} = 1.13 \cdot in$ (AISC Eq. F2-7)

For Channel = $c := \frac{h_o}{2} \cdot \sqrt{\frac{I_y}{C_w}} = 1.08$

Limiting Width Thickness Ratios: $\lambda_p := 0.38 \cdot \sqrt{\frac{E}{F_y}} = 11$ (AISC Table B4.1)

$$\lambda_r := 1.0 \cdot \sqrt{\frac{E}{F_y}} = 28$$

Flange to Web Thickness Ratio = $\frac{b_f}{2t_f} = 3$ < $\lambda_p = 11$ (compact section)

Yielding Moment

Nominal Plastic Moment = $M_p := F_y \cdot Z_x$ (AISC Eq. F2-1)

$$M_p = 152 \cdot kft$$

Lateral Torsional Buckling Moment

Length Between Brace Points = $L_b := 7 \cdot ft$ (Support Bracket Spacing)

Limiting Lengths for Flexure:

$$L_p := 1.76 \cdot r_y \cdot \sqrt{\frac{E}{F_y}} = 45 \cdot in$$ (AISC Eq. F2-5)

$$L_r := 1.95 \cdot r_{ts} \cdot \frac{E}{0.7 \cdot F_y} \cdot \sqrt{\frac{J \cdot c}{S_x \cdot h_o}} \cdot \sqrt{1 + \sqrt{1 + 6.76 \cdot \left(\frac{0.7 \cdot F_y}{E} \cdot \frac{S_x \cdot h_o}{J \cdot c}\right)^2}}$$ (AISC Eq. F2-6)

$$L_r = 14.5\,ft$$

Critical Flexural Stress = $F_{cr} := \frac{C_b \cdot \pi^2 \cdot E}{\left(\frac{L_b}{r_{ts}}\right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{S_x \cdot h_o} \cdot \left(\frac{L_b}{r_{ts}}\right)^2}$ (AISC Eq. F2-4)

$$F_{cr} = 69.2 \cdot ksi$$

Nominal Flexural Strength = (AISC Eq. F2-1, F2-2 and F2-3)

$$M_n := \begin{cases} F_y \cdot Z_x & \text{if } L_b < L_p \\ C_b \cdot \left[M_p - \left(M_p - 0.7 \cdot F_y \cdot S_x\right) \cdot \left(\frac{L_b - L_p}{L_r - L_p} \right) \right] & \text{if } L_p < L_b < L_r \\ F_{cr} \cdot S_x & \text{otherwise} \end{cases}$$

$$M_n = 133 \cdot kft$$

Allowable Flexural Strength for 2 Channel = $M_c := \frac{2M_n}{\Omega_b}$

$$M_c = 159 \cdot kft \quad \geq \quad M_b = 93 \cdot kft$$

Use 2-C15x33.9 Channels for Wale

Design Case 2 - Braced Height of Support of 18 Feet on Gilman Street

The design height of support will be 18 feet with a levels of bracing. To avoid existing utilities the level of bracing will be installed at a depth of 6 feet. The piles will be installed at an 8-foot spacing for this area.

Design Case 2a - Cantilever Height of Support of 9 Feet

The design cantilever height of support will be 9 feet for installation of tiebacks at 7 feet. This condition was analyzed in Design Case 1a and the results from pages B1 to B4 will be used.

Maximum Bending Moment = $M_{2a} := M_{1a}$

$$M_{2a} = 126 \cdot kft$$

Minimum Soldier Pile Length = $L_{2a} := L_{1a}$

$$L_{2a} = 22.56\,ft$$

Design Case 2b - Braced Height of Support of 18 Feet

The braced design height of support will be 18 feet with a level of bracing at 7 feet. Ground water will be set at subgrade.

Height of Excavation = $H := 18 \cdot ft$

Apparent Earth Pressure = $P_a := 0.65 \cdot K_{af} \cdot \gamma_{fill} \cdot H$

$$P_a = 24 \cdot H \cdot pcf$$

$$P_a = 426 \cdot psf$$

Total Apparent Soil Load = $TL_{soil} := P_a \cdot H$

$$TL_{soil} = 7.7 \cdot klf$$

Maximum Apparent Soil Pressure = $p := \dfrac{TL_{soil}}{\frac{2}{3} \cdot H}$

$$p = 639 \cdot psf$$

Active Pressure

Active Pressure at Subgrade = $P_{a1} := K_{as} \cdot \left(10 \cdot ft \cdot \gamma_{fill} + 8 \cdot ft \cdot \gamma_{clay}\right)$

$$P_{a1} = 598 \cdot psf$$

Slope of Active in Sand = $S_{a1} := K_{as} \cdot \gamma_{bs}$

$$S_{a1} = 19 \cdot \frac{psf}{ft}$$

Active Pressure at Till = $P_{a2} := K_{at} \cdot \left(10 \cdot ft \cdot \gamma_{fill} + 8 \cdot ft \cdot \gamma_{clay} + 0 \cdot ft \cdot \gamma_{sand} + 17 \cdot ft \cdot \gamma_{bs}\right)$

$$P_{a2} = 778 \cdot psf$$

Slope of Active in Till = $S_{a2} := K_{at} \cdot \gamma_{bt}$

$$S_{a2} = 18 \cdot \frac{psf}{ft}$$

Passive Earth Pressures

Slope of Passive in Sand Below Water = $S_{p1} := K_{ps} \cdot \gamma_{bs}$

$$S_{p1} = 246 \cdot \frac{psf}{ft}$$

Passive Pressure at Till = $P_{p2} := K_{pt} \cdot \left(17 \cdot ft \cdot \gamma_{bs}\right)$

$$P_{p2} = 13206 \cdot psf$$

Slope of Passive in Till = $S_{p2} := K_{pt} \cdot \gamma_{bt}$

$$S_{p2} = 884 \cdot \frac{psf}{ft}$$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages C1 to C4 of these calculations.

Maximum Bending Moment = $M_{2b} := 90.29 \cdot kft$

Lateral Brace Loading = $B_{2b} := 8.7 \cdot klf$

Minimum Soldier Pile Length = $L_{2b} := 24.24 \cdot ft$

Design Loads for Excavation Support System

Maximum Bending Moment = $M_{max} := \max(M_{2a}, M_{2b})$

$$M_{max} = 126.2 \cdot kft$$

Bracing Loads = $B := B_{2b}$

$$B = 8.7 \cdot klf$$

Minimum Soldier Pile Length = $L_{min} := \max(L_{2a}, L_{2b})$

$$L_{min} = 24.2\,ft$$

Soldier Pile Design

The soldier pile design will determine the required pile section and length based on the analysis above along with determining the estimated maximum deflection.

Soldier Pile Section

The required soldier pile section will be determined based on AISC allowable bending stresses for design of the temporary excavation support system.

Yield Strength = $F_y := 50 \cdot ksi$ (ASTM A572 Steel)

Maximum Bending Moment = $M_b := M_{max}$

$$M_b = 126.18 \cdot kft$$

Required Section Modulus = $S_x := \dfrac{M_b}{0.667 \cdot F_y}$

$$S_x = 45.40 \cdot in^3$$

Use HP12x53 Section with S_x = 66.7 in^3

(see page A3 for specification sheet)

Soldier Pile Length

The required soldier pile length is determined by the CT-Shoring Program. The results of this analysis are given above.

Minimum Soldier Pile Length = $L_{min} = 24.24\,ft$

Provide 25-Foot Long Soldier Piles

Estimated Lateral Deflection of Soldier Pile Wall

Lateral deflection of soldier pile wall will be estimated using the CT-Shoring program. The moment of inertia for the HP12x53 soldier pile section is input (S_x = 393 in^4) and the program generates an estimated lateral deflections for the cantilever and braced conditions. The results are on pages B9 and C5 of these calculations.

Estimated Cantilever Deflection = $\delta_{1a} := 0.86 \cdot in$

Estimated Maximum Final Braced Deflection = $\delta_{1b} := 0.16 \cdot in$

Based on this result the estimated maximum lateral of the soldier pile wall will be approximately 1 inch. This is only an estimate and the actual deflection may vary based on specific soil and surcharge conditions.

Use HP12x53 with 25-Foot Length

Design of Tieback Anchors

The tiebacks will be installed at a depth of 7 feet and at 8-foot spacing. The design of the tieback anchors will be done based on the bracing design load determined above.

Bracing Design Load = $B = 8.7 \cdot klf$

Spacing of Tiebacks = $S_{tb} := 8 \cdot ft$

Installation Angle of Tiebacks = $\alpha := 20 \cdot deg$

Design Load per Tieback = $DL := \dfrac{B \cdot S_{tb}}{\cos(\alpha)}$

$$DL = 74 \cdot kips$$

The tieback tendons will consist of 7-wire strand (f_u=270 ksi). The specification sheet for these tendons is on page A4 of these calculations. For the given design load a 3-strand tendon will be used which has an allowable design tensile load of up to 105.5 kips (60% GUTS).

Tieback Design Load = 74 kips

Estimate of Tieback Free Length

The tiebacks will be installed at 11 feet above subgrade. The active soil wedge failure plane will extend up from subgrade at approximately 30 degrees from vertical. The minimum required free length will be calculated here per PTI Section 6.8.1.

Height Above Subgrade to Tieback = $H_{tb} := 11 \cdot ft$

Angle of Failure Plane to Vertical = $\omega := 30 \cdot deg$

Minimum of Free Length = $L_{u.min} := \dfrac{\tan(\omega) \cdot H_{tb}}{\cos(\alpha)} + 5 \cdot ft$

$L_{u.min} = 11.8\,ft$

The minimum required free length, as per Section 6.8 of PTI *"Recommendations for Prestressed Rock and Soil Anchors"*, is 15 feet for strand anchors. Therefore the free length for the tiebacks shall be 15 feet.

Tieback Free Length = 15 feet

Estimate of Tieback Bond Length

The above tieback loads are to be achieved with regrouted tiebacks drilled into the clay and sand layers. The estimated bond length will be determined based on the allowable grout to soil bond stress. The estimated bond stress will be taken from Table 5.3 of FHWA NHI-05-039 *"Micropile Design and Construction"* for anchors with one phase of secondary grouting, i.e. regrouted (Type C, see page A4).

Maximum Tieback Load = $DL = 74 \cdot kips$

Tieback Diameter = $d_{bond} := 4.5 \cdot in$

Estimated Bond Stress = $\beta := 25 \cdot psi$ (Tiebacks in Clay, Type C Grouting)

Factor of Safety = $FS := 1.50$

Allowable Bond Stress = $\varepsilon := \dfrac{\beta}{FS}$

$\varepsilon = 17 \cdot psi$

Estimated Capacity Per Foot of Anchor = $\lambda := \varepsilon \cdot (\pi \cdot d_{bond})$

$\lambda = 2.83 \cdot klf$

Estimated Bond Length for Tiebacks = $L_{bond} := \frac{DL}{\lambda}$

$$L_{bond} = 26 \cdot ft$$

The estimated bond length of 26 feet for the 74 kip tiebacks is given for informational purposes. All tiebacks will be tested in the field to verify that they can provide the required tieback reaction. For construction a bond length of 30 feet will be recommend.

Estimated Tieback Bond Length = 30 feet

Wale Design

The wale designed for Design Case 1 will be used for Design Case 2.

Use 2-C15x33.9 Channels for Wale

Bearing Plate Design

The tieback bearing plate will be designed to span the 6-inch gap between the double channel wale section. The tieback load will be applied to a wedge plate that will be set on the bearing plate. The tieback load will be applied as a uniform load over the width of the wedge plate. The resulting bending moment will be used for design of the bearing plate.

Maximum Tieback Load = $P_b := 93 \cdot kips$ (Design Case 1)

Span Between Channels = $L_c := 6 \cdot in$

Diameter of Wedge Plate = $A := 3.15 \cdot in$

Uniform Load Over Wedge Plate = $w := \frac{P_b}{A}$

$$w = 29.5 \cdot kpi$$

Bending Moment in Plate = $M_b := \frac{DL}{2} \cdot \left(\frac{L_c - A}{2} + \frac{\frac{DL}{2}}{2.w} \right)$

$$M_b = 6.33 \cdot kft$$

Yield Stress of Bearing Plate = $F_y := 50 \cdot ksi$

Side Dimension of Bearing Plate at Wedge Plate Hole = $x := 12 \cdot in - A$

$$x = 8.85 \cdot in$$

Minimum Required Plate Thickness = $t_{min} := \sqrt{\dfrac{6 \cdot M_b}{x \cdot (0.75 \cdot F_y)}}$

$t_{min} = 1.17 \cdot in$

Provide 12"x12"x1.25" (Gr. 50) Tieback Bearing Plates

Wale Support Bracket Design

The tieback wale will be set on chairs that will be welded to each soldier pile. Each chair will be designed for the vertical load in shear. The required weld will be determined here based on the maximum tieback load.

Weld Force Per Bracket = $P_b = 93 \cdot kips$ (Design Case 1)

Vertical Shear Loading = $F_v := P_b \cdot \sin(\alpha)$

$F_v = 32 \cdot kips$

Ultimate Strength of Weld = $F_u := 70 \cdot ksi$

Allowable Stress on Weld = $F_w := 30\% \cdot F_u$

$F_w = 21 \cdot ksi$

Weld Size = $W := \frac{1}{4} \cdot in$

Required Weld Length at Each Pile = $L_w := \dfrac{F_v}{\cos(45 \cdot deg) \cdot F_w \cdot W}$

$L_w = 8.6 \cdot in$

Provide 12 Inches of 1/4-inch E70 Weld Per Bracket

Check Web Crippling at Bracket

The wale will be supported by tee sections of HP10x42 used for brackets. The HP10x42 will be analyzed for local web yielding or web crippling. AISC Manual (13th Ed.) will be used to analyze local web yielding and web crippling at the bracket to pile connection.

For HP10x42 $d := 9.70 \cdot in$ $t_w := 0.415 \cdot in$

$b_f := 10.1 \cdot in$ $t_f := 0.420 \cdot in$ $k := 1.125 \cdot in$

For 2-C15x33.9 $N := 2\cdot(3.40\cdot in)$

$N = 6.8\cdot in$

Normal Force = $R := P_b$

$R = 93\cdot kip$

Modulus of Elasticity = $E := 29000\cdot ksi$

Web Local Yielding:
(AISC Eq. J10-2)

Safety Factor for Web Yielding = $\Omega_{wy} := 1.50$

Nominal Strength = $R_n := (5\cdot k + N)F_y\cdot t_w$

$R_n = 258\cdot kips$

Allowable Strength = $\frac{R_n}{\Omega_{wy}} = 172\cdot kips$ > $R = 93\cdot kip$ *OK*

Web Crippling:
(AISC Eq. J10-3)

Safety Factor for Web Crippling = $\Omega_{wc} := 2.00$

Nominal Strength = $R_n := 0.80\cdot {t_w}^2\cdot\left[1 + 3\cdot\left(\frac{N}{d}\right)\cdot\left(\frac{t_w}{t_f}\right)^{1.5}\right]\cdot\sqrt{\frac{E\cdot F_y\cdot t_f}{t_w}}$

$R_n = 512\cdot kips$

Allowable Strength = $\frac{R_n}{\Omega_{wc}} = 256\cdot kips$ > $R = 93\cdot kip$ *OK*

No Web Yielding or Web Crippling for HP10x42 bracket

Design Case 3 - Cantilever Height of Support of 16 Feet

The cantilever design height of support will be 16 feet. The piles will be installed at 7-foot spacing. Ground water level will be set at subgrade.

Height of Excavation = $H := 16\cdot ft$

Active Pressure

Active Pressure at Bottom of Fill = $P_{a1} := K_{af} \cdot (10 \cdot ft \cdot \gamma_{fill})$

$$P_{a1} = 364 \cdot psf$$

Active Pressure at Clay = $P_{a2} := (10 \cdot ft \cdot \gamma_{fill}) - 2 \cdot S_u$

$P_{a2} = -700 \cdot psf$ $\leq$ 0 psf *Use P_a=0 psf*

Depth in Clay to Positive Active Pressure = $h_c := \frac{P_{a2}}{\gamma_{clay}} = -5.6\,ft$ Use 5 ft.

Slope of Active in Clay Below Water = $S_{a2} := \gamma_{bc}$

$$S_{a2} = 63 \cdot \frac{psf}{ft}$$

Active Pressure at Sand = $P_{a3} := K_{as} \cdot (10 \cdot ft \cdot \gamma_{fill} + 6 \cdot ft \cdot \gamma_{clay} + 2 \cdot ft \cdot \gamma_{bc})$

$$P_{a3} = 566 \cdot psf$$

Slope of Active in Sand Below Water = $S_{a3} := K_{as} \cdot \gamma_{bs}$

$$S_{a3} = 19 \cdot \frac{psf}{ft}$$

Active Pressure at Till = $P_{a4} := K_{at} \cdot (10 \cdot ft \cdot \gamma_{fill} + 6 \cdot ft \cdot \gamma_{clay} + 2 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs})$

$$P_{a4} = 750 \cdot psf$$

Slope of Active in Till = $S_{a4} := K_{at} \cdot \gamma_{bt}$

$$S_{a4} = 18 \cdot \frac{psf}{ft}$$

Passive Earth Pressures

Passive Pressure at Subgrade = $P_{p1} := 2 \cdot S_u$

$$P_{p1} = 2000 \cdot psf$$

Slope of Passive in Clay = $S_{p1} := \gamma_{bc}$

$$S_{p1} = 63 \cdot \frac{psf}{ft}$$

Passive Pressure at Sand = $P_{p2} := K_{ps} \cdot (2 \cdot ft \cdot \gamma_{bc})$

$$P_{p2} = 425 \cdot psf$$

Slope of Passive in Sand Below Water = $S_{p2} := K_{ps} \cdot \gamma_{bs}$

$$S_{p2} = 246 \cdot \frac{psf}{ft}$$

Passive Pressure at Till = $P_{p3} := K_{pt} \cdot (2 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs})$

$$P_{p3} = 14546 \cdot psf$$

Slope of Passive in Till = $S_{p3} := K_{pt} \cdot \gamma_{bt}$

$$S_{p3} = 884 \cdot \frac{psf}{ft}$$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages D1 to D4 of these calculations.

Maximum Bending Moment = $M_3 := 275.20 \cdot kft$

Minimum Soldier Pile Length = $L_3 := 34.99 \cdot ft$

Soldier Pile Design

The soldier pile design will determine the required pile section and length based on the analysis above along with determining the estimated maximum deflection.

Soldier Pile Section

The required soldier pile section will be determined based on AISC allowable bending stresses for design of the temporary excavation support system.

Yield Strength = $F_y := 50 \cdot ksi$ (ASTM A572 Steel)

Maximum Bending Moment = $M_b := M_3$

$$M_b = 275.2 \cdot kft$$

Required Section Modulus = $S_x := \frac{M_b}{0.667 \cdot F_y}$

$$S_x = 99.02 \cdot in^3$$

Use HP14x117 Section with $S_x = 172\ in^3$

(see page A3 for specification sheet)

Soldier Pile Length

The required soldier pile length is determined by the CT-Shoring Program. The results of this analysis are given above.

Minimum Soldier Pile Length = $L_{min} := L_3$

$L_{min} = 35\,ft$

Provide 35-Foot Long Soldier Piles

Estimated Lateral Deflection of Soldier Pile Wall

Lateral deflection of soldier pile wall will be estimated using the CT-Shoring program. The moment of inertia for the HP14x117 soldier pile section is input (S_x = 1220 in^4) and the program generates an estimated lateral deflections for the cantilever condition. The results for the cantilever deflection are taken from page D5 of these calculations.

Estimated Maximum Cantilever Deflection = $\delta_3 := 1.96 \cdot in$

Based on this result the estimated maximum lateral of the soldier pile wall will be approximately 2 inches. This is only an estimate and the actual deflection may vary based on specific soil and surcharge conditions.

Use HP14x117 with Length of 35 Feet

Design Case 4 - Cantilever Height of Support of 15 Feet

The cantilever design height of support will be 15 feet. The piles will be installed at 8-foot spacing. Ground water level will be set at subgrade.

Height of Excavation = $H := 15 \cdot ft$

Active Pressure

Active Pressure at Bottom of Fill = $P_{a1} := K_{af} \cdot (10 \cdot ft \cdot \gamma_{fill})$

$P_{a1} = 364 \cdot psf$

Active Pressure at Clay = $P_{a2} := (10 \cdot ft \cdot \gamma_{fill}) - 2 \cdot S_u$

$P_{a2} = -700 \cdot psf$ $\leq$ 0 psf *Use P_a=0 psf*

Depth in Clay to Positive Active Pressure = $h_c := \frac{P_{a2}}{\gamma_{clay}} = -5.6\,ft$ Use 5 ft.

Slope of Active in Clay Below Water = $S_{a2} := \gamma_{bc}$

$$S_{a2} = 63 \cdot \frac{psf}{ft}$$

Active Pressure at Sand = $P_{a3} := K_{as} \cdot (10 \cdot ft \cdot \gamma_{fill} + 5 \cdot ft \cdot \gamma_{clay} + 3 \cdot ft \cdot \gamma_{bc})$

$$P_{a3} = 549 \cdot psf$$

Slope of Active in Sand Below Water = $S_{a3} := K_{as} \cdot \gamma_{bs}$

$$S_{a3} = 19 \cdot \frac{psf}{ft}$$

Active Pressure at Till = $P_{a4} := K_{at} \cdot (10 \cdot ft \cdot \gamma_{fill} + 5 \cdot ft \cdot \gamma_{clay} + 3 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs})$

$$P_{a4} = 736 \cdot psf$$

Slope of Active in Till = $S_{a4} := K_{at} \cdot \gamma_{bt}$

$$S_{a4} = 18 \cdot \frac{psf}{ft}$$

Passive Earth Pressures

Passive Pressure at Subgrade = $P_{p1} := 2 \cdot S_u$

$$P_{p1} = 2000 \cdot psf$$

Slope of Passive in Clay = $S_{p1} := \gamma_{bc}$

$$S_{p1} = 63 \cdot \frac{psf}{ft}$$

Passive Pressure at Sand = $P_{p2} := K_{ps} \cdot (3 \cdot ft \cdot \gamma_{bc})$

$$P_{p2} = 637 \cdot psf$$

Slope of Passive in Sand Below Water = $S_{p2} := K_{ps} \cdot \gamma_{bs}$

$$S_{p2} = 246 \cdot \frac{psf}{ft}$$

Passive Pressure at Till = $P_{p3} := K_{pt} \cdot (3 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs})$

$$P_{p3} = 15215 \cdot psf$$

Slope of Passive in Till = $S_{p3} := K_{pt} \cdot \gamma_{bt}$

$$S_{p3} = 884 \cdot \frac{psf}{ft}$$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages E1 to E4 of these calculations.

Maximum Bending Moment = $M_4 := 274.72 \cdot \text{kft}$

Minimum Soldier Pile Length = $L_4 := 33.78 \cdot \text{ft}$

Soldier Pile Design

The soldier pile design will determine the required pile section and length based on the analysis above along with determining the estimated maximum deflection.

Soldier Pile Section

The required soldier pile section will be determined based on AISC allowable bending stresses for design of the temporary excavation support system.

Yield Strength = $F_y := 50 \cdot \text{ksi}$ (ASTM A572 Steel)

Maximum Bending Moment = $M_b := M_4$

$$M_b = 274.72 \cdot \text{kft}$$

Required Section Modulus = $S_x := \dfrac{M_b}{0.667 \cdot F_y}$

$$S_x = 98.85 \cdot \text{in}^3$$

Use HP14x117 Section with S_x = 172 in^3

(see page A3 for specification sheet)

Soldier Pile Length

The required soldier pile length is determined by the CT-Shoring Program. The results of this analysis are given above.

Minimum Soldier Pile Length = $L_{min} := L_4$

$$L_{min} = 34\,\text{ft}$$

Provide 34-Foot Long Soldier Piles

Estimated Lateral Deflection of Soldier Pile Wall

Lateral deflection of soldier pile wall will be estimated using the CT-Shoring program. The moment of inertia for the HP14x117 soldier pile section is input (S_x = 1220 in^4) and the program generates an estimated lateral deflections for the cantilever condition. The results for the cantilever deflection are taken from page E5 of these calculations.

Estimated Maximum Cantilever Deflection = $\delta_4 := 1.78 \cdot in$

Based on this result the estimated maximum lateral of the soldier pile wall will be approximately 2 inches. This is only an estimate and the actual deflection may vary based on specific soil and surcharge conditions.

Use HP14x117 with Length of 35 Feet

Design Case 5 - Cantilever Height of Support of 14 Feet

The cantilever design height of support will be 14 feet. The piles will be installed at 8-foot spacing. Ground water level will be set at subgrade.

Height of Excavation = $H := 13 \cdot ft$

Active Pressure

Active Pressure at Bottom of Fill = $P_{a1} := K_{af} \cdot (10 \cdot ft \cdot \gamma_{fill})$

$P_{a1} = 364 \cdot psf$

Active Pressure at Clay = $P_{a2} := (10 \cdot ft \cdot \gamma_{fill}) - 2 \cdot S_u$

$P_{a2} = -700 \cdot psf$ $\leq$ 0 psf *Use P_a=0 psf*

Depth in Clay to Positive Active Pressure = $h_c := \frac{P_{a2}}{\gamma_{clay}} = -5.6\, ft$ Use 5 ft.

Slope of Active in Clay Below Water = $S_{a2} := \gamma_{bc}$

$S_{a2} = 63 \cdot \frac{psf}{ft}$

Active Pressure at Sand = $P_{a3} := K_{as} \cdot (10 \cdot ft \cdot \gamma_{fill} + 4 \cdot ft \cdot \gamma_{clay} + 4 \cdot ft \cdot \gamma_{bc})$

$P_{a3} = 533 \cdot psf$

Slope of Active in Sand Below Water = $S_{a3} := K_{as} \cdot \gamma_{bs}$

$$S_{a3} = 19 \cdot \frac{psf}{ft}$$

Active Pressure at Till = $P_{a4} := K_{at} \cdot (10 \cdot ft \cdot \gamma_{fill} + 4 \cdot ft \cdot \gamma_{clay} + 4 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs})$

$$P_{a4} = 723 \cdot psf$$

Slope of Active in Till = $S_{a4} := K_{at} \cdot \gamma_{bt}$

$$S_{a4} = 18 \cdot \frac{psf}{ft}$$

Passive Earth Pressures

Passive Pressure at Subgrade = $P_{p1} := 2 \cdot S_u$

$$P_{p1} = 2000 \cdot psf$$

Slope of Passive in Clay = $S_{p1} := \gamma_{bc}$

$$S_{p1} = 63 \cdot \frac{psf}{ft}$$

Passive Pressure at Sand = $P_{p2} := K_{ps} \cdot (4 \cdot ft \cdot \gamma_{bc})$

$$P_{p2} = 849 \cdot psf$$

Slope of Passive in Sand Below Water = $S_{p2} := K_{ps} \cdot \gamma_{bs}$

$$S_{p2} = 246 \cdot \frac{psf}{ft}$$

Passive Pressure at Till = $P_{p3} := K_{pt} \cdot (4 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs})$

$$P_{p3} = 15885 \cdot psf$$

Slope of Passive in Till = $S_{p3} := K_{pt} \cdot \gamma_{bt}$

$$S_{p3} = 884 \cdot \frac{psf}{ft}$$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages F1 to F4 of these calculations.

Maximum Bending Moment = $M_5 := 242.22 \cdot kft$

Minimum Soldier Pile Length = $L_5 := 31.39 \cdot ft$

Soldier Pile Design

The soldier pile design will determine the required pile section and length based on the analysis above along with determining the estimated maximum deflection.

Soldier Pile Section

The required soldier pile section will be determined based on AISC allowable bending stresses for design of the temporary excavation support system.

Yield Strength = $F_y := 50 \cdot ksi$ (ASTM A572 Steel)

Maximum Bending Moment = $M_b := M_5$

$$M_b = 242.22 \cdot kft$$

Required Section Modulus = $S_x := \dfrac{M_b}{0.667 \cdot F_y}$

$$S_x = 87.16 \cdot in^3$$

Use HP14x89 Section with $S_x = 131\ in^3$

(see page A3 for specification sheet)

Soldier Pile Length

The required soldier pile length is determined by the CT-Shoring Program. The results of this analysis are given above.

Minimum Soldier Pile Length = $L_{min} := L_5$

$$L_{min} = 31.4\,ft$$

Provide 32-Foot Long Soldier Piles

Estimated Lateral Deflection of Soldier Pile Wall

Lateral deflection of soldier pile wall will be estimated using the CT-Shoring program. The moment of inertia for the HP14x89 soldier pile section is input ($S_x = 904\ in^4$) and the program generates an estimated lateral deflections for the cantilever condition. The results for the cantilever deflection are taken from page f5 of these calculations.

Estimated Maximum Cantilever Deflection = $\delta_5 := 1.80 \cdot in$

Based on this result the estimated maximum lateral of the soldier pile wall will be approximately 2 inches. This is only an estimate and the actual deflection may vary based on specific soil and surcharge conditions.

<u>Use HP14x89 with Length of 32 Feet</u>

Design Case 6 - Cantilever Height of Support of 13 Feet

The cantilever design height of support will be 13 feet. The piles will be installed at 8-foot spacing. Ground water level will be set at subgrade.

Height of Excavation = $H := 13 \cdot ft$

Active Pressure

Active Pressure at Bottom of Fill = $P_{a1} := K_{af} \cdot (10 \cdot ft \cdot \gamma_{fill})$

$P_{a1} = 364 \cdot psf$

Active Pressure at Clay = $P_{a2} := (10 \cdot ft \cdot \gamma_{fill}) - 2 \cdot S_u$

$P_{a2} = -700 \cdot psf \quad \leq \quad 0 \text{ psf}$ *Use P_a=0 psf*

Depth in Clay to Positive Active Pressure = $h_c := \dfrac{P_{a2}}{\gamma_{clay}} = -5.6\,ft$ Use 5 ft.

Slope of Active in Clay Below Water = $S_{a2} := \gamma_{bc}$

$S_{a2} = 63 \cdot \dfrac{psf}{ft}$

Active Pressure at Sand = $P_{a3} := K_{as} \cdot (10 \cdot ft \cdot \gamma_{fill} + 3 \cdot ft \cdot \gamma_{clay} + 5 \cdot ft \cdot \gamma_{bc})$

$P_{a3} = 517 \cdot psf$

Slope of Active in Sand Below Water = $S_{a3} := K_{as} \cdot \gamma_{bs}$

$S_{a3} = 19 \cdot \dfrac{psf}{ft}$

Active Pressure at Till = $P_{a4} := K_{at} \cdot (10 \cdot ft \cdot \gamma_{fill} + 3 \cdot ft \cdot \gamma_{clay} + 5 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs})$

$P_{a4} = 709 \cdot psf$

Slope of Active in Till = $S_{a4} := K_{at} \cdot \gamma_{bt}$

$$S_{a4} = 18 \cdot \frac{psf}{ft}$$

Passive Earth Pressures

Passive Pressure at Subgrade = $P_{p1} := 2 \cdot S_u$

$$P_{p1} = 2000 \cdot psf$$

Slope of Passive in Clay = $S_{p1} := \gamma_{bc}$

$$S_{p1} = 63 \cdot \frac{psf}{ft}$$

Passive Pressure at Sand = $P_{p2} := K_{ps} \cdot \left(5 \cdot ft \cdot \gamma_{bc}\right)$

$$P_{p2} = 1062 \cdot psf$$

Slope of Passive in Sand Below Water = $S_{p2} := K_{ps} \cdot \gamma_{bs}$

$$S_{p2} = 246 \cdot \frac{psf}{ft}$$

Passive Pressure at Till = $P_{p3} := K_{pt} \cdot \left(5 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs}\right)$

$$P_{p3} = 16555 \cdot psf$$

Slope of Passive in Till = $S_{p3} := K_{pt} \cdot \gamma_{bt}$

$$S_{p3} = 884 \cdot \frac{psf}{ft}$$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages G1 to G4 of these calculations.

Maximum Bending Moment = $M_6 := 216.56 \cdot kft$

Minimum Soldier Pile Length = $L_6 := 29.30 \cdot ft$

Soldier Pile Design

The soldier pile design will determine the required pile section and length based on the analysis above along with determining the estimated maximum deflection.

Soldier Pile Section

The required soldier pile section will be determined based on AISC allowable bending stresses for design of the temporary excavation support system.

Yield Strength = $F_y := 50 \cdot ksi$ (ASTM A572 Steel)

Maximum Bending Moment = $M_b := M_6$

$$M_b = 216.56 \cdot kft$$

Required Section Modulus = $S_x := \dfrac{M_b}{0.667 \cdot F_y}$

$$S_x = 77.92 \cdot in^3$$

Use HP14x73 Section with S_x = 107 in^3

(see page A3 for specification sheet)

Soldier Pile Length

The required soldier pile length is determined by the CT-Shoring Program. The results of this analysis are given above.

Minimum Soldier Pile Length = $L_{min} := L_6$

$$L_{min} = 29.3\,ft$$

Provide 30-Foot Long Soldier Piles

Estimated Lateral Deflection of Soldier Pile Wall

Lateral deflection of soldier pile wall will be estimated using the CT-Shoring program. The moment of inertia for the HP14x73 soldier pile section is input (S_x = 729 in^4) and the program generates an estimated lateral deflections for the cantilever condition. The results for the cantilever deflection are taken from page G5 of these calculations.

Estimated Maximum Cantilever Deflection = $\delta_6 := 1.67 \cdot in$

Based on this result the estimated maximum lateral of the soldier pile wall will be approximately 1.5 inches. This is only an estimate and the actual deflection may vary based on specific soil and surcharge conditions.

Use HP14x73 with Length of 30 Feet

Design Case 7 - Cantilever Height of Support of 12 Feet

The cantilever design height of support will be 12 feet. The piles will be installed at 8-foot spacing. Ground water level will be set at subgrade.

Height of Excavation = $H := 12 \cdot ft$

Active Pressure

Active Pressure at Bottom of Fill = $P_{a1} := K_{af} \cdot (10 \cdot ft \cdot \gamma_{fill})$

$$P_{a1} = 364 \cdot psf$$

Active Pressure at Clay = $P_{a2} := (10 \cdot ft \cdot \gamma_{fill}) - 2 \cdot S_u$

$P_{a2} = -700 \cdot psf$ $\leq$ 0 psf *Use P_a=0 psf*

Depth in Clay to Positive Active Pressure = $h_c := \dfrac{P_{a2}}{\gamma_{clay}} = -5.6\,ft$ Use 5 ft.

Slope of Active in Clay Below Water = $S_{a2} := \gamma_{bc}$

$$S_{a2} = 63 \cdot \frac{psf}{ft}$$

Active Pressure at Sand = $P_{a3} := K_{as} \cdot (10 \cdot ft \cdot \gamma_{fill} + 2 \cdot ft \cdot \gamma_{clay} + 6 \cdot ft \cdot \gamma_{bc})$

$$P_{a3} = 501 \cdot psf$$

Slope of Active in Sand Below Water = $S_{a3} := K_{as} \cdot \gamma_{bs}$

$$S_{a3} = 19 \cdot \frac{psf}{ft}$$

Active Pressure at Till = $P_{a4} := K_{at} \cdot (10 \cdot ft \cdot \gamma_{fill} + 2 \cdot ft \cdot \gamma_{clay} + 6 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs})$

$$P_{a4} = 695 \cdot psf$$

Slope of Active in Till = $S_{a4} := K_{at} \cdot \gamma_{bt}$

$$S_{a4} = 18 \cdot \frac{psf}{ft}$$

Passive Earth Pressures

Passive Pressure at Subgrade = $P_{p1} := 2 \cdot S_u$

$$P_{p1} = 2000 \cdot psf$$

Slope of Passive in Clay = $S_{p1} := \gamma_{bc}$

$$S_{p1} = 63 \cdot \frac{psf}{ft}$$

Passive Pressure at Sand = $P_{p2} := K_{ps} \cdot (6 \cdot ft \cdot \gamma_{bc})$

$$P_{p2} = 1274 \cdot psf$$

Slope of Passive in Sand Below Water = $S_{p2} := K_{ps} \cdot \gamma_{bs}$

$$S_{p2} = 246 \cdot \frac{psf}{ft}$$

Passive Pressure at Till = $P_{p3} := K_{pt} \cdot (6 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs})$

$$P_{p3} = 17225 \cdot psf$$

Slope of Passive in Till = $S_{p3} := K_{pt} \cdot \gamma_{bt}$

$$S_{p3} = 884 \cdot \frac{psf}{ft}$$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages H1 to H4 of these calculations.

Maximum Bending Moment = $M_7 := 186.68 \cdot kft$

Minimum Soldier Pile Length = $L_7 := 26.73 \cdot ft$

Soldier Pile Design

The soldier pile design will determine the required pile section and length based on the analysis above along with determining the estimated maximum deflection.

Soldier Pile Section

The required soldier pile section will be determined based on AISC allowable bending stresses for design of the temporary excavation support system.

Yield Strength = $F_y := 50 \cdot ksi$ (ASTM A572 Steel)

Maximum Bending Moment = $M_b := M_7$

$$M_b = 186.68 \cdot kft$$

Required Section Modulus = $S_x := \dfrac{M_b}{0.667 \cdot F_y}$

$$S_x = 67.17 \cdot in^3$$

Use HP14x73 Section with S_x = 107 in^3

(see page A3 for specification sheet)

Soldier Pile Length

The required soldier pile length is determined by the CT-Shoring Program. The results of this analysis are given above.

Minimum Soldier Pile Length = $L_{min} := L_7$

$$L_{min} = 26.7\,ft$$

Provide 27-Foot Long Soldier Piles

Estimated Lateral Deflection of Soldier Pile Wall

Lateral deflection of soldier pile wall will be estimated using the CT-Shoring program. The moment of inertia for the HP14x73 soldier pile section is input (S_x = 729 in^4) and the program generates an estimated lateral deflections for the cantilever condition. The results for the cantilever deflection are taken from page H5 of these calculations.

Estimated Maximum Cantilever Deflection = $\delta_7 := 1.18 \cdot in$

Based on this result the estimated maximum lateral of the soldier pile wall will be approximately 2 inches. This is only an estimate and the actual deflection may vary based on specific soil and surcharge conditions.

Use HP14x73 with Length of 27 Feet

Design Case 8 - Cantilever Height of Support of 11 Feet

The cantilever design height of support will be 11 feet. The piles will be installed at 8-foot spacing. Ground water level will be set at subgrade.

Height of Excavation = $H := 11 \cdot ft$

Active Pressure

Active Pressure at Bottom of Fill = $P_{a1} := K_{af} \cdot (10 \cdot ft \cdot \gamma_{fill})$

$P_{a1} = 364 \cdot psf$

Active Pressure at Clay = $P_{a2} := (10 \cdot ft \cdot \gamma_{fill}) - 2 \cdot S_u$

$P_{a2} = -700 \cdot psf$ ≤ 0 psf *Use P_a=0 psf*

Depth in Clay to Positive Active Pressure = $h_c := \frac{P_{a2}}{\gamma_{clay}} = -5.6\, ft$ Use 5 ft.

Slope of Active in Clay Below Water = $S_{a2} := \gamma_{bc}$

$S_{a2} = 63 \cdot \frac{psf}{ft}$

Active Pressure at Sand = $P_{a3} := K_{as} \cdot (10 \cdot ft \cdot \gamma_{fill} + 1 \cdot ft \cdot \gamma_{clay} + 7 \cdot ft \cdot \gamma_{bc})$

$P_{a3} = 484 \cdot psf$

Slope of Active in Sand Below Water = $S_{a3} := K_{as} \cdot \gamma_{bs}$

$S_{a3} = 19 \cdot \frac{psf}{ft}$

Active Pressure at Till = $P_{a4} := K_{at} \cdot (10 \cdot ft \cdot \gamma_{fill} + 1 \cdot ft \cdot \gamma_{clay} + 7 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs})$

$P_{a4} = 681 \cdot psf$

Slope of Active in Till = $S_{a4} := K_{at} \cdot \gamma_{bt}$

$S_{a4} = 18 \cdot \frac{psf}{ft}$

Passive Earth Pressures

Passive Pressure at Subgrade = $P_{p1} := 2 \cdot S_u$

$P_{p1} = 2000 \cdot psf$

Slope of Passive in Clay = $S_{p1} := \gamma_{bc}$

$S_{p1} = 63 \cdot \frac{psf}{ft}$

Passive Pressure at Sand = $P_{p2} := K_{ps} \cdot (7 \cdot ft \cdot \gamma_{bc})$

$$P_{p2} = 1486 \cdot psf$$

Slope of Passive in Sand Below Water = $S_{p2} := K_{ps} \cdot \gamma_{bs}$

$$S_{p2} = 246 \cdot \frac{psf}{ft}$$

Passive Pressure at Till = $P_{p3} := K_{pt} \cdot (7 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs})$

$$P_{p3} = 17895 \cdot psf$$

Slope of Passive in Till = $S_{p3} := K_{pt} \cdot \gamma_{bt}$

$$S_{p3} = 884 \cdot \frac{psf}{ft}$$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages J1 to J4 of these calculations.

Maximum Bending Moment = $M_8 := 167.57 \cdot kft$

Minimum Soldier Pile Length = $L_8 := 26.49 \cdot ft$

Soldier Pile Design

The soldier pile design will determine the required pile section and length based on the analysis above along with determining the estimated maximum deflection.

Soldier Pile Section

The required soldier pile section will be determined based on AISC allowable bending stresses for design of the temporary excavation support system.

Yield Strength = $F_y := 50 \cdot ksi$ (ASTM A572 Steel)

Maximum Bending Moment = $M_b := M_8$

$$M_b = 167.57 \cdot kft$$

Required Section Modulus = $S_x := \frac{M_b}{0.667 \cdot F_y}$

$S_x = 60.30 \cdot in^3$

Use HP12x53 Section with S_x = 66.7 in^3

(see page A3 for specification sheet)

Soldier Pile Length

The required soldier pile length is determined by the CT-Shoring Program. The results of this analysis are given above.

Minimum Soldier Pile Length = $L_{min} := L_8$

$L_{min} = 26.5\,ft$

Provide 27-Foot Long Soldier Piles

Estimated Lateral Deflection of Soldier Pile Wall

Lateral deflection of soldier pile wall will be estimated using the CT-Shoring program. The moment of inertia for the HP12x53 soldier pile section is input (S_x = 393 in^4) and the program generates an estimated lateral deflections for the cantilever condition. The results for the cantilever deflection are taken from page J5 of these calculations.

Estimated Maximum Cantilever Deflection = $\delta_8 := 1.74 \cdot in$

Based on this result the estimated maximum lateral of the soldier pile wall will be approximately 2 inches. This is only an estimate and the actual deflection may vary based on specific soil and surcharge conditions.

Use HP14x53 with Length of 27 Feet

Design Case 9 - Cantilever Height of Support of 10 Feet

The cantilever design height of support will be 10 feet. The piles will be installed at 8-foot spacing. Ground water level will be set at subgrade.

Height of Excavation = $H := 10 \cdot ft$

Active Pressure

Active Pressure at Bottom of Fill = $P_{a1} := K_{af} \cdot (10 \cdot ft \cdot \gamma_{fill})$

$P_{a1} = 364 \cdot psf$

Active Pressure at Clay = $P_{a2} := (10 \cdot ft \cdot \gamma_{fill}) - 2 \cdot S_u$

$P_{a2} = -700 \cdot psf$ $\leq$ 0 psf *Use P_a=0 psf*

Depth in Clay to Positive Active Pressure = $h_c := \frac{P_{a2}}{\gamma_{clay}} = -5.6\,ft$ Use 5 ft.

Slope of Active in Clay Below Water = $S_{a2} := \gamma_{bc}$

$S_{a2} = 63 \cdot \frac{psf}{ft}$

Active Pressure at Sand = $P_{a3} := K_{as} \cdot (10 \cdot ft \cdot \gamma_{fill} + 8 \cdot ft \cdot \gamma_{bc})$

$P_{a3} = 468 \cdot psf$

Slope of Active in Sand Below Water = $S_{a3} := K_{as} \cdot \gamma_{bs}$

$S_{a3} = 19 \cdot \frac{psf}{ft}$

Active Pressure at Till = $P_{a4} := K_{at} \cdot (10 \cdot ft \cdot \gamma_{fill} + 8 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs})$

$P_{a4} = 668 \cdot psf$

Slope of Active in Till = $S_{a4} := K_{at} \cdot \gamma_{bt}$

$S_{a4} = 18 \cdot \frac{psf}{ft}$

Passive Earth Pressures

Passive Pressure at Subgrade = $P_{p1} := 2 \cdot S_u$

$P_{p1} = 2000 \cdot psf$

Slope of Passive in Clay = $S_{p1} := \gamma_{bc}$

$S_{p1} = 63 \cdot \frac{psf}{ft}$

Passive Pressure at Sand = $P_{p2} := K_{ps} \cdot (8 \cdot ft \cdot \gamma_{bc})$

$P_{p2} = 1699 \cdot psf$

Slope of Passive in Sand Below Water = $S_{p2} := K_{ps} \cdot \gamma_{bs}$

$S_{p2} = 246 \cdot \frac{psf}{ft}$

Passive Pressure at Till = $P_{p3} := K_{pt} \cdot (8 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs})$

$$P_{p3} = 18565 \cdot psf$$

Slope of Passive in Till = $S_{p3} := K_{pt} \cdot \gamma_{bt}$

$$S_{p3} = 884 \cdot \frac{psf}{ft}$$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages K1 to K4 of these calculations.

Maximum Bending Moment = $M_9 := 140.92 \cdot kft$

Minimum Soldier Pile Length = $L_9 := 24.27 \cdot ft$

Soldier Pile Design

The soldier pile design will determine the required pile section and length based on the analysis above along with determining the estimated maximum deflection.

Soldier Pile Section

The required soldier pile section will be determined based on AISC allowable bending stresses for design of the temporary excavation support system.

Yield Strength = $F_y := 50 \cdot ksi$ (ASTM A572 Steel)

Maximum Bending Moment = $M_b := M_9$

$$M_b = 140.92 \cdot kft$$

Required Section Modulus = $S_x := \frac{M_b}{0.667 \cdot F_y}$

$$S_x = 50.71 \cdot in^3$$

Use HP12x53 Section with S_x = 66.7 in^3

(see page A3 for specification sheet)

Soldier Pile Length

The required soldier pile length is determined by the CT-Shoring Program. The results of this analysis are given above.

Minimum Soldier Pile Length = $L_{min} := L_9$

$$L_{min} = 24.3\,\text{ft}$$

Provide 25-Foot Long Soldier Piles

Estimated Lateral Deflection of Soldier Pile Wall

Lateral deflection of soldier pile wall will be estimated using the CT-Shoring program. The moment of inertia for the HP12x53 soldier pile section is input (S_x = 393 in^4) and the program generates an estimated lateral deflections for the cantilever condition. The results for the cantilever deflection are taken from page K5 of these calculations.

Estimated Maximum Cantilever Deflection = $\delta_9 := 1.19 \cdot \text{in}$

Based on this result the estimated maximum lateral of the soldier pile wall will be approximately 1 inch. This is only an estimate and the actual deflection may vary based on specific soil and surcharge conditions.

Use HP12x53 with Length of 25 Feet

Design Case 10 - Cantilever Height of Support of 8 Feet

The cantilever design height of support will be 8 feet. The piles will be installed at 8-foot spacing. Ground water level will be set at subgrade.

Height of Excavation = $H := 8 \cdot \text{ft}$

Active Pressure

Active Pressure at Bottom of Subgrade = $P_{a1} := K_{af} \cdot (8 \cdot \text{ft} \cdot \gamma_{fill})$

$$P_{a1} = 291 \cdot \text{psf}$$

Slope of Active in Fill Below Water = $S_{a1} := K_{af} \cdot \gamma_{bf}$

$$S_{a1} = 19 \cdot \frac{\text{psf}}{\text{ft}}$$

Active Pressure at Clay = $P_{a2} := (8 \cdot \text{ft} \cdot \gamma_{fill} + 2 \cdot \text{ft} \cdot \gamma_{bf}) - 2 \cdot S_u$

$P_{a2} = -825 \cdot \text{psf}$ $\leq$ 0 psf *Use P_a=0 psf*

Depth in Clay to Positive Active Pressure = $h_c := \frac{P_{a2}}{\gamma_{clay}} = -6.6\,\text{ft}$ Use 6 ft.

Slope of Active in Clay Below Water = $S_{a2} := \gamma_{bc}$

$$S_{a2} = 63 \cdot \frac{psf}{ft}$$

Active Pressure at Sand = $P_{a3} := K_{as} \cdot (8 \cdot ft \cdot \gamma_{fill} + 2 \cdot ft \cdot \gamma_{bf} + 8 \cdot ft \cdot \gamma_{bc})$

$$P_{a3} = 436 \cdot psf$$

Slope of Active in Sand Below Water = $S_{a3} := K_{as} \cdot \gamma_{bs}$

$$S_{a3} = 19 \cdot \frac{psf}{ft}$$

Active Pressure at Till = $P_{a4} := K_{at} \cdot (8 \cdot ft \cdot \gamma_{fill} + 2 \cdot ft \cdot \gamma_{bf} + 8 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs})$

$$P_{a4} = 640 \cdot psf$$

Slope of Active in Till = $S_{a4} := K_{at} \cdot \gamma_{bt}$

$$S_{a4} = 18 \cdot \frac{psf}{ft}$$

Passive Earth Pressures

Slope of Passive in Fill = $S_p := K_{pf} \cdot \gamma_{bf}$

$$S_p = 239 \cdot \frac{psf}{ft}$$

Passive Pressure at Clay = $P_{p1} := K_{pc} \cdot (2 \cdot ft \cdot \gamma_{bc}) + 2 \cdot S_u$

$$P_{p1} = 2125 \cdot psf$$

Slope of Passive in Clay = $S_{p1} := \gamma_{bc}$

$$S_{p1} = 63 \cdot \frac{psf}{ft}$$

Passive Pressure at Sand = $P_{p2} := K_{ps} \cdot (2 \cdot ft \cdot \gamma_{bc} + 8 \cdot ft \cdot \gamma_{bc})$

$$P_{p2} = 2123 \cdot psf$$

Slope of Passive in Sand Below Water = $S_{p2} := K_{ps} \cdot \gamma_{bs}$

$$S_{p2} = 246 \cdot \frac{psf}{ft}$$

Passive Pressure at Till = $P_{p3} := K_{pt} \cdot \left(2 \cdot ft \cdot \gamma_{bc} + 8 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs}\right)$

$$P_{p3} = 19904 \cdot psf$$

Slope of Passive in Till = $S_{p3} := K_{pt} \cdot \gamma_{bt}$

$$S_{p3} = 884 \cdot \frac{psf}{ft}$$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages L1 to L4 of these calculations.

Maximum Bending Moment = $M_{10} := 113.65 \cdot kft$

Minimum Soldier Pile Length = $L_{10} := 22.55 \cdot ft$

Soldier Pile Design

The soldier pile design will determine the required pile section and length based on the analysis above along with determining the estimated maximum deflection.

Soldier Pile Section

The required soldier pile section will be determined based on AISC allowable bending stresses for design of the temporary excavation support system.

Yield Strength = $F_y := 50 \cdot ksi$ (ASTM A572 Steel)

Maximum Bending Moment = $M_b := M_{10}$

$$M_b = 113.65 \cdot kft$$

Required Section Modulus = $S_x := \frac{M_b}{0.667 \cdot F_y}$

$$S_x = 40.89 \cdot in^3$$

Use HP10x42 Section with S_x = 43.4 in^3

(see page A3 for specification sheet)

Soldier Pile Length

The required soldier pile length is determined by the CT-Shoring Program. The results of this analysis are given above.

Minimum Soldier Pile Length = $L_{min} := L_{10}$

$$L_{min} = 22.6\,\text{ft}$$

Provide 23-Foot Long Soldier Piles

Estimated Lateral Deflection of Soldier Pile Wall

Lateral deflection of soldier pile wall will be estimated using the CT-Shoring program. The moment of inertia for the HP10x42 soldier pile section is input (S_x = 210 in^4) and the program generates an estimated lateral deflections for the cantilever condition. The results for the cantilever deflection are taken from page L5 of these calculations.

Estimated Maximum Cantilever Deflection = $\delta_{10} := 1.25 \cdot in$

Based on this result the estimated maximum lateral of the soldier pile wall will be approximately 1 inch. This is only an estimate and the actual deflection may vary based on specific soil and surcharge conditions.

Use HP10x42 with Length of 23 Feet

Reduced Passive Resistance

In the area along Congress Street from piles 47 to 55 the subgrade within the site will be sloped from the soldier piles down to the interior mat slab at elev. 32. The sloping ground will result in a lower passive resistance in the sand layer. A reduced passive pressure coefficient will be used in this area. The interior sloping ground will be approximately 25 degrees. The design for these piles with the reduced passive pressure coefficient will be done here.

Slope of Ground at Base of Wall = $\omega := -25 \cdot deg$ (angle from horizontal)

Batter of Wall = $\alpha := 90 \cdot deg$ (angle from horizontal)

o Sand
(18' to 35')

Friction Angle = $\phi_s := 33 \cdot deg$

Friction Angle Steel to Sand = $\delta := 0 \cdot deg$ (Rankine)

Passive Pressure Coefficient = $K_{ps} := \left[\frac{\sin(\alpha - \phi_s)^2}{\sin(\alpha)^2 \cdot \sin(\alpha + \delta) \cdot \left(1 - \sqrt{\frac{\sin(\phi_s + \delta) \cdot \sin(\phi_s + \omega)}{\sin(\alpha + \delta) \cdot \sin(\alpha + \omega)}} \right)^2} \right]$

$K_{ps} = 1.392$

Design Case 11 - Cantilever Height of Support of 10 Feet

The cantilever design height of support will be 10 feet. The piles will be installed at 8-foot spacing. Ground water level will be set at subgrade.

Height of Excavation = $H := 10 \cdot ft$

Active Pressure

Active Pressure at Bottom of Subgrade = $P_{a1} := K_{af} \cdot (10 \cdot ft \cdot \gamma_{fill})$

$P_{a1} = 364 \cdot psf$

Slope of Active in Fill Below Water = $S_{a1} := K_{af} \cdot \gamma_{bf}$

$S_{a1} = 19 \cdot \frac{psf}{ft}$

Active Pressure at Clay = $P_{a2} := (10 \cdot ft \cdot \gamma_{fill}) - 2 \cdot S_u$

$P_{a2} = -700 \cdot psf$ $\leq$ 0 psf *Use P_a=0 psf*

Depth in Clay to Positive Active Pressure = $h_c := \frac{P_{a2}}{\gamma_{clay}} = -5.6\,ft$ Use 5 ft.

Slope of Active in Clay Below Water = $S_{a2} := \gamma_{bc}$

$S_{a2} = 63 \cdot \frac{psf}{ft}$

Active Pressure at Sand = $P_{a3} := K_{as} \cdot (10 \cdot ft \cdot \gamma_{fill} + 8 \cdot ft \cdot \gamma_{bc})$

$P_{a3} = 468 \cdot psf$

Slope of Active in Sand Below Water = $S_{a3} := K_{as} \cdot \gamma_{bs}$

$S_{a3} = 19 \cdot \frac{psf}{ft}$

Active Pressure at Till = $P_{a4} := K_{at} \cdot (10 \cdot ft \cdot \gamma_{fill} + 8 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs})$

$$P_{a4} = 668 \cdot psf$$

Slope of Active in Till = $S_{a4} := K_{at} \cdot \gamma_{bt}$

$$S_{a4} = 18 \cdot \frac{psf}{ft}$$

<u>Passive Earth Pressures</u>

Passive Pressure at Clay = $P_{p1} := 2 \cdot S_u$

$$P_{p1} = 2000 \cdot psf$$

Slope of Passive in Clay = $S_{p1} := \gamma_{bc}$

$$S_{p1} = 63 \cdot \frac{psf}{ft}$$

Passive Pressure at Sand = $P_{p2} := K_{ps} \cdot (8 \cdot ft \cdot \gamma_{bc})$

$$P_{p2} = 697 \cdot psf$$

Slope of Passive in Sand Below Water = $S_{p2} := K_{ps} \cdot \gamma_{bs}$

$$S_{p2} = 101 \cdot \frac{psf}{ft}$$

Passive Pressure at Till = $P_{p3} := K_{pt} \cdot (8 \cdot ft \cdot \gamma_{bc} + 17 \cdot ft \cdot \gamma_{bs})$

$$P_{p3} = 18565 \cdot psf$$

Slope of Passive in Till = $S_{p3} := K_{pt} \cdot \gamma_{bt}$

$$S_{p3} = 884 \cdot \frac{psf}{ft}$$

Using the above lateral loadings on the excavation support system a computer analysis was run to determine the maximum bending moment. The model was run a second time with a factor of safety of 1.50 applied to the passive pressures in order to determine the required pile embedment for moment equilibrium. The results of these analyses along with the pressure diagrams are on pages M1 to M4 of these calculations.

Maximum Bending Moment = $M_{11} := 142.98 \cdot kft$

Minimum Soldier Pile Length = $L_{11} := 26.89 \cdot ft$

Soldier Pile Design

The soldier pile design will determine the required pile section and length based on the analysis above along with determining the estimated maximum deflection.

Soldier Pile Section

The required soldier pile section will be determined based on AISC allowable bending stresses for design of the temporary excavation support system.

Yield Strength = $F_y := 50 \cdot ksi$ (ASTM A572 Steel)

Maximum Bending Moment = $M_b := M_{11}$

$$M_b = 142.98 \cdot kft$$

Required Section Modulus = $S_x := \dfrac{M_b}{0.667 \cdot F_y}$

$$S_x = 51.45 \cdot in^3$$

Use HP12x53 Section with S_x = 66.7 in^3

(see page A3 for specification sheet)

Soldier Pile Length

The required soldier pile length is determined by the CT-Shoring Program. The results of this analysis are given above.

Minimum Soldier Pile Length = $L_{min} := L_{11}$

$$L_{min} = 26.9\,ft$$

Provide 27-Foot Long Soldier Piles

Estimated Lateral Deflection of Soldier Pile Wall

Lateral deflection of soldier pile wall will be estimated using the CT-Shoring program. The moment of inertia for the HP12x53 soldier pile section is input (S_x = 393 in^4) and the program generates an estimated lateral deflections for the cantilever condition. The results for the cantilever deflection are taken from page M5 of these calculations.

Estimated Maximum Cantilever Deflection = $\delta_{11} := 1.23 \cdot in$

Based on this result the estimated maximum lateral of the soldier pile wall will be approximately 1 inch. This is only an estimate and the actual deflection may vary based on specific soil and surcharge conditions.

Use HP12x53 with Length of 27 Feet

Design of Timber Lagging

The timber lagging will be used between the soldier piles to retain the earth. Lagging will be designed to resist the lateral loadings due to soil loading. The loading will be reduced by 1/2 to account for arching, as per FHWA RD 75-128. The required lagging will be determined for a height of support of 21 feet and a pile spacing of 7 feet.

The timber lagging will consist of mixed hardwoods. For design the working stress values given for spruce, pine and fir will be used, as given in AASHTO *"Standard Specifications for Highway Bridges"*, Table 13.5.1A (copy on page A5). The load factors used in the design are standard factors used in timber design and can be found in AITC *"Timber Construction Manual"*, *"Design of Wood Structures"* by Breyer or AASHTO *"Standard Specifications for Highway Bridges"*.

Allowable Bending Stress for 3-Inch Thick Lagging

Working Stress for Lagging = $F_{wb} := 875 \cdot psi$

Size Factor = $C_F := 1.1$ (3"x10" Lagging)

Flat Use Factor = $C_{fu} := 1.2$ (3"x10" Lagging)

Load Duration Factor = $C_D := 1.15$ (2 month for load combination)

Wet Service Factor = $C_M := \begin{cases} 1.00 & \text{if } F_{wb} \cdot C_F < 1150 \cdot psi \\ 0.85 & \text{otherwise} \end{cases}$

$C_M = 1.00$

Allowable Bending Stress = $F_b := F_{wb} \cdot C_{fu} \cdot C_F \cdot C_D \cdot C_M$

$F_b = 1328 \cdot psi$

Turner to confirm duration of excavation.

Lagging Design

Soldier Pile Spacing = $S_{pile} := 8 \cdot ft$

Pile Flange Width = $b_f := 12 \cdot in$ (HP12x53 Soldier Pile)

Design Span for Lagging = $L := S_{pile} - b_f$

$L = 7\,ft$

Height of Soil Retailed = $H_{soil} := 21 \cdot ft$

Soil Loading = $P_{soil} := 24 \cdot pcf \cdot H$

$$P_{soil} = 240 \cdot psf$$

Maximum Bending Moment = $M_{max} := \left[\frac{\left[(P_{soil}) \cdot \frac{1}{2} \right] \cdot L^2 \cdot 1 \cdot ft}{8} \right]$

$$M_{max} = 0.74 \cdot kft$$

Required Section Modulus = $S_x := \frac{M_{max}}{F_b}$

$$S_x = 6.6 \cdot in^3$$

Required Thickness = $t := \sqrt{\frac{S_x \cdot 6}{12 \cdot in}}$

$$t = 1.8 \cdot in$$

Use 3" Thick Timbers for Lagging

- ***Lagging Connection to Pile Design***

  The lagging attachment detail will consist of a 1/2" diameter threaded rod welded to the pile flange. The required weld will be designed here.

Force On Weld = $P_w := (P_{soil}) \cdot 4 \cdot ft \cdot 1 \cdot ft$

$$P_w = 960 \cdot lbf$$

Ultimate Strength of Weld = $F_u := 70 \cdot ksi$

Allowable Stress on Weld = $F_w := 30\% \cdot F_u$

$$F_w = 21 \cdot ksi$$

Diameter of Threaded Rod = $d_{rod} := 0.5 \cdot in$

Welded Circumference of Rod = $C := \pi \cdot d_{rod}$

$$C = 1.6 \cdot in$$

Required Weld Size = $W := \frac{P_w}{\cos(45 \cdot deg) \cdot F_w \cdot C}$

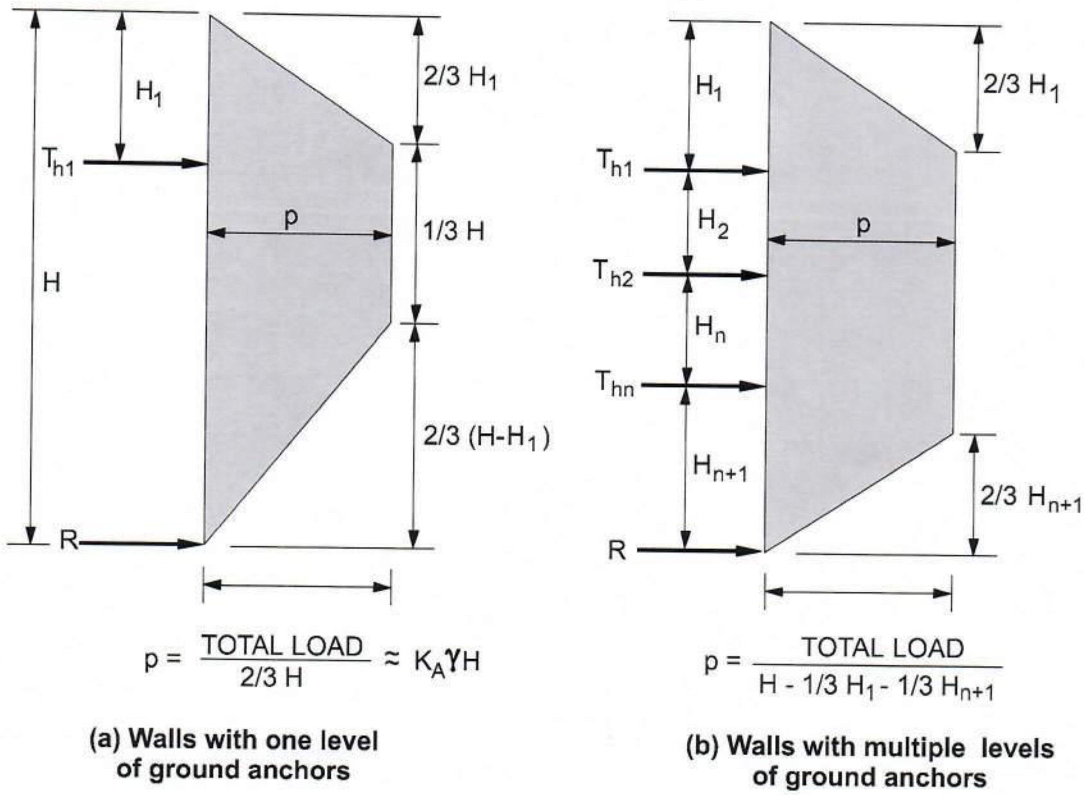
$W = 0.04 \cdot in$

Provide 1/4-inch E70 Full Perimeter Weld Per Rod

END OF CALCULATIONS

$$p = 0.65 K_A \gamma H \qquad \text{(Equation 10b)}$$

where ϕ' is the effective stress friction angle of the sand. Using this value of lateral earth pressure, the total lateral earth load from the rectangular apparent earth pressure diagram (figure 23a) for sands is $0.65\ K_a\gamma H^2$. The recommended apparent earth pressure envelope for single level anchored walls and walls with two or more levels of ground anchors is trapezoidal and is shown in figure 24.



H_1 = Distance from ground surface to uppermost ground anchor

H_{n+1} = Distance from base of excavation to lowermost ground anchor

T_{hi} = Horizontal load in ground anchor i

R = Reaction force to be resisted by subgrade (i.e., below base of excavation)

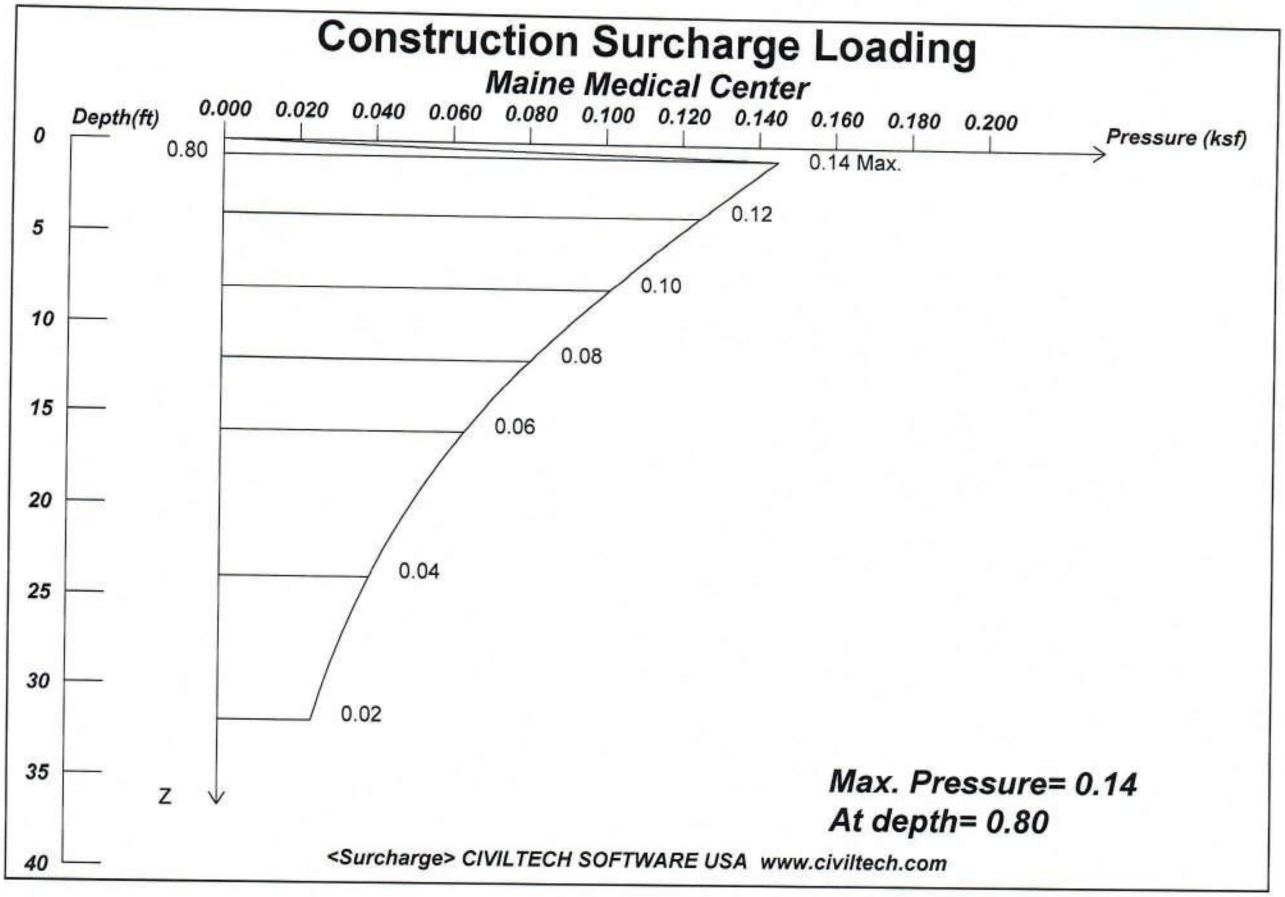
p = Maximum ordinate of diagram

TOTAL LOAD = $0.65\ K_A \gamma H^2$

Figure 24. Recommended apparent earth pressure diagram for sands.

A2

Construction Surcharge Loading



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Wall Height, H= 16 Load Depth, D= 0

Load Factor of Surcharge Loading = 1

Flexible Wall Condition -- Movement or deflection are allowed.

Max. Pressure = 0.145 at depth = 0.80

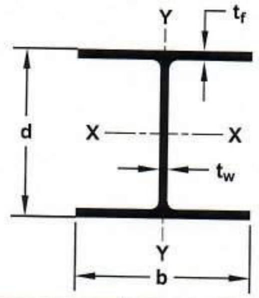
X	Width	Strip Load
.0	30.0	.30

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

NUCOR SKYLINE A3

HP

Steel H-Pile



SECTION	Weight lb/ft (kg/m)	Area in² (cm²)	Depth d in (mm)	Flange Width b in (mm)	THICKNESS Flange (t_f) in (mm)	THICKNESS Web (t_w) in (mm)	Coating Area ft²/ft (m²/m)	PROPERTIES AXIS X-X I in⁴ (cm⁴)	AXIS X-X S in³ (cm³)	AXIS X-X Z in³ (cm³)	AXIS X-X r in (cm)	AXIS Y-Y I in⁴ (cm⁴)	AXIS Y-Y S in³ (cm³)	AXIS Y-Y Z in³ (cm³)	AXIS Y-Y r in (cm)
HP 8 HP 200	36 54	10.6 68.4	8.02 204	8.16 207	0.445 11.3	0.445 11.3	3.92 1.19	119 4953	29.8 488	33.6 550.6	3.36 8.53	40.3 1677	9.88 162	15.2 249.1	1.95 4.95
HP 10 HP 250	42 63	12.4 80.0	9.70 246	10.10 257	0.420 10.7	0.415 10.5	4.83 1.47	210 8741	43.4 711	48.3 791.5	4.13 10.5	71.7 2984	14.2 233	21.8 357.2	2.41 6.12
	57 85	16.7 108	9.99 254	10.20 259	0.565 14.4	0.565 14.4	4.91 1.50	294 12237	58.8 964	66.5 1089.7	4.18 10.6	101 4204	19.7 323	30.3 496.5	2.45 6.22
HP 12 HP 310	53 79	15.5 100	11.80 300	12.00 305	0.435 11.0	0.435 11.0	5.82 1.77	393 16358	66.7 1093	74.0 1212.6	5.03 12.8	127 5286	21.1 346	32.2 527.7	2.86 7.26
	63 94	18.4 119	11.90 302	12.10 307	0.515 13.1	0.515 13.1	5.86 1.79	472 19646	79.1 1296	88.3 1447.0	5.06 12.9	153 6368	25.3 415	38.7 634.2	2.88 7.32
	74 110	21.8 141	12.10 307	12.20 310	0.610 15.5	0.605 15.4	5.91 1.80	569 23683	93.8 1537	105 1720.6	5.11 13.0	186 7742	30.4 498	46.6 763.6	2.92 7.42
	84 125	24.6 159	12.30 312	12.30 312	0.685 17.4	0.685 17.4	5.97 1.82	650 27055	106 1737	120 1966.4	5.14 13.1	213 8866	34.6 567	53.2 871.8	2.94 7.47
	89 132	25.9 167	12.36 314	12.32 313	0.720 18.3	0.720 18.3	6.04 1.84	689 28700	111.6 1830	126.3 2070	5.16 13.1	225 9370	36.5 599	56.2 922	2.94 7.48
	102 152	29.9 193	12.56 319	12.64 321	0.819 20.8	0.819 20.8	6.17 1.88	811 33800	129.3 2120	147.6 2420	5.20 13.2	276 11500	43.7 716	67.1 1100	3.04 7.71
	117 174	34.4 222	12.76 324	12.87 327	0.929 23.6	0.929 23.6	6.26 1.91	946 39400	148.2 2430	170.8 2800	5.24 13.3	331 13800	51.4 843	79.3 1300	3.11 7.89
HP 14 HP 360	73 109	21.4 138	13.60 345	14.60 371	0.505 12.8	0.505 12.8	6.96 2.12	729 30343	107 1753	118 1933.7	5.84 14.8	261 10864	35.8 587	54.6 894.7	3.49 8.86
	89 132	26.1 168	13.80 351	14.70 373	0.615 15.6	0.615 15.6	7.02 2.14	904 37627	131 2147	146 2392.5	5.88 14.9	326 13569	44.3 726	67.7 1109.4	3.53 8.97
	102 152	30.1 194	14.00 356	14.80 376	0.705 17.9	0.705 17.9	7.06 2.15	1050 43704	150 2458	169 2769.4	5.92 15.0	380 15817	51.4 842	78.8 1291.3	3.56 9.04
	117 174	34.4 222	14.20 361	14.90 378	0.805 20.4	0.805 20.4	7.12 2.34	1220 50780	172 2819	194 3179.1	5.96 15.1	443 18439	59.5 975	91.4 1497.8	3.59 9.12
HP 16 HP 410	88 131	25.8 167	15.30 389	15.70 399	0.540 13.7	0.540 13.7	7.52 2.29	1110 46201	145 2376	161 2638.3	6.56 16.7	349 14526	44.5 729	68.2 1117.6	3.68 9.35
	101 150	29.9 193	15.50 394	15.80 401	0.625 15.9	0.625 15.9	7.56 2.30	1300 54110	168 2753	187 3064.4	6.59 16.7	412 17149	52.2 855	80.1 1312.6	3.71 9.42
	121 180	35.8 231	15.80 401	15.90 404	0.750 19.1	0.750 19.1	7.62 2.32	1590 66180	201 3294	226 3703.5	6.66 16.9	504 20978	63.4 1039	97.6 1599.4	3.75 9.53
	141 210	41.7 269	16.00 406	16.00 406	0.875 22.2	0.875 22.2	7.69 2.34	1870 77835	234 3835	264 4326.2	6.70 17.0	599 24932	74.9 1227	116 1900.9	3.79 9.63
	162 241	47.7 308	16.30 414	16.10 409	1.000 25.4	1.000 25.4	7.75 2.36	2190 91154	269 4408	306 5014.4	6.78 17.2	697 29011	86.6 1419	134 2195.9	3.82 9.70
	183 272	54.1 349	16.50 419	16.30 414	1.130 28.7	1.130 28.7	7.81 2.38	2510 104473	304 4982	349 5719.1	6.81 17.3	818 34047	100.0 1639	156 2556.4	3.89 9.88
HP 18 HP 460	135 201	39.9 257	17.50 445	17.80 452	0.750 19.1	0.750 19.1	8.54 2.60	2200 91570	251 4113	281 4604.7	7.43 18.9	706 29386	79.3 1299	122 1999.2	4.21 10.7
	157 234	46.2 298	17.70 450	17.90 455	0.870 22.1	0.870 22.1	8.60 2.62	2570 106971	290 4752	327 5358.5	7.46 18.9	833 34672	93.1 1526	143 2343.3	4.25 10.8
	181 269	53.2 343	18.00 457	18.00 457	1.000 25.4	1.000 25.4	8.66 2.64	3020 125701	336 5506	379 6210.7	7.53 19.1	974 40541	108.0 1770	167 2736.6	4.28 10.9
	204 304	60.2 388	18.30 465	18.10 460	1.130 28.7	1.130 28.7	8.73 2.66	3480 144847	380 6227	433 7095.6	7.60 19.3	1120 46618	124.0 2032	191 3129.9	4.31 11.0

A4

Multi-Strand Anchors - ASTM A416						
No. of 0.6" Strands	**Nominal Cross Section Area (Aps)** in^2 mm^2	**Ultimate Strength (Fpu x Aps)** kips kN	**Maximum Jacking Load (0.8 x Fpu x Aps)** kips kN	**Maximum Design Load (0.6 x Fpu x Aps)** kips kN	**Minimum Lockoff Load (0.5 x Fpu x Aps)** kips kN	**Nominal Steel Weight (Bare Strand)** lbs/ft kg/m
1	0.217 140	58.6 261	46.9 209	35.2 156	29.3 130	0.74 1.10
2	0.434 280	117.2 521	93.8 417	70.3 313	58.6 261	1.48 2.20
3	0.651 420	175.8 782	140.6 626	105.5 469	87.9 391	2.22 3.31
4	0.868 560	234.4 1043	187.5 834	140.6 626	117.2 521	2.96 4.41
5	1.085 700	293.0 1303	234.4 1043	175.8 782	146.5 652	3.70 5.51
6	1.302 840	351.6 1564	281.3 1251	211.0 938	175.8 782	4.44 6.61
7	1.519 980	410.2 1825	328.2 1460	246.1 1095	205.1 912	5.18 7.71
8	1.736 1120	468.8 2085	375.0 1668	281.3 1251	234.4 1043	5.92 8.82
9	1.953 1260	527.4 2346	421.9 1877	316.4 1408	263.7 1173	6.66 9.92
10	2.170 1400	586.0 2607	468.8 2085	351.6 1564	293.0 1303	7.40 11.02
11	2.387 1540	644.6 2867	515.7 2294	386.8 1720	322.3 1434	8.14 12.12
12	2.604 1680	703.2 3128	562.6 2503	421.9 1877	351.6 1564	8.88 13.22
13	2.821 1820	761.8 3389	609.4 2711	457.1 2033	380.9 1694	9.62 14.33
14	3.038 1960	820.4 3649	656.3 2920	492.2 2190	410.2 1825	10.36 15.43
15	3.255 2100	879.0 3910	703.2 3128	527.4 2346	439.5 1955	11.10 16.53
16	3.472 2240	937.6 4171	750.1 3337	562.6 2503	468.8 2085	11.84 17.63
17	3.689 2380	996.2 4432	797.0 3545	597.7 2659	498.1 2216	12.58 18.73
18	3.906 2520	1054.8 4692	843.8 3754	632.9 2815	527.4 2346	13.32 19.84
19	4.123 2660	1113.4 4953	890.7 3962	668.0 2972	556.7 2476	14.06 20.94

Aps = Area Prestressing Steel, Fpu = Minimum Ultimate Tensile Strength
Strand Anchors utilize 0.6" (15.2mm) dia. 7-wire, Low Relaxation 270 KSI Steel Strand conforming to ASTM A 416.
*Maximum lockoff load shall not exceed (0.7 x Fpu x Aps), maximum jacking load shall not exceed (0.8xFpu x Aps)
Now available: Hot Melt Extrusion Coated Strand. Consult your sales representative for information on load distributive or removable strand anchors.

Please note: As we continuously improve the design of our products, product details are subject to change.

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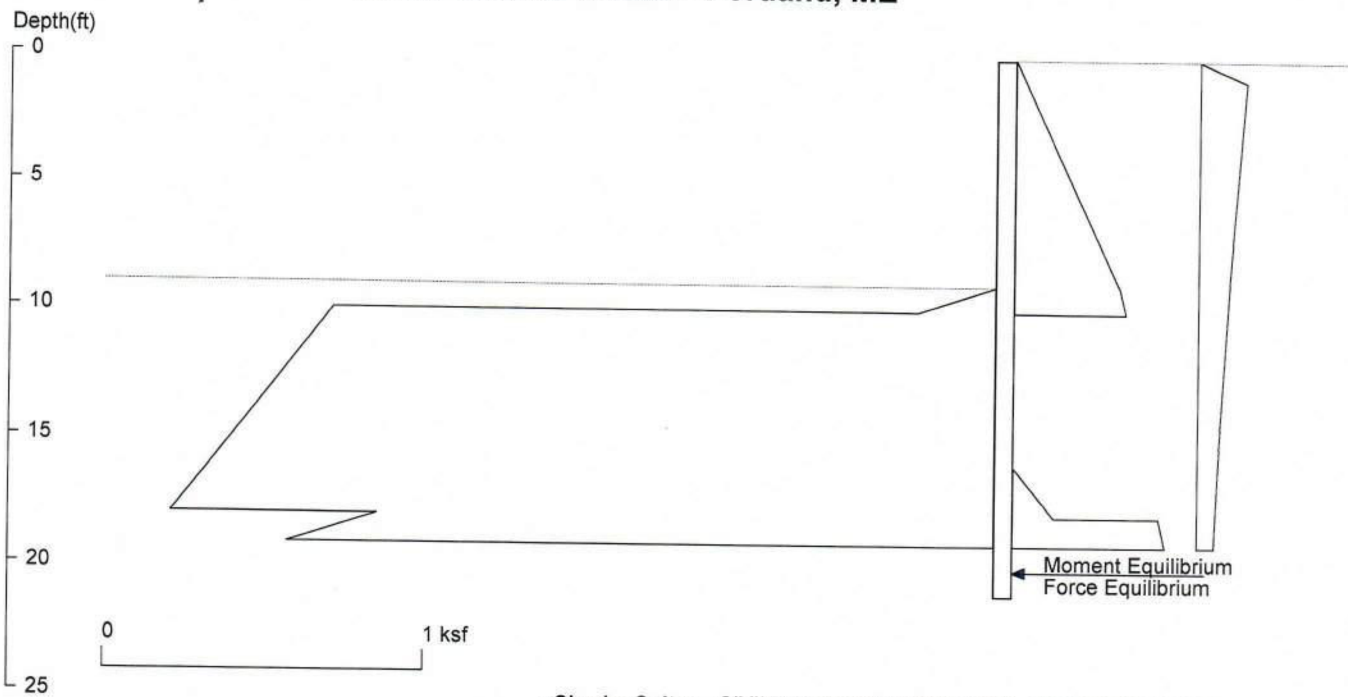
Maine Medical Center - Portland, ME

B1



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Wall Height=9.0 Pile Diameter=1.0 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=10.14 Min. Pile Length=19.14
MOMENT IN PILE: Max. Moment=126.18 per Pile Spacing=8.0 at Depth=13.14

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	9	0.328	0.0364
9	0.328	10	0.347	0.019
16	0	18	0.126	0.063
18	0.452	35	0.775	0.019
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446

B2

13.60	0.073	14.40	0.070	-0.00429
14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
9	0	10	0.239	0.239
10	2.068	18	2.572	0.063
18	1.928	35	6.110	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	9.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	9.00	3.00

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

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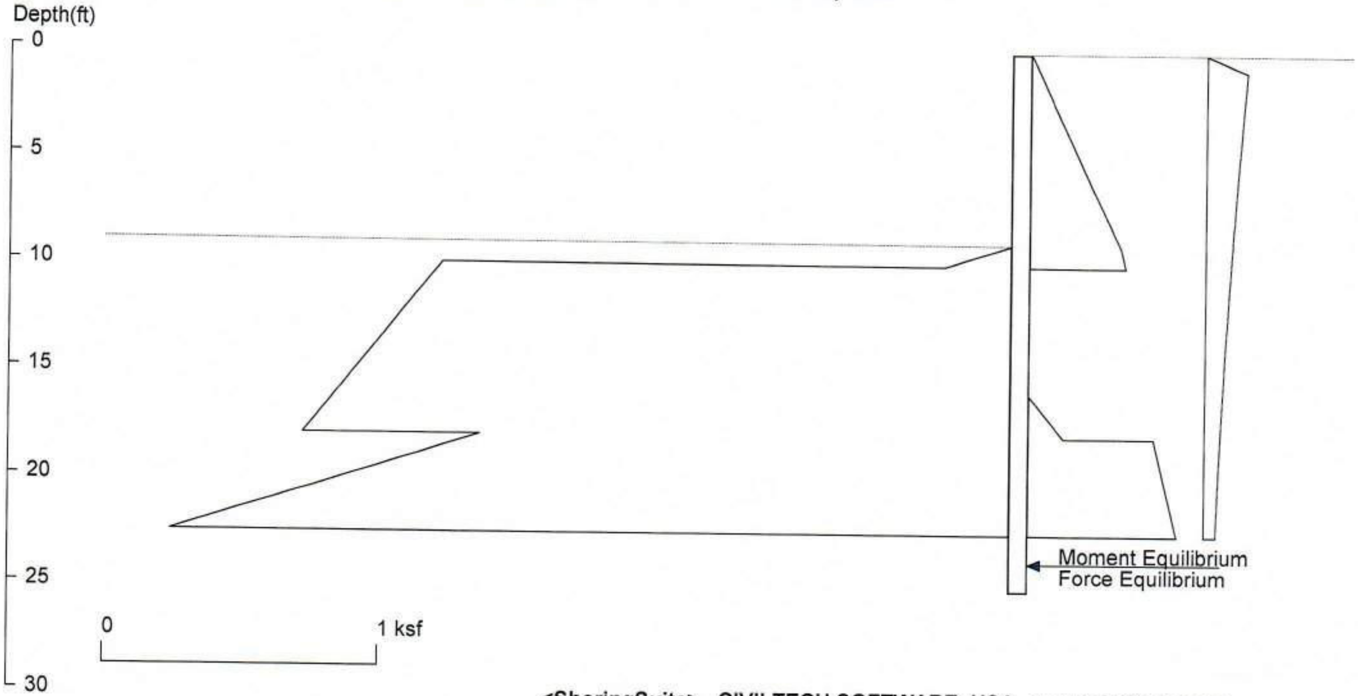
Maine Medical Center - Portland, ME

B3



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Wall Height=9.0 Pile Diameter=1.0 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=13.56 Min. Pile Length=22.56
MOMENT IN PILE: Max. Moment=142.46 per Pile Spacing=8.0 at Depth=14.66

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	9	0.328	0.0364
9	0.328	10	0.347	0.019
16	0	18	0.126	0.063
18	0.452	35	0.775	0.019
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446

B4

13.60	0.073	14.40	0.070	-0.00429
14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276
22.40	0.043	24.00	0.039	-0.00249
24.00	0.039	25.60	0.035	-0.00224

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
9	0	10	0.239	0.239
10	2.068	18	2.572	0.063
18	1.928	35	6.110	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	9.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	9.00	3.00

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

Southwest Corner SOE
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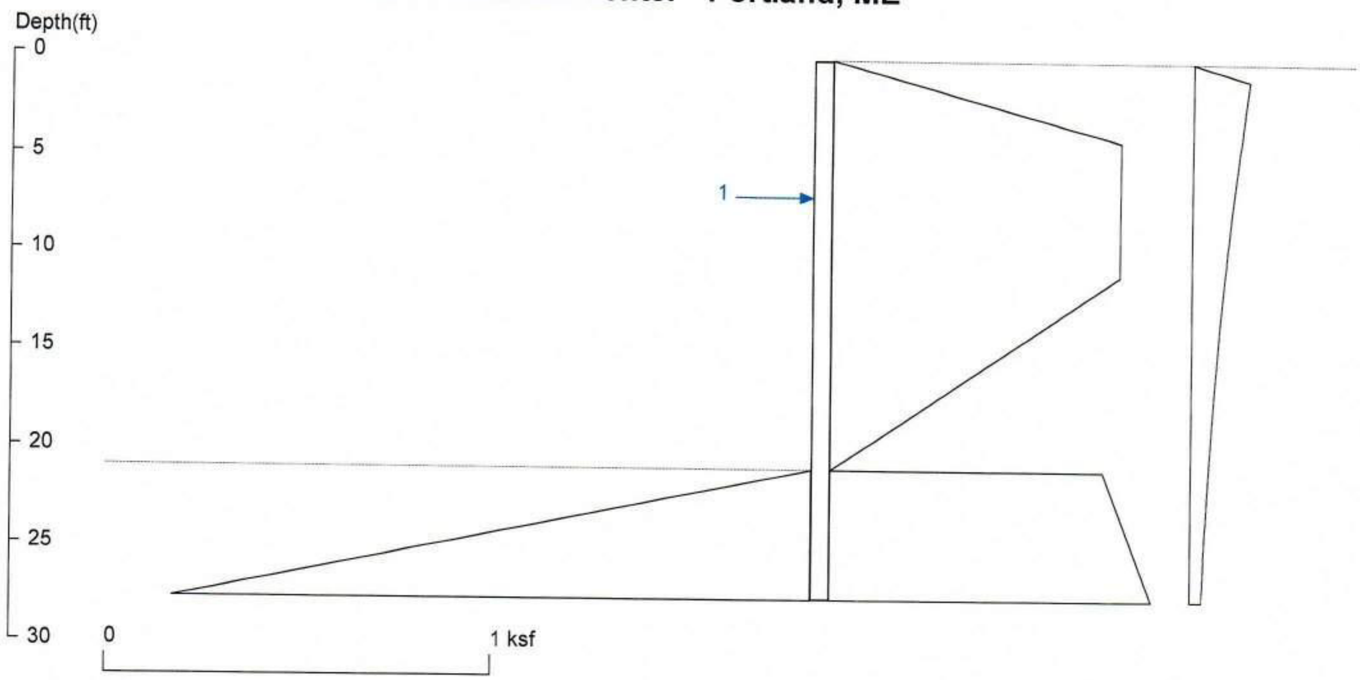
B5



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File: C:\Shoring8\Ework\2020\20090 H21b.sh8

Wall Height=21.0 Pile Diameter=1.0 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=6.73 Min. Pile Length=27.73
MOMENT IN PILE: Max. Moment=101.43 per Pile Spacing=8.0 at Depth=7.00

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

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	7.0	0.0	1.0	10.9	10.9	0.0	0.0	0.0

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
*	Soil	Load	*	
0	0	4	0.745	0.186250
4	0.745	11	0.745	0.000000
11	0.745	21	0	-0.07450
21	0.703	35	0.969	0.019
*	Surch	arge	*	
0.000	0.000	0.850	0.145	0.170108
0.850	0.145	1.700	0.139	-0.00634
1.700	0.139	2.550	0.134	-0.00630
2.550	0.134	3.400	0.129	-0.00624
3.400	0.129	4.250	0.123	-0.00616
4.250	0.123	5.100	0.118	-0.00606
5.100	0.118	5.950	0.113	-0.00595
5.950	0.113	6.800	0.108	-0.00582
6.800	0.108	7.650	0.103	-0.00568
7.650	0.103	8.500	0.099	-0.00553
8.500	0.099	9.350	0.094	-0.00537
9.350	0.094	10.20	0.090	-0.00520

B6

10.20	0.090	11.05	0.085	-0.00502
11.05	0.085	11.90	0.081	-0.00484
11.90	0.081	12.75	0.077	-0.00466
12.75	0.077	13.60	0.073	-0.00447
13.60	0.073	14.45	0.070	-0.00428
14.45	0.070	15.30	0.066	-0.00410
15.30	0.066	16.15	0.063	-0.00391
16.15	0.063	17.00	0.060	-0.00373
17.00	0.060	18.70	0.054	-0.00347
18.70	0.054	20.40	0.049	-0.00313
20.40	0.049	22.10	0.044	-0.00282
22.10	0.044	23.80	0.039	-0.00253
23.80	0.039	25.50	0.036	-0.00227
25.50	0.036	27.20	0.032	-0.00203
27.20	0.032	28.90	0.029	-0.00181

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
21	0	35	3.444	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	21.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	21.00	3.00

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

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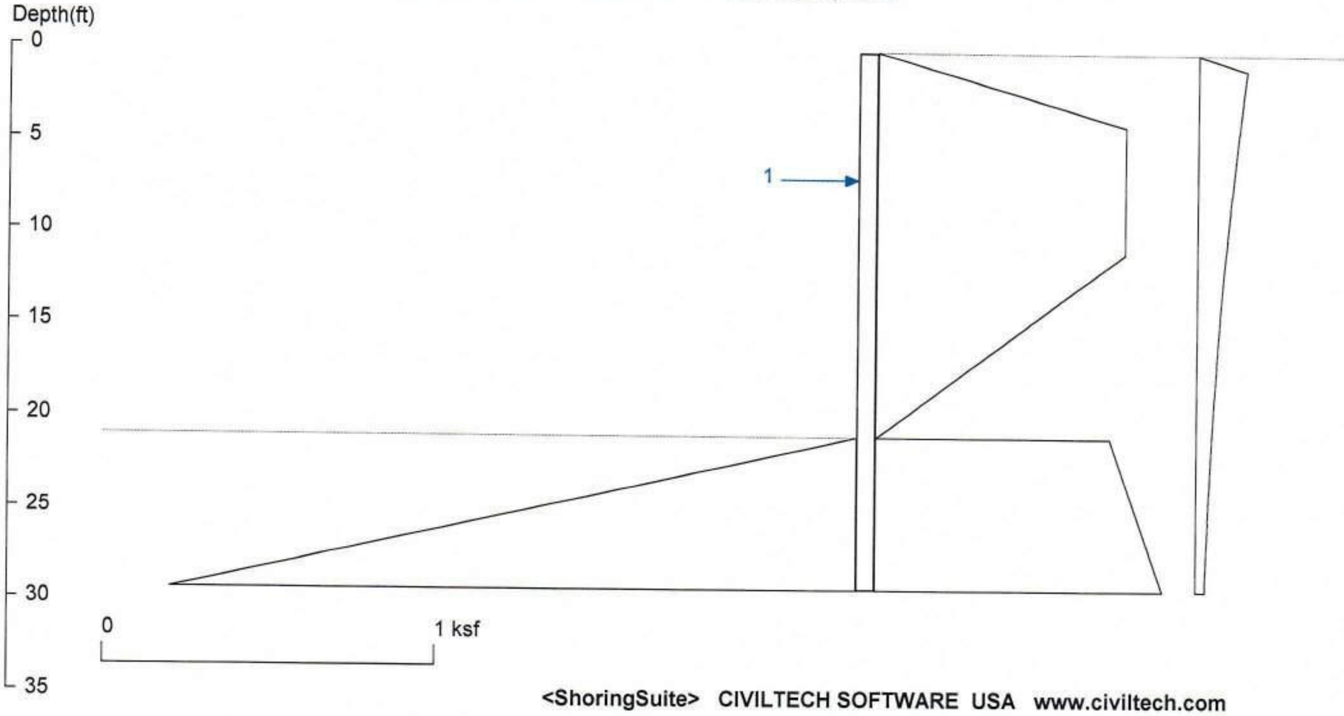
B7



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Wall Height=21.0 Pile Diameter=1.0 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=8.40 Min. Pile Length=29.40
MOMENT IN PILE: Max. Moment=102.49 per Pile Spacing=8.0 at Depth=15.77

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

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	7.0	0.0	1.0	11.0	11.0	0.0	0.0	0.0

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
*	Soil	Load	*	
0	0	4	0.745	0.186250
4	0.745	11	0.745	0.000000
11	0.745	21	0	-0.07450
21	0.703	35	0.969	0.019
*	Surch	arge	*	
0.000	0.000	0.850	0.145	0.170108
0.850	0.145	1.700	0.139	-0.00634
1.700	0.139	2.550	0.134	-0.00630
2.550	0.134	3.400	0.129	-0.00624
3.400	0.129	4.250	0.123	-0.00616
4.250	0.123	5.100	0.118	-0.00606
5.100	0.118	5.950	0.113	-0.00595
5.950	0.113	6.800	0.108	-0.00582
6.800	0.108	7.650	0.103	-0.00568
7.650	0.103	8.500	0.099	-0.00553
8.500	0.099	9.350	0.094	-0.00537
9.350	0.094	10.20	0.090	-0.00520

10.20	0.090	11.05	0.085	-0.00502
11.05	0.085	11.90	0.081	-0.00484
11.90	0.081	12.75	0.077	-0.00466
12.75	0.077	13.60	0.073	-0.00447
13.60	0.073	14.45	0.070	-0.00428
14.45	0.070	15.30	0.066	-0.00410
15.30	0.066	16.15	0.063	-0.00391
16.15	0.063	17.00	0.060	-0.00373
17.00	0.060	18.70	0.054	-0.00347
18.70	0.054	20.40	0.049	-0.00313
20.40	0.049	22.10	0.044	-0.00282
22.10	0.044	23.80	0.039	-0.00253
23.80	0.039	25.50	0.036	-0.00227
25.50	0.036	27.20	0.032	-0.00203
27.20	0.032	28.90	0.029	-0.00181
28.90	0.029	30.60	0.026	-0.00161

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
21	0	35	3.444	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	21.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	21.00	3.00

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

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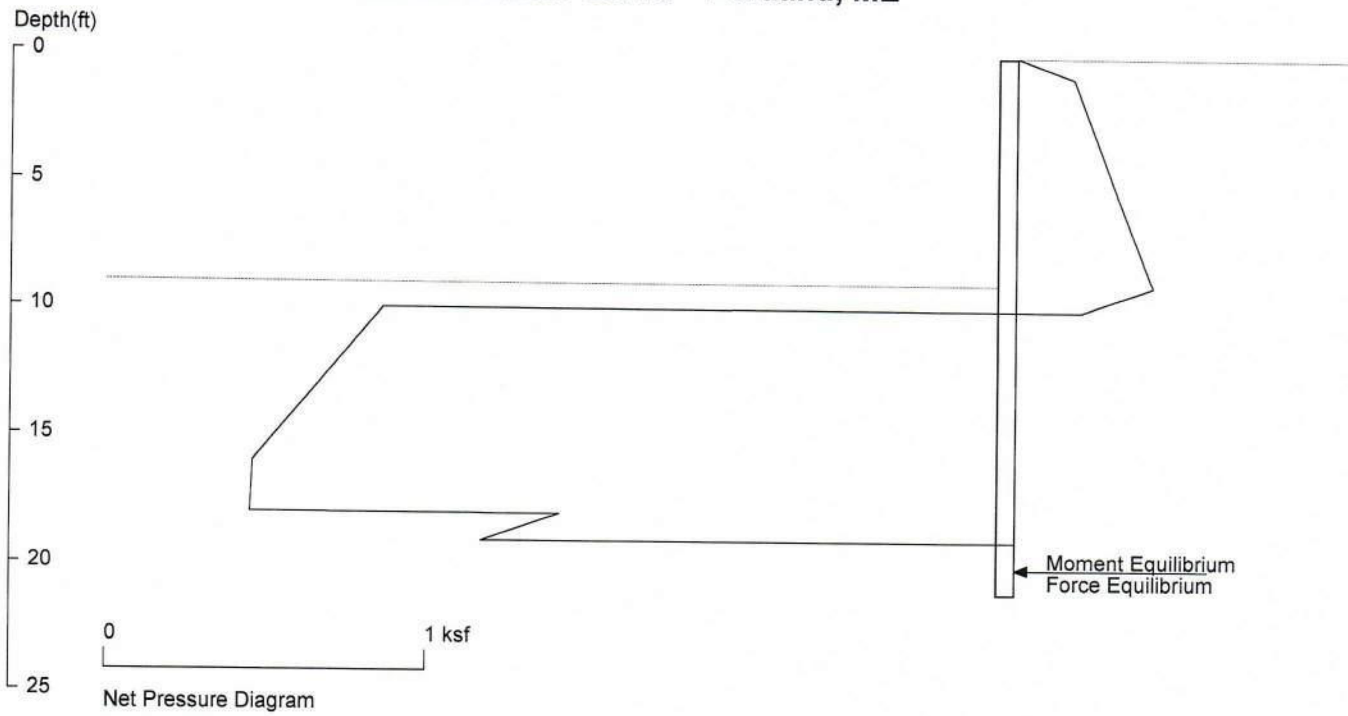

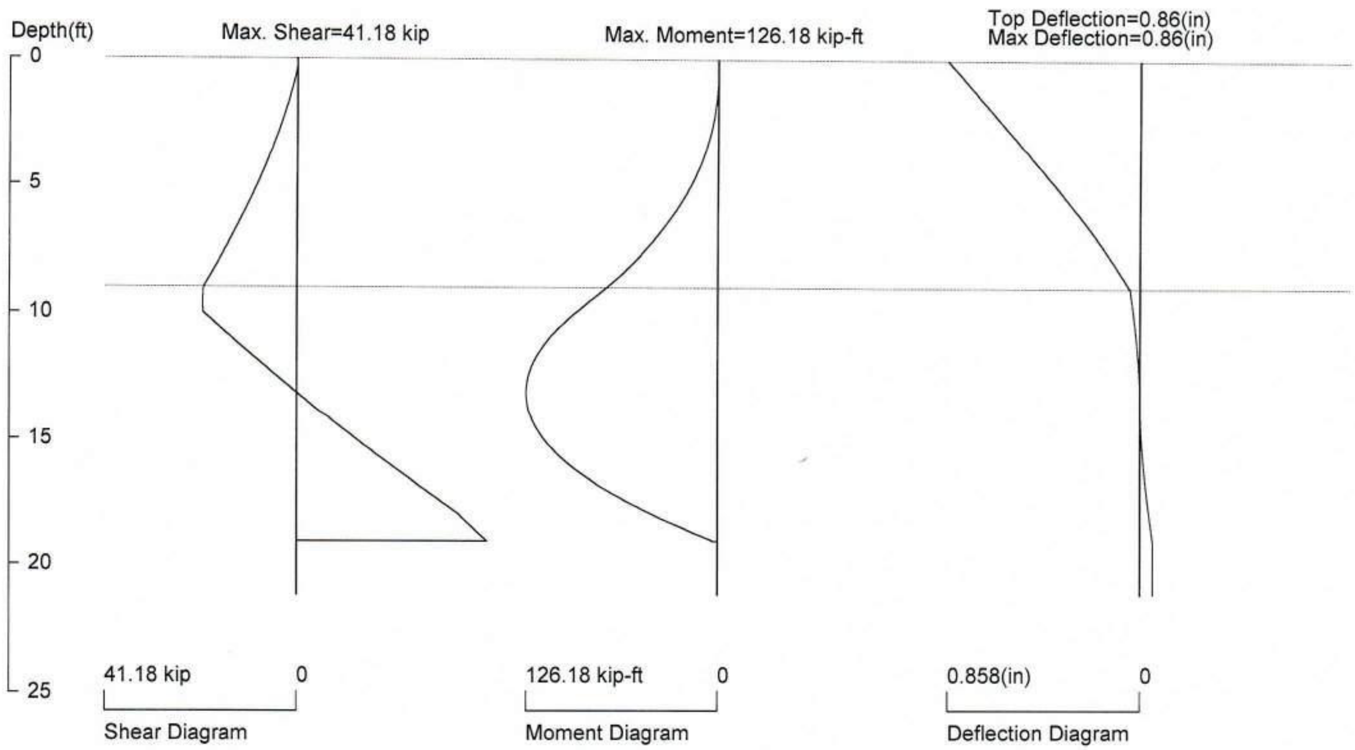

PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 8.0 foot or meter

User Input Pile, HP12x53: E (ksi)=29000.0, I (in4)/pile=393.0

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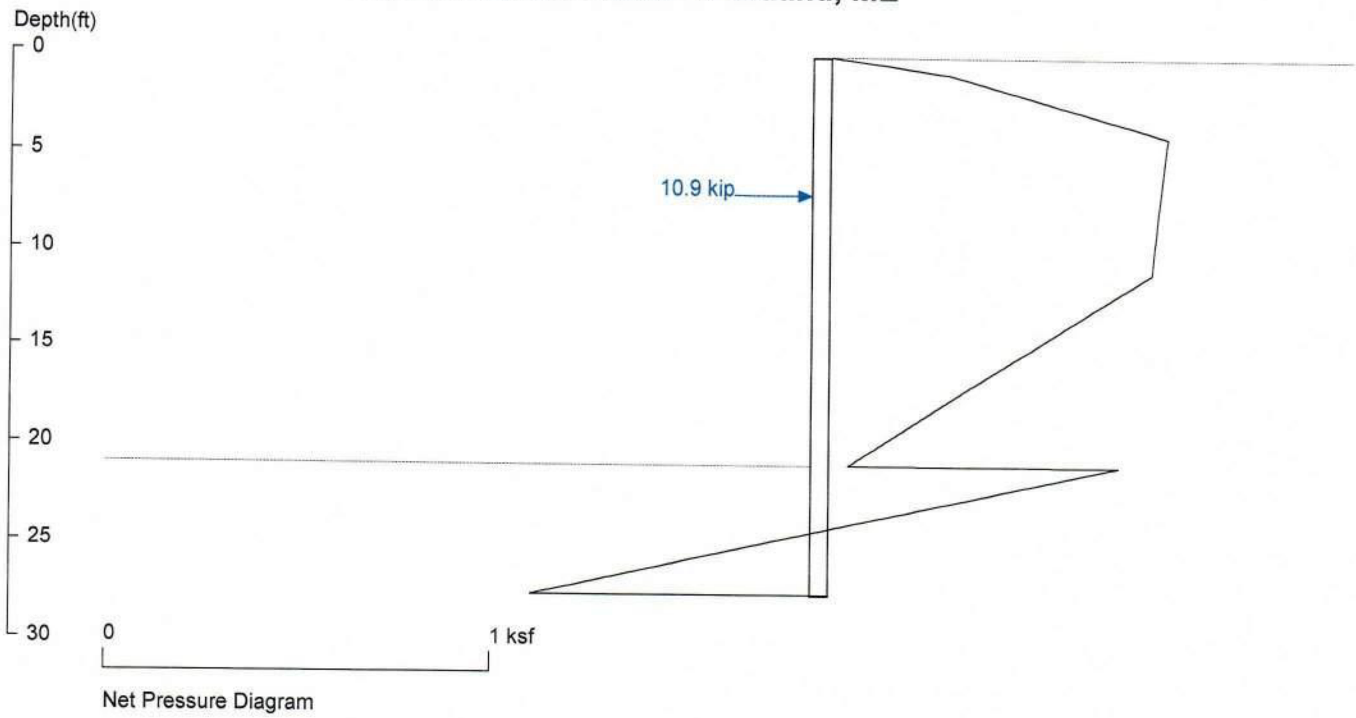
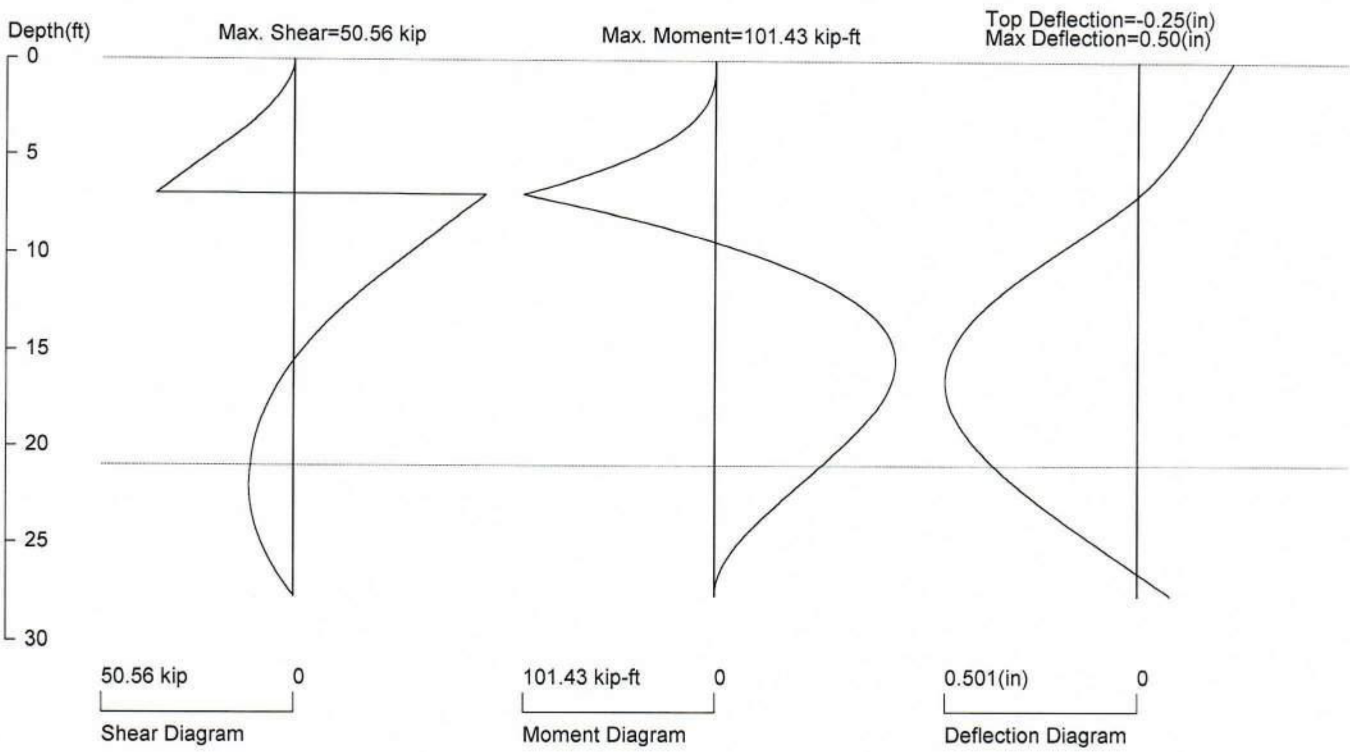
B10





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 8.0 foot or meter

User Input Pile, HP12x53: E (ksi)=29000.0, I (in4)/pile=393.0

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Southwest Corner SOE

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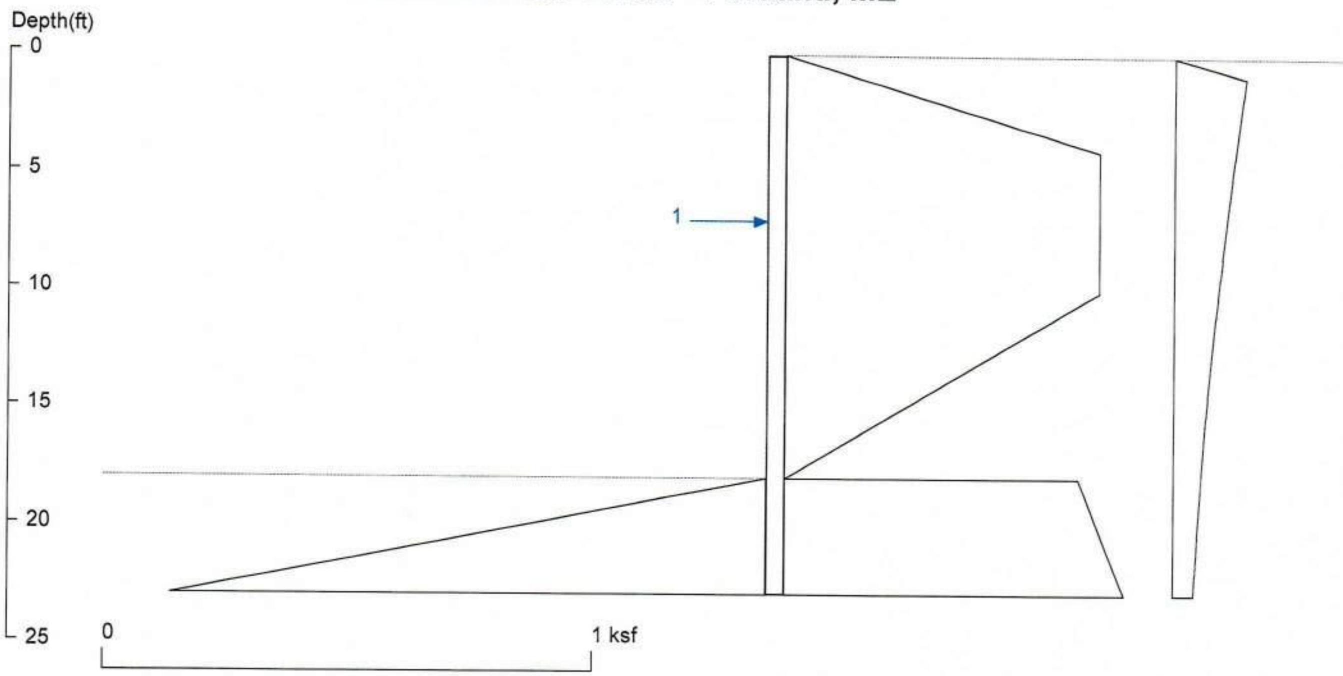
C1



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Wall Height=18.0 Pile Diameter=1.0 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=4.95 (5~10ft is recommended!!!) Min. Pile Length=22.95
MOMENT IN PILE: Max. Moment=90.29 per Pile Spacing=8.0 at Depth=7.00

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

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	7.0	0.0	1.0	8.7	8.7	0.0	0.0	0.0

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
*	Soil	Load	*	
0	0	4	0.639	0.159750
4	0.639	10	0.639	0.000000
10	0.639	18	0	-0.079875
18	0.598	35	0.921	0.019
*	Surch	arge	*	
0.000	0.000	0.850	0.145	0.170108
0.850	0.145	1.700	0.139	-0.00634
1.700	0.139	2.550	0.134	-0.00630
2.550	0.134	3.400	0.129	-0.00624
3.400	0.129	4.250	0.123	-0.00616
4.250	0.123	5.100	0.118	-0.00606
5.100	0.118	5.950	0.113	-0.00595
5.950	0.113	6.800	0.108	-0.00582
6.800	0.108	7.650	0.103	-0.00568
7.650	0.103	8.500	0.099	-0.00553
8.500	0.099	9.350	0.094	-0.00537
9.350	0.094	10.20	0.090	-0.00520

C2

10.20	0.090	11.05	0.085	-0.00502
11.05	0.085	11.90	0.081	-0.00484
11.90	0.081	12.75	0.077	-0.00466
12.75	0.077	13.60	0.073	-0.00447
13.60	0.073	14.45	0.070	-0.00428
14.45	0.070	15.30	0.066	-0.00410
15.30	0.066	16.15	0.063	-0.00391
16.15	0.063	17.00	0.060	-0.00373
17.00	0.060	18.70	0.054	-0.00347
18.70	0.054	20.40	0.049	-0.00313
20.40	0.049	22.10	0.044	-0.00282
22.10	0.044	23.80	0.039	-0.00253

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
18	0	35	4.182	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	18.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	18.00	3.00

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

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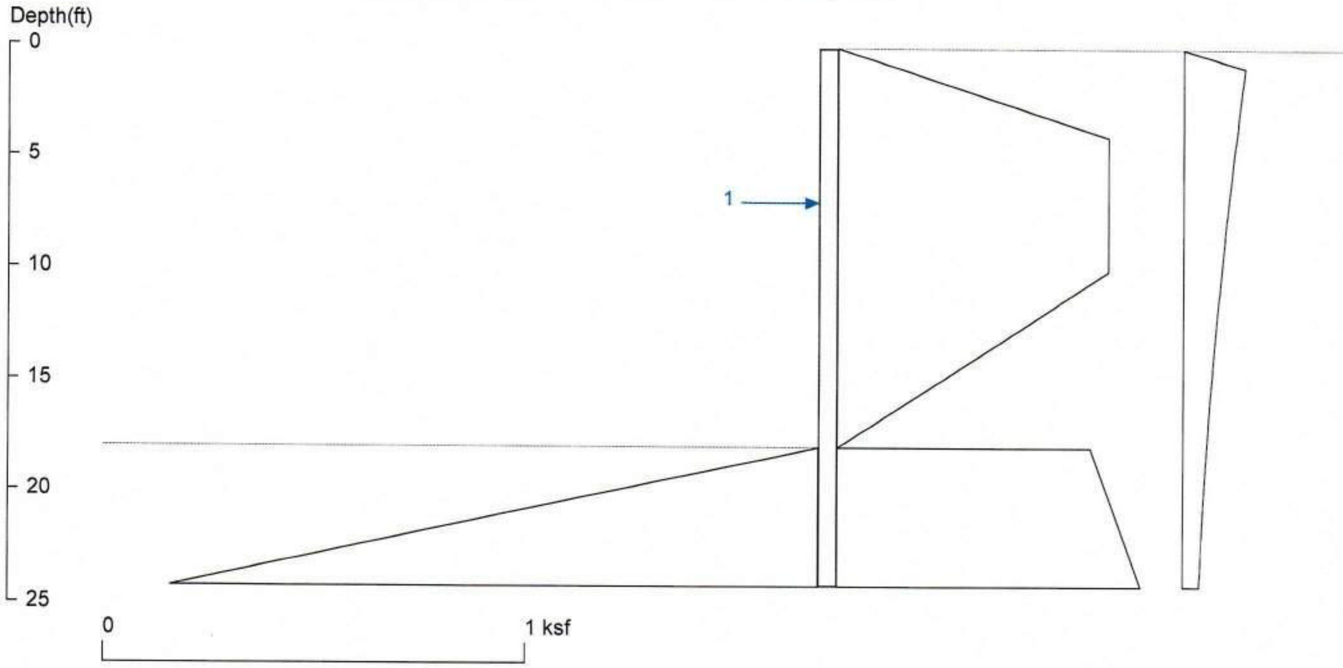
C3



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Wall Height=18.0 Pile Diameter=1.0 Pile Spacing=8.0 Wall Type: 2. Soldier Pile, Drilled

PILE LENGTH: Min. Embedment=6.24 Min. Pile Length=24.24
MOMENT IN PILE: Max. Moment=89.98 per Pile Spacing=8.0 at Depth=7.01

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

No. & Type	Depth	Angle	Space	Total F.	Horiz. F.	Vert. F.	N/A	N/A
1. Strut	7.0	0.0	1.0	8.7	8.7	0.0	0.0	0.0

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
*	Soil	Load	*	
0	0	4	0.639	0.159750
4	0.639	10	0.639	0.000000
10	0.639	18	0	-0.079875
18	0.598	35	0.921	0.019
*	Surch	arge	*	
0.000	0.000	0.850	0.145	0.170108
0.850	0.145	1.700	0.139	-0.00634
1.700	0.139	2.550	0.134	-0.00630
2.550	0.134	3.400	0.129	-0.00624
3.400	0.129	4.250	0.123	-0.00616
4.250	0.123	5.100	0.118	-0.00606
5.100	0.118	5.950	0.113	-0.00595
5.950	0.113	6.800	0.108	-0.00582
6.800	0.108	7.650	0.103	-0.00568
7.650	0.103	8.500	0.099	-0.00553
8.500	0.099	9.350	0.094	-0.00537
9.350	0.094	10.20	0.090	-0.00520

C4

10.20	0.090	11.05	0.085	-0.00502
11.05	0.085	11.90	0.081	-0.00484
11.90	0.081	12.75	0.077	-0.00466
12.75	0.077	13.60	0.073	-0.00447
13.60	0.073	14.45	0.070	-0.00428
14.45	0.070	15.30	0.066	-0.00410
15.30	0.066	16.15	0.063	-0.00391
16.15	0.063	17.00	0.060	-0.00373
17.00	0.060	18.70	0.054	-0.00347
18.70	0.054	20.40	0.049	-0.00313
20.40	0.049	22.10	0.044	-0.00282
22.10	0.044	23.80	0.039	-0.00253
23.80	0.039	25.50	0.036	-0.00227

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
18	0	35	4.182	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	18.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	18.00	3.00

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

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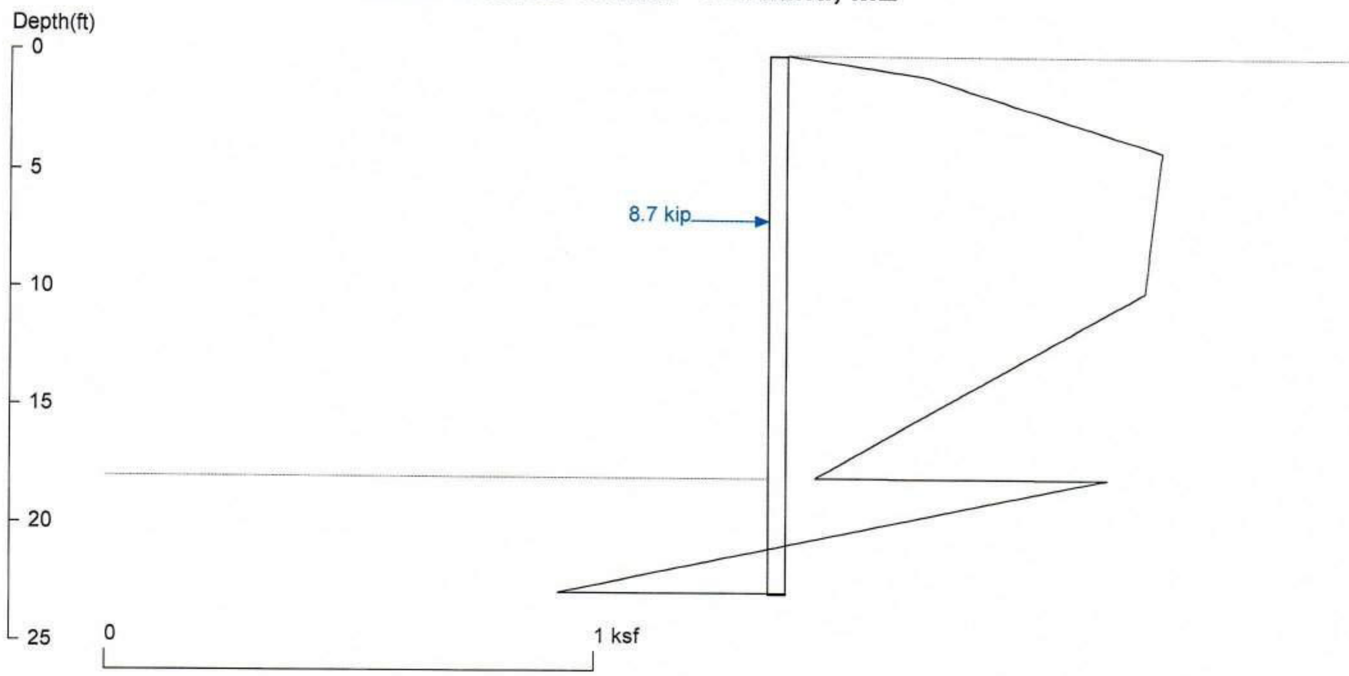
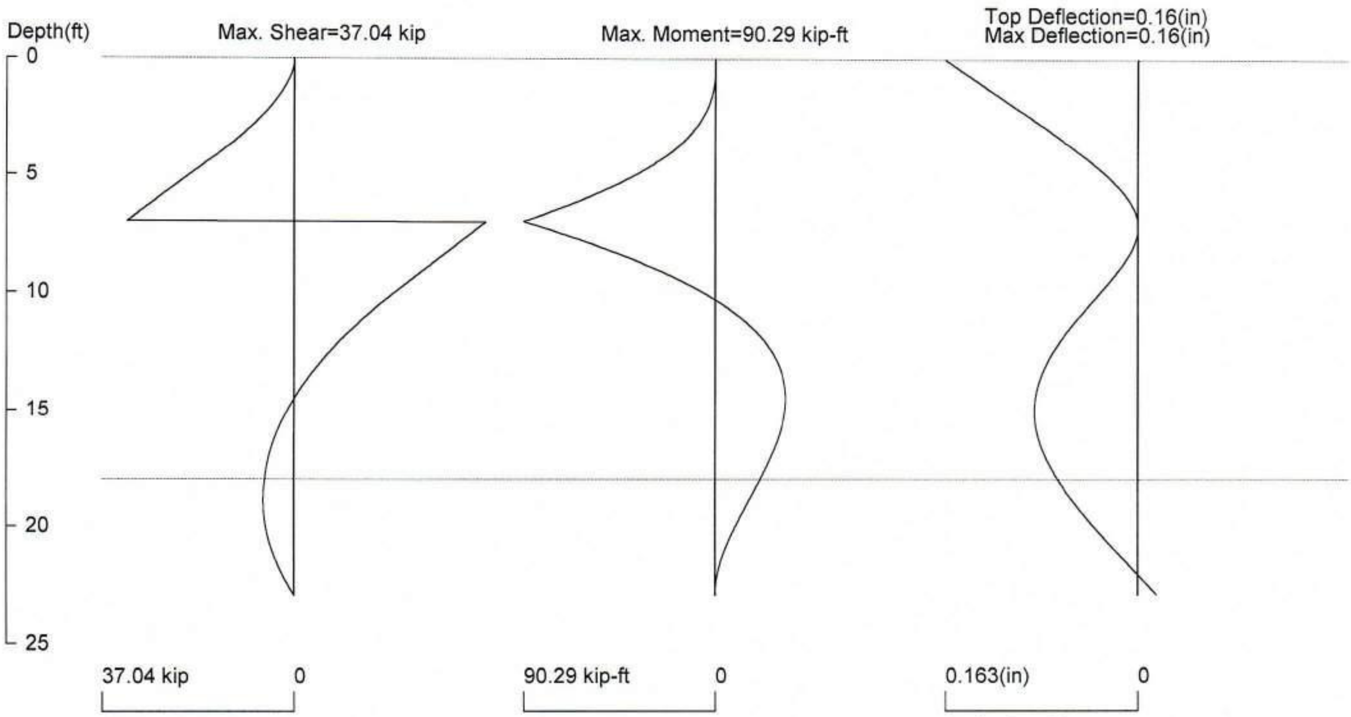
C5



Net Pressure Diagram



Shear Diagram | Moment Diagram | Deflection Diagram

PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 8.0 foot or meter

User Input Pile, HP12x53: E (ksi)=29000.0, I (in4)/pile=393.0

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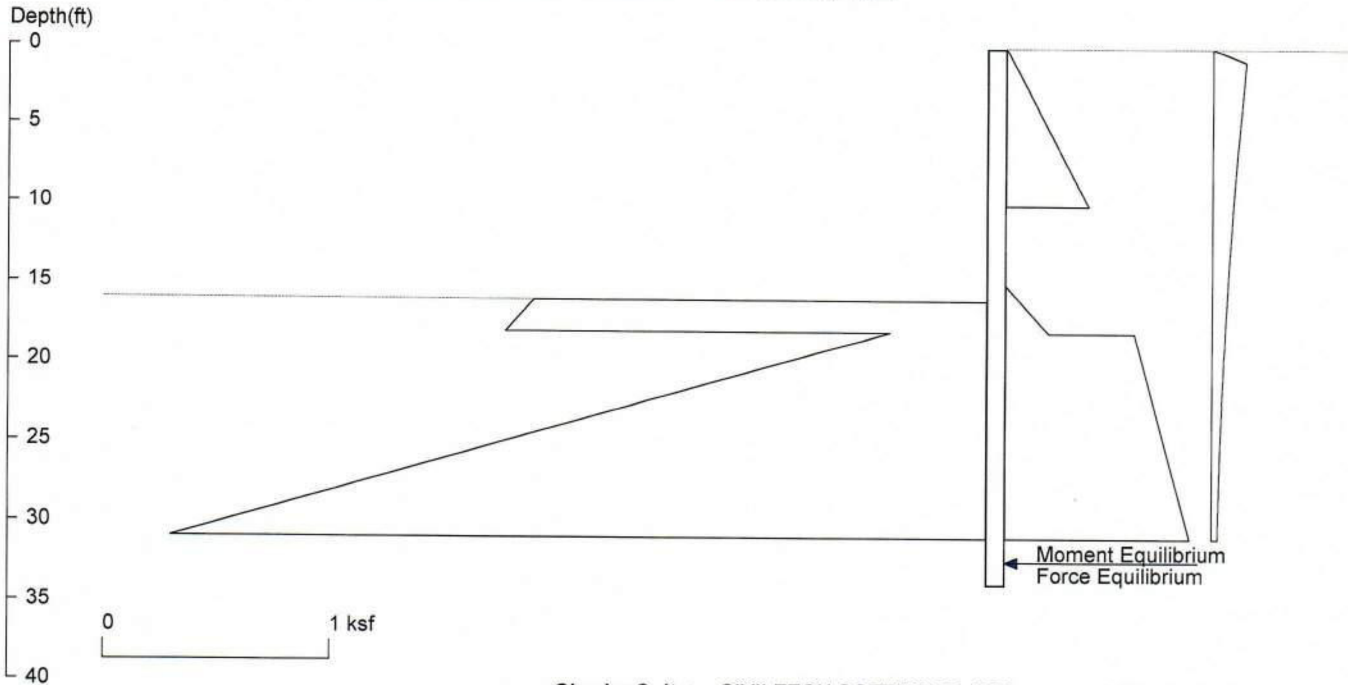
DP



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Wall Height=16.0 Pile Diameter=1.2 Pile Spacing=7.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=14.93 Min. Pile Length=30.93
MOMENT IN PILE: Max. Moment=275.20 per Pile Spacing=7.0 at Depth=21.92

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
15	0	18	0.189	0.063
18	0.566	35	0.889	0.019
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446
13.60	0.073	14.40	0.070	-0.00429

D2

14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276
22.40	0.043	24.00	0.039	-0.00249
24.00	0.039	25.60	0.035	-0.00224
25.60	0.035	27.20	0.032	-0.00202
27.20	0.032	28.80	0.029	-0.00181
28.80	0.029	30.40	0.027	-0.00163
30.40	0.027	32.00	0.024	-0.00147
32.00	0.024	35.20	0.020	-0.00125

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
16	2	18	2.126	0.063
18	0.425	35	4.607	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	7.00
2	16.00	1.20

PASSIVE SPACING:

No.	Z depth	Spacing
1	16.00	3.60

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

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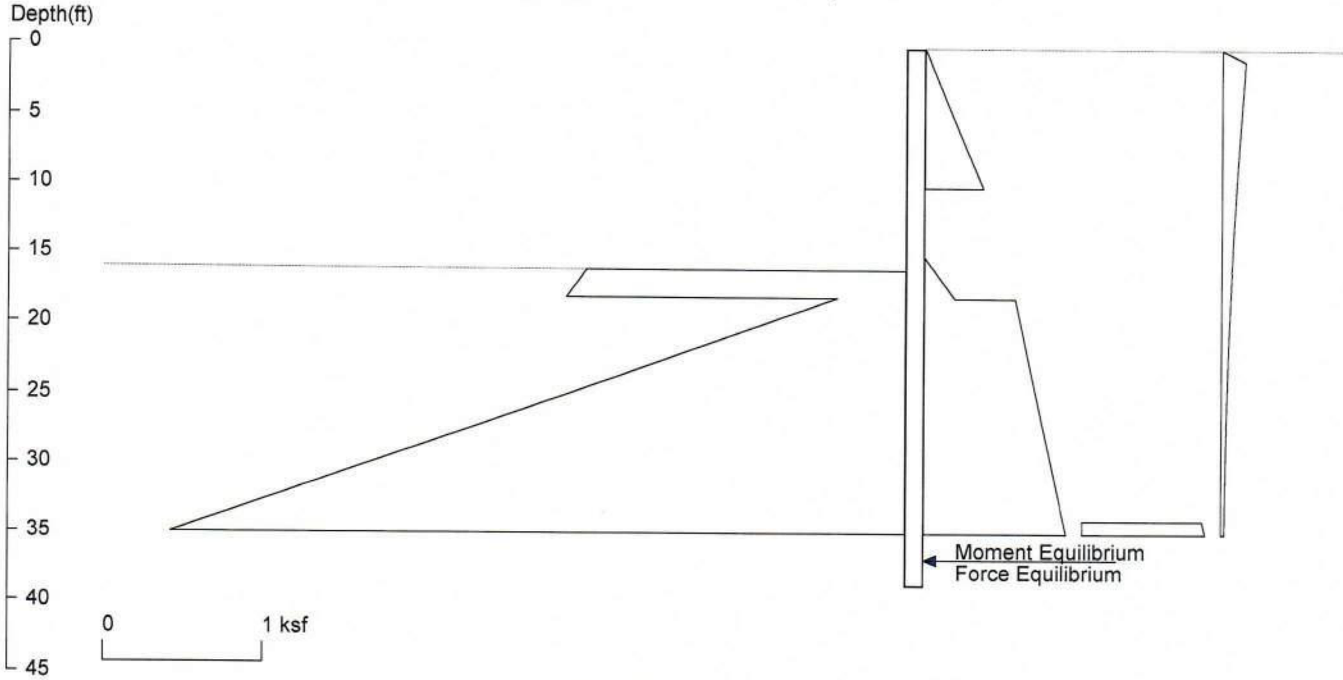
D3



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Wall Height=16.0 Pile Diameter=1.2 Pile Spacing=7.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=18.99 Min. Pile Length=34.99
MOMENT IN PILE: Max. Moment=320.19 per Pile Spacing=7.0 at Depth=24.68

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
15	0	18	0.189	0.063
18	0.566	35	0.889	0.019
34	0.750	60	1.218	0.018
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446

D4

13.60	0.073	14.40	0.070	-0.00429
14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276
22.40	0.043	24.00	0.039	-0.00249
24.00	0.039	25.60	0.035	-0.00224
25.60	0.035	27.20	0.032	-0.00202
27.20	0.032	28.80	0.029	-0.00181
28.80	0.029	30.40	0.027	-0.00163
30.40	0.027	32.00	0.024	-0.00147
32.00	0.024	35.20	0.020	-0.00125
35.20	0.020	38.40	0.017	-0.00101
38.40	0.017	41.60	0.014	-0.00082

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
16	2	18	2.126	0.063
18	0.425	35	4.607	0.246
35	14.54	60	36.64	0.884

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	7.00
2	16.00	1.20

PASSIVE SPACING:

No.	Z depth	Spacing
1	16.00	3.60

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

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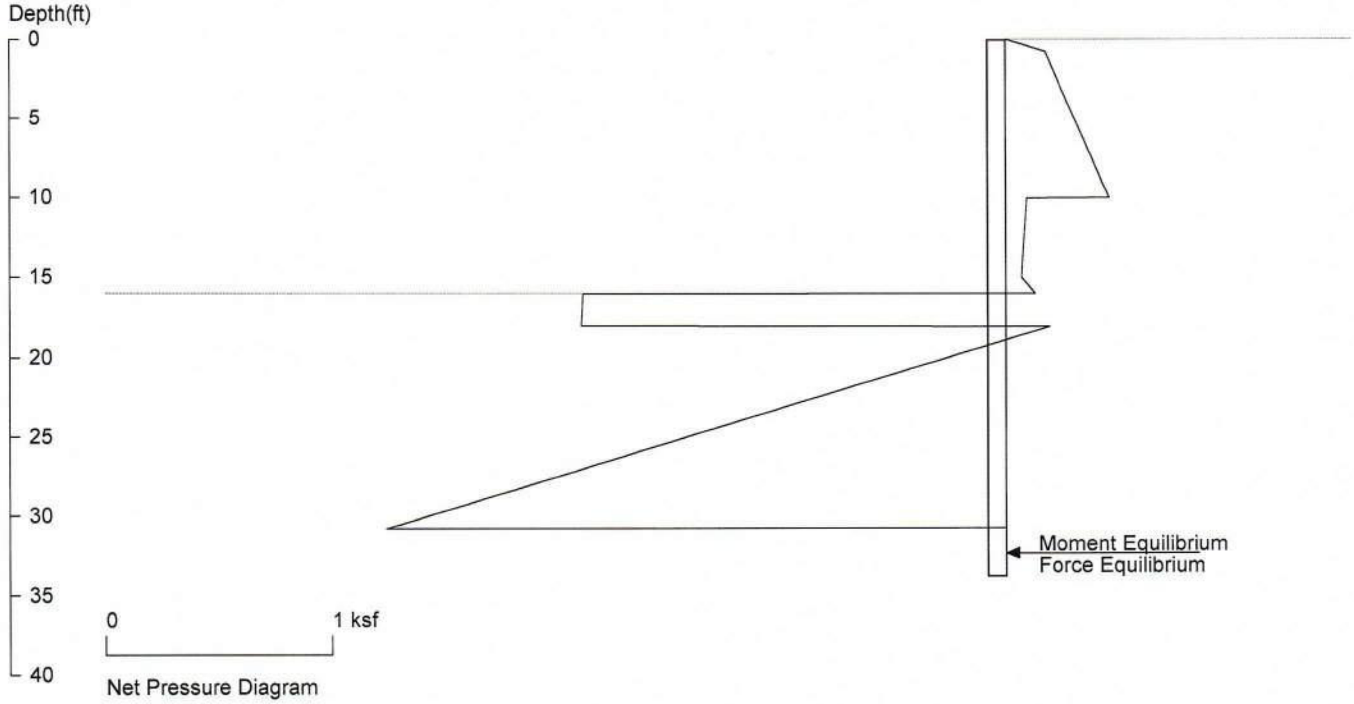
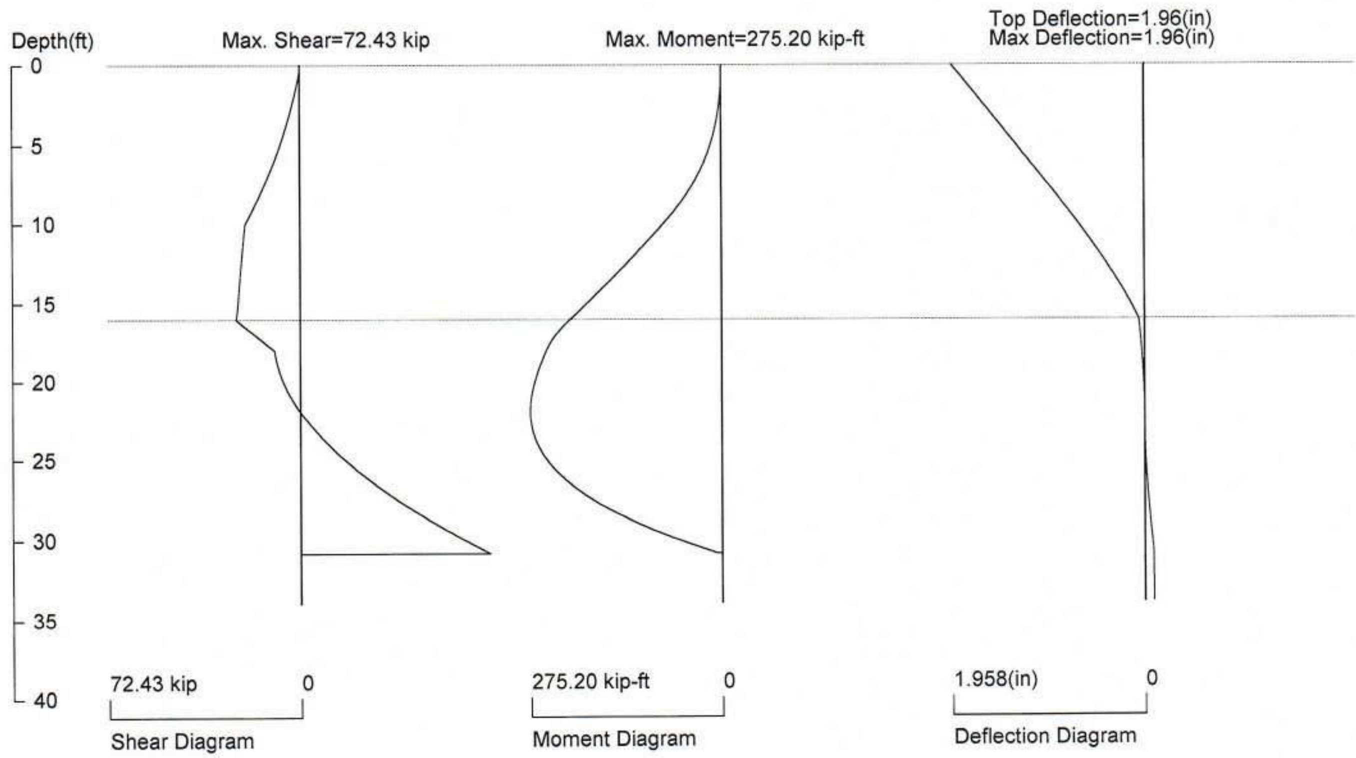
DS





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 7.0 foot or meter

User Input Pile, HP14x117: E (ksi)=29000.0, I (in4)/pile=1220.0

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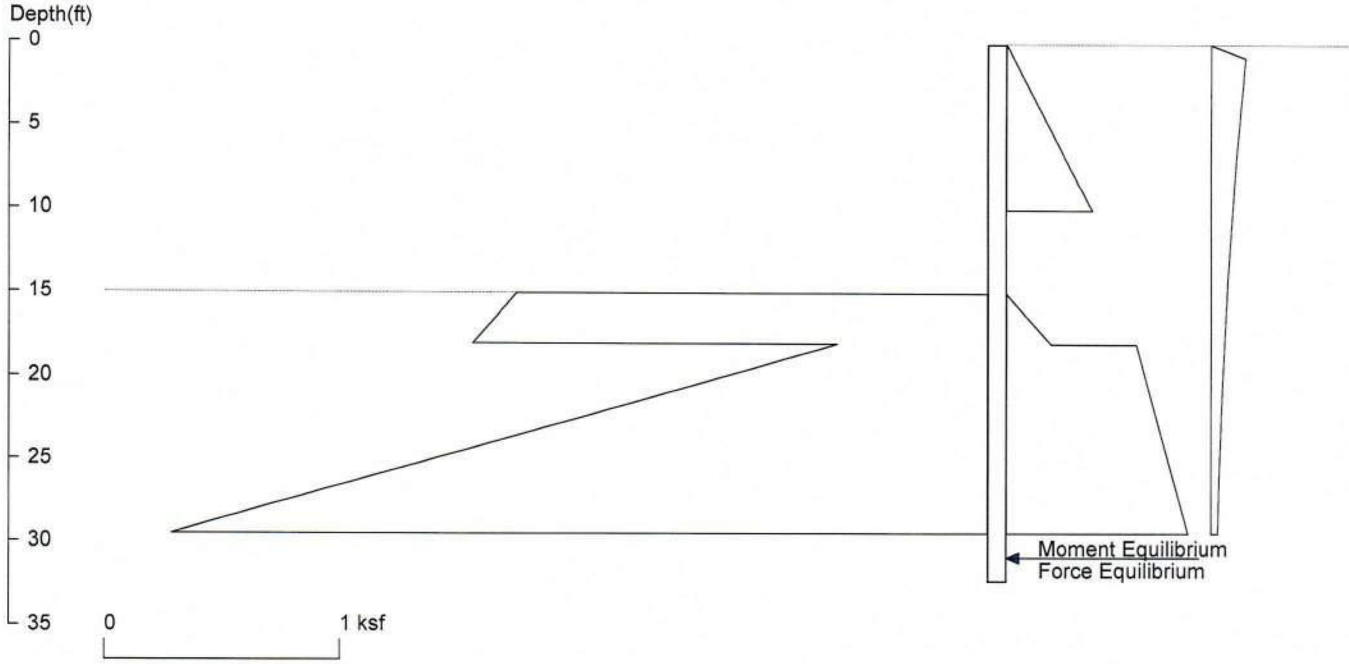
E1



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Wall Height=15.0 Pile Diameter=1.2 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=14.51 Min. Pile Length=29.51
MOMENT IN PILE: Max. Moment=274.72 per Pile Spacing=8.0 at Depth=19.96

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
15	0	18	0.189	0.063
18	0.549	35	0.872	0.019
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446
13.60	0.073	14.40	0.070	-0.00429

E2

14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276
22.40	0.043	24.00	0.039	-0.00249
24.00	0.039	25.60	0.035	-0.00224
25.60	0.035	27.20	0.032	-0.00202
27.20	0.032	28.80	0.029	-0.00181
28.80	0.029	30.40	0.027	-0.00163
30.40	0.027	32.00	0.024	-0.00147
32.00	0.024	35.20	0.020	-0.00125

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
15	2	18	2.189	0.063
18	0.637	35	4.819	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	15.00	1.20

PASSIVE SPACING:

No.	Z depth	Spacing
1	15.00	3.60

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

E3

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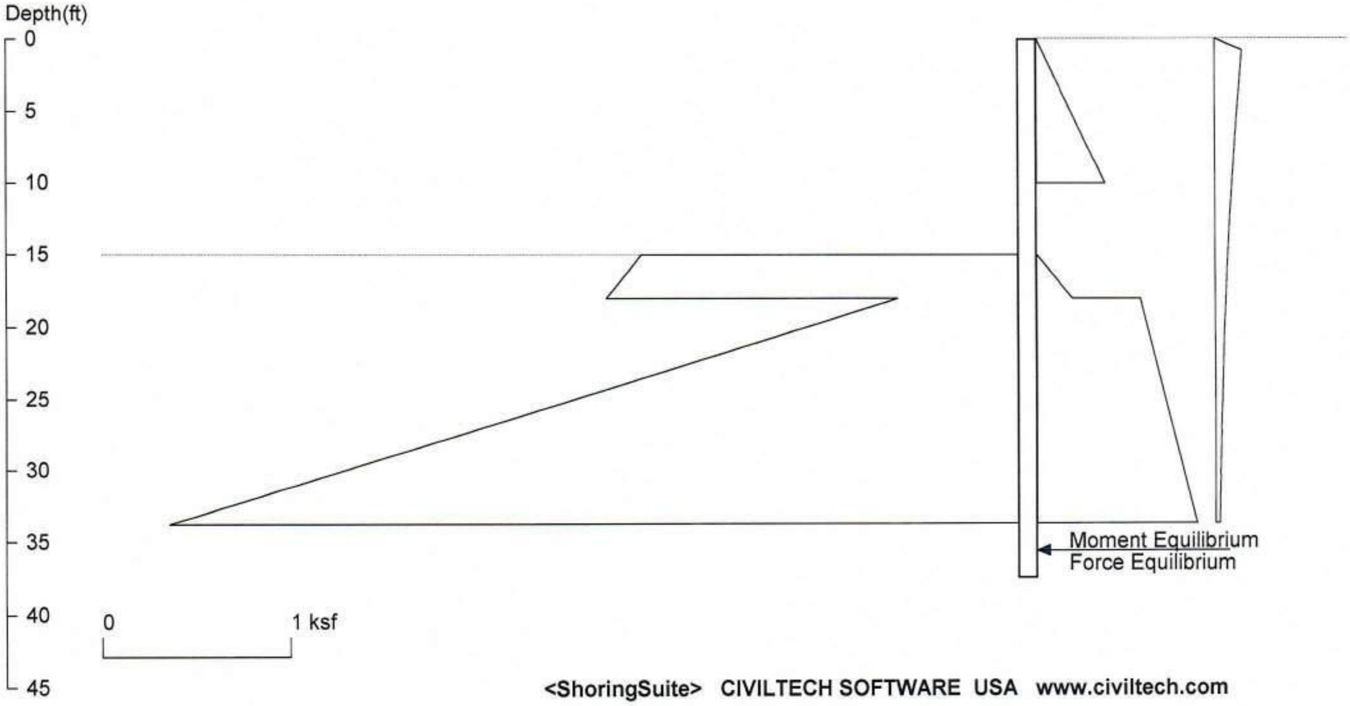

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Wall Height=15.0 Pile Diameter=1.2 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=18.78 Min. Pile Length=33.78
MOMENT IN PILE: Max. Moment=320.23 per Pile Spacing=8.0 at Depth=23.30

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
15	0	18	0.189	0.063
18	0.549	35	0.872	0.019
34	0.736	60	1.204	0.018
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446

E4

13.60	0.073	14.40	0.070	-0.00429
14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276
22.40	0.043	24.00	0.039	-0.00249
24.00	0.039	25.60	0.035	-0.00224
25.60	0.035	27.20	0.032	-0.00202
27.20	0.032	28.80	0.029	-0.00181
28.80	0.029	30.40	0.027	-0.00163
30.40	0.027	32.00	0.024	-0.00147
32.00	0.024	35.20	0.020	-0.00125
35.20	0.020	38.40	0.017	-0.00101

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
15	2	18	2.189	0.063
18	0.637	35	4.819	0.246
35	15.21	60	37.31	0.884

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	15.00	1.20

PASSIVE SPACING:

No.	Z depth	Spacing
1	15.00	3.60

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

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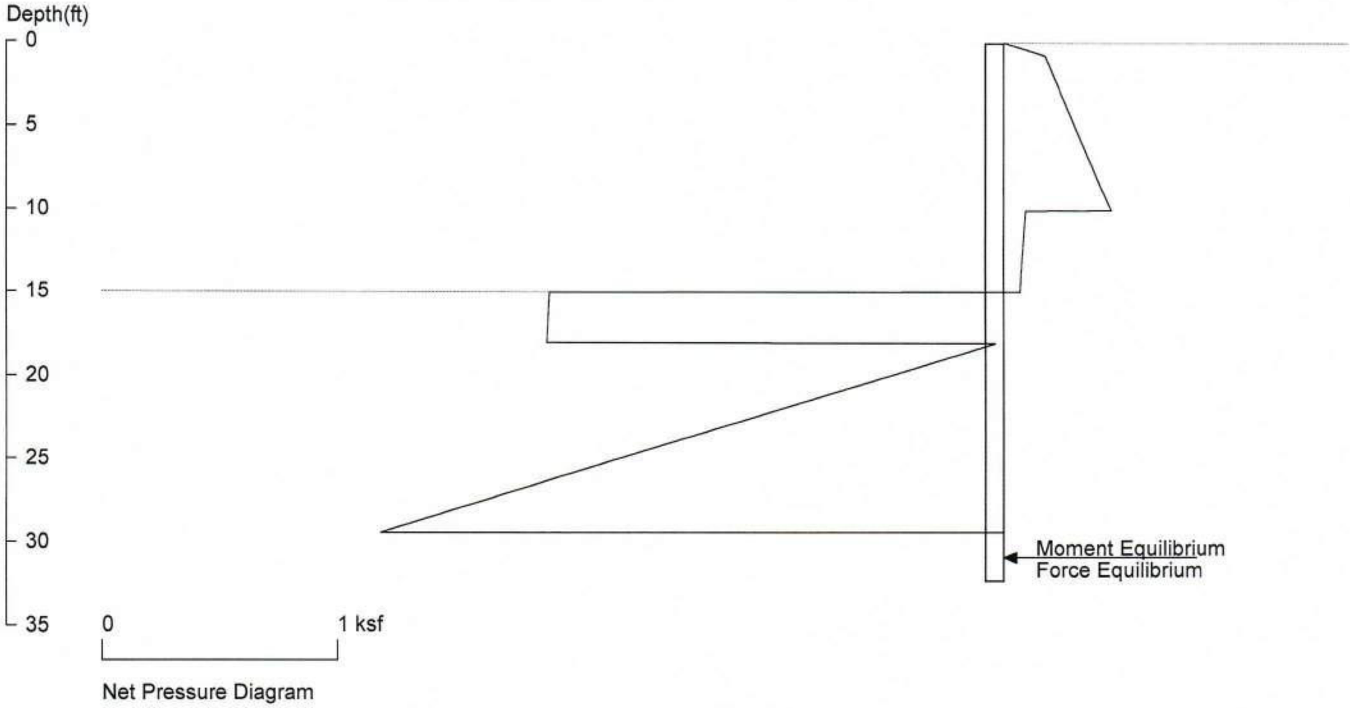

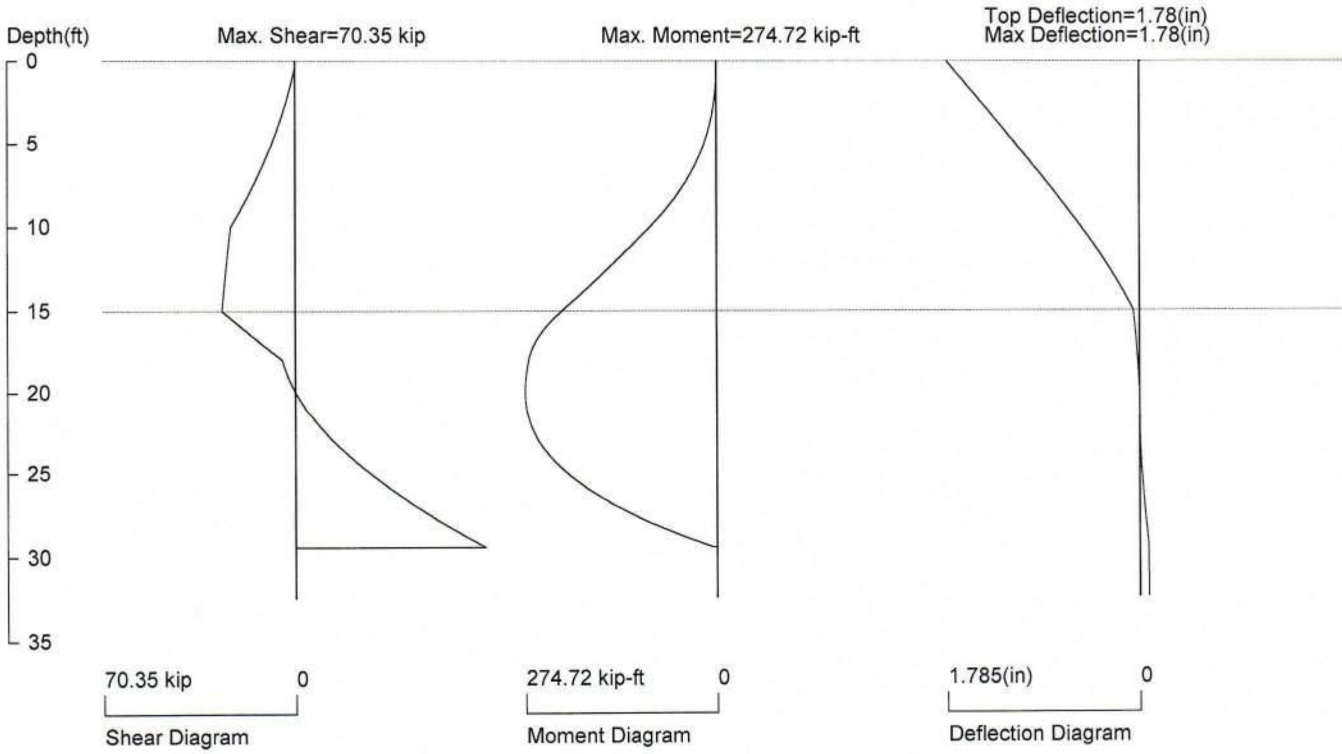

PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 8.0 foot or meter

User Input Pile, HP14x117: E (ksi)=29000.0, I (in4)/pile=1220.0

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F1

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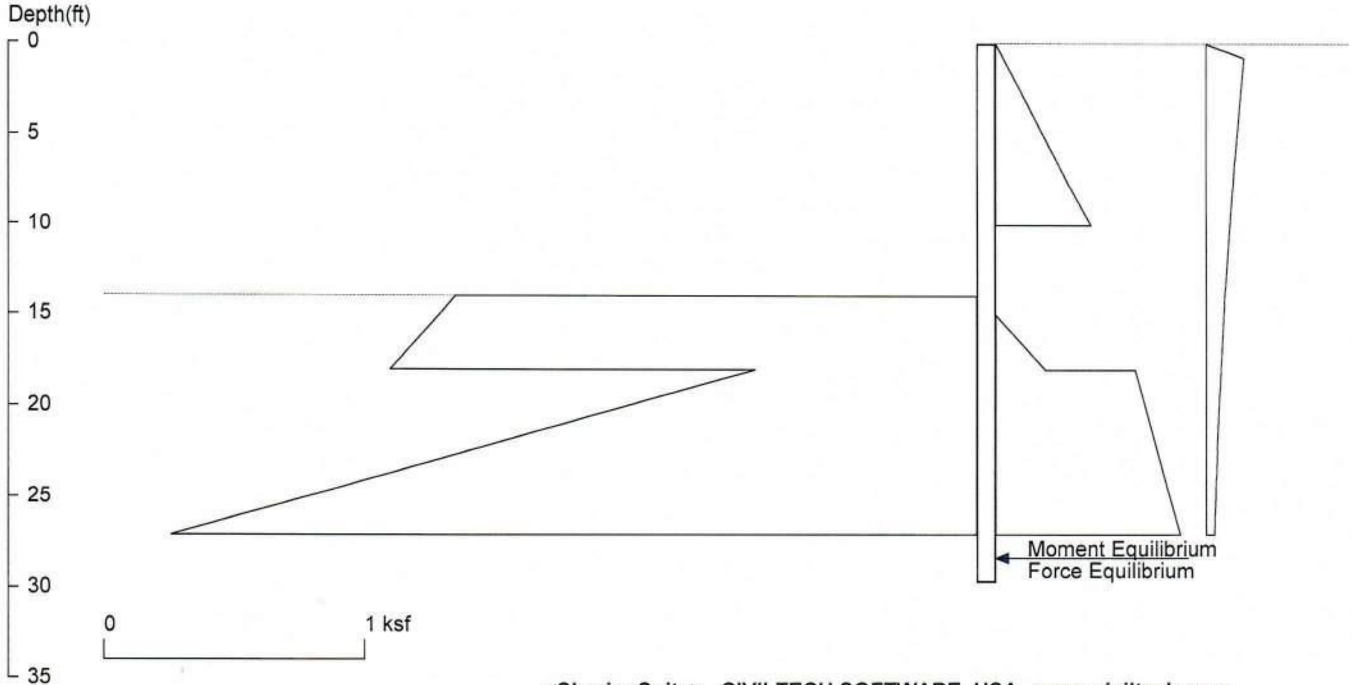

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Wall Height=14.0 Pile Diameter=1.2 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=13.12 Min. Pile Length=27.12
MOMENT IN PILE: Max. Moment=242.22 per Pile Spacing=8.0 at Depth=17.53

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
15	0	18	0.189	0.063
18	0.533	35	0.856	0.019
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446
13.60	0.073	14.40	0.070	-0.00429

F2

14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276
22.40	0.043	24.00	0.039	-0.00249
24.00	0.039	25.60	0.035	-0.00224
25.60	0.035	27.20	0.032	-0.00202
27.20	0.032	28.80	0.029	-0.00181
28.80	0.029	30.40	0.027	-0.00163

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
14	2	18	2.252	0.063
18	0.849	35	5.031	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	14.00	1.20

PASSIVE SPACING:

No.	Z depth	Spacing
1	14.00	3.60

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

F3

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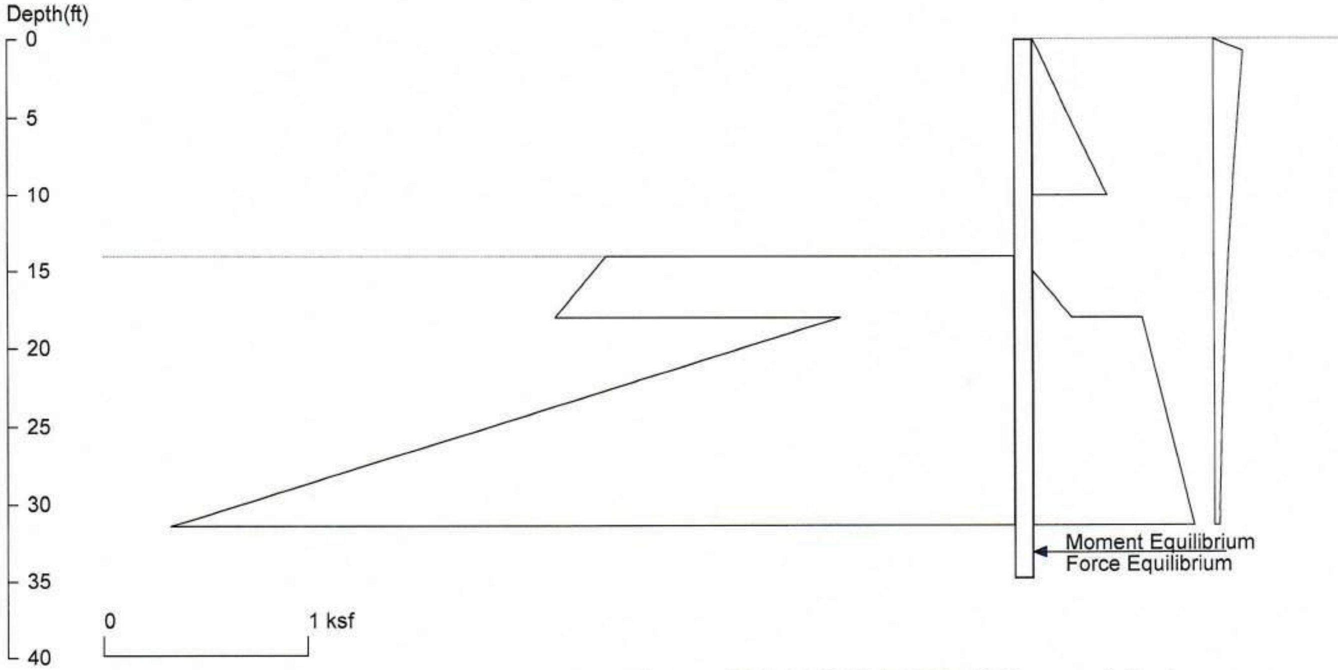

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Wall Height=14.0 Pile Diameter=1.2 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=17.39 Min. Pile Length=31.39
MOMENT IN PILE: Max. Moment=272.14 per Pile Spacing=8.0 at Depth=20.95

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
15	0	18	0.189	0.063
18	0.533	35	0.856	0.019
34	0.723	60	1.191	0.018
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446

F4

13.60	0.073	14.40	0.070	-0.00429
14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276
22.40	0.043	24.00	0.039	-0.00249
24.00	0.039	25.60	0.035	-0.00224
25.60	0.035	27.20	0.032	-0.00202
27.20	0.032	28.80	0.029	-0.00181
28.80	0.029	30.40	0.027	-0.00163
30.40	0.027	32.00	0.024	-0.00147
32.00	0.024	35.20	0.020	-0.00125

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
14	2	18	2.252	0.063
18	0.849	35	5.031	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	14.00	1.20

PASSIVE SPACING:

No.	Z depth	Spacing
1	14.00	3.60

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

F5

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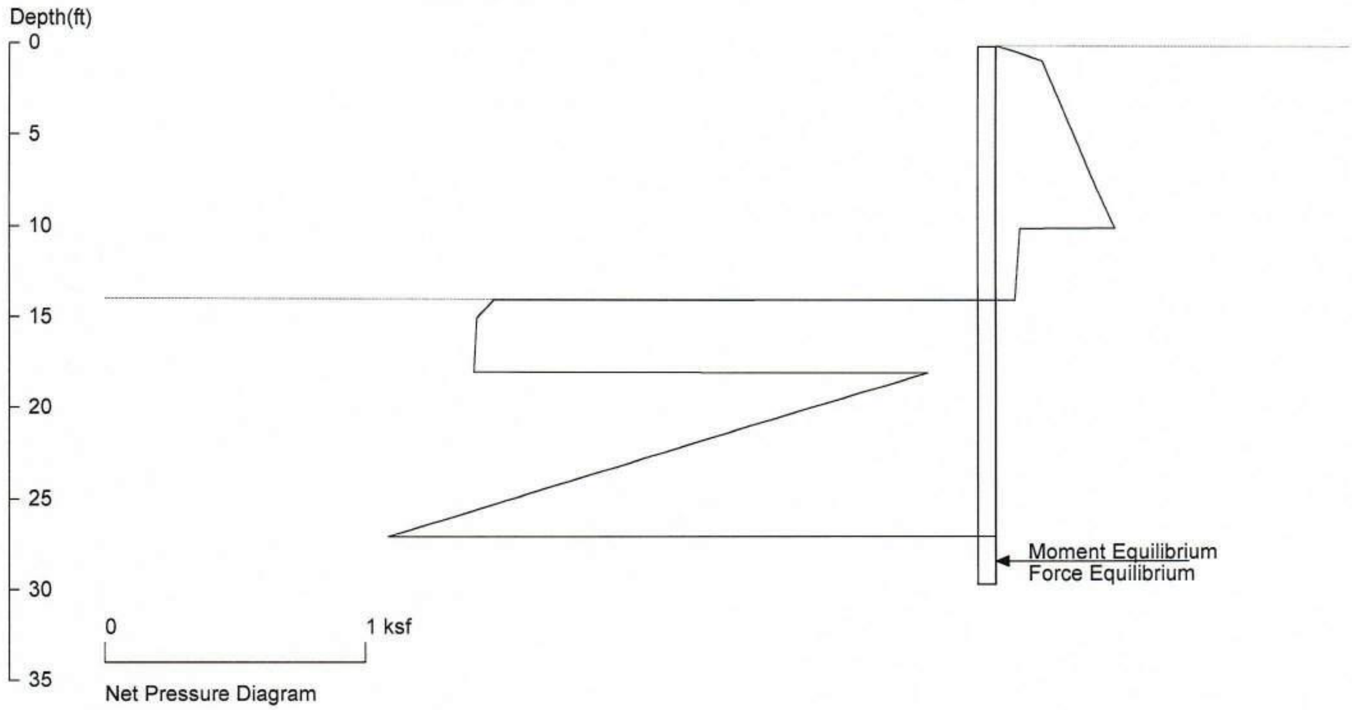

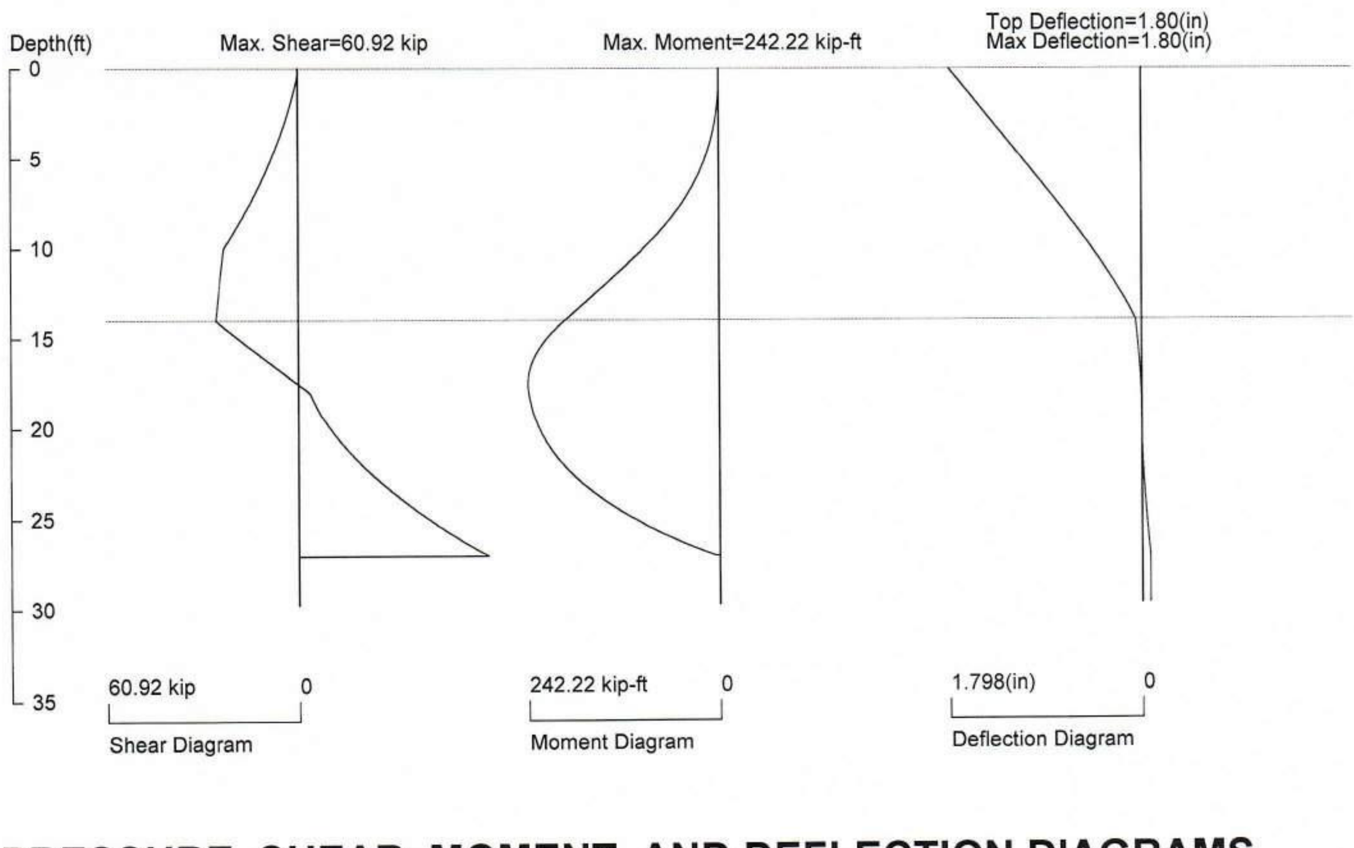

PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

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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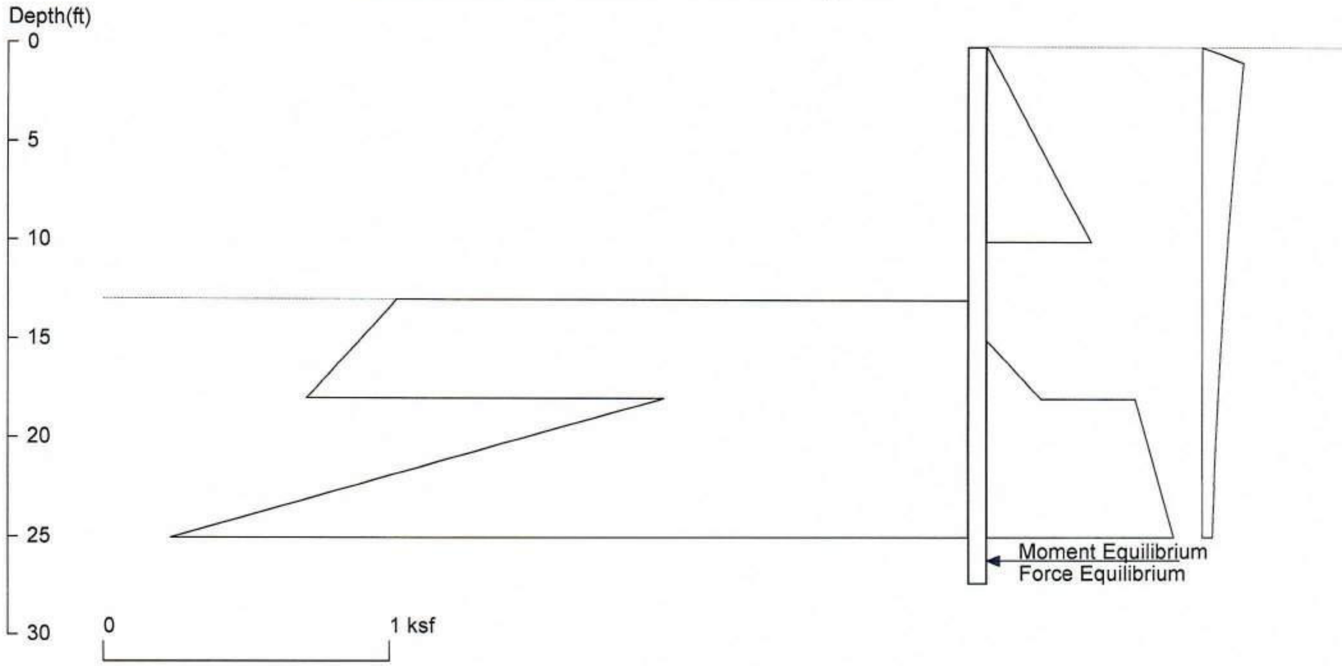
G1



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Wall Height=13.0 Pile Diameter=1.2 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=12.03 Min. Pile Length=25.03
MOMENT IN PILE: Max. Moment=216.56 per Pile Spacing=8.0 at Depth=16.54

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
15	0	18	0.189	0.063
18	0.517	35	0.840	0.019
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446
13.60	0.073	14.40	0.070	-0.00429

G2

14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276
22.40	0.043	24.00	0.039	-0.00249
24.00	0.039	25.60	0.035	-0.00224
25.60	0.035	27.20	0.032	-0.00202
27.20	0.032	28.80	0.029	-0.00181

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
13	2	18	2.315	0.063
18	1.062	35	5.244	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	15.00	1.20

PASSIVE SPACING:

No.	Z depth	Spacing
1	13.00	3.60

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

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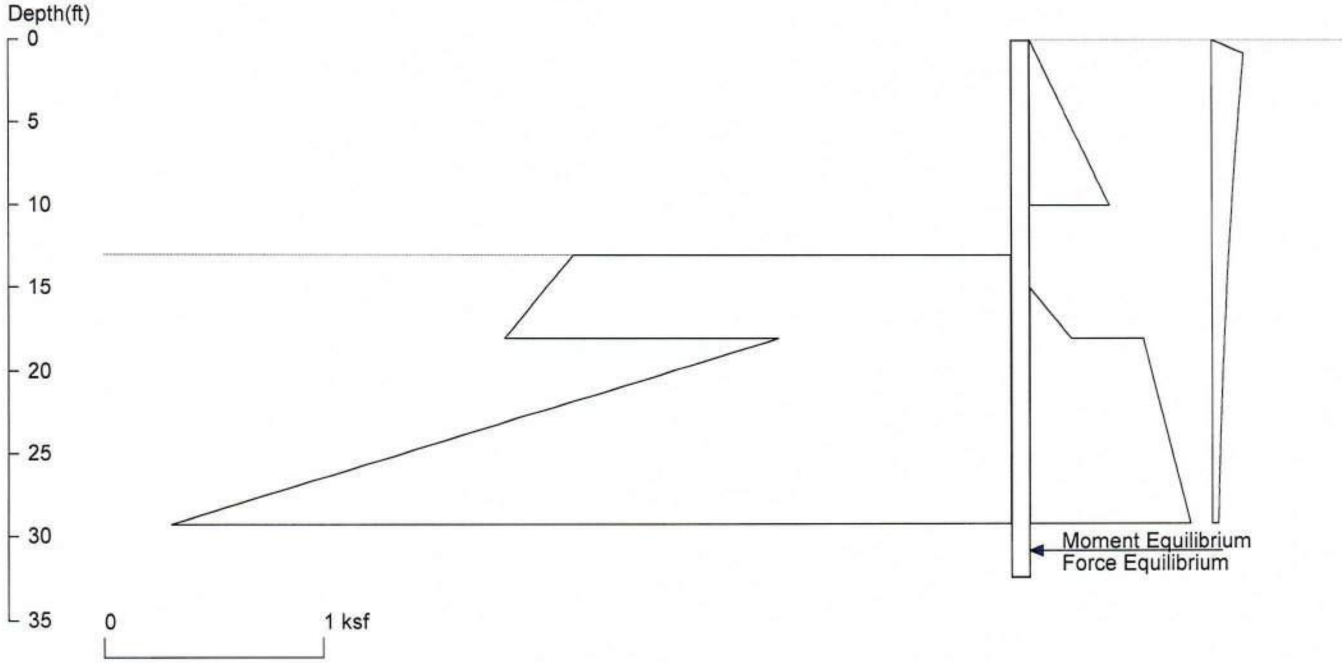

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Wall Height=13.0 Pile Diameter=1.2 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=16.30 Min. Pile Length=29.30
MOMENT IN PILE: Max. Moment=240.37 per Pile Spacing=8.0 at Depth=18.71

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
15	0	18	0.189	0.063
18	0.517	35	0.840	0.019
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446
13.60	0.073	14.40	0.070	-0.00429

G4

14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276
22.40	0.043	24.00	0.039	-0.00249
24.00	0.039	25.60	0.035	-0.00224
25.60	0.035	27.20	0.032	-0.00202
27.20	0.032	28.80	0.029	-0.00181
28.80	0.029	30.40	0.027	-0.00163
30.40	0.027	32.00	0.024	-0.00147
32.00	0.024	35.20	0.020	-0.00125

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
13	2	18	2.315	0.063
18	1.062	35	5.244	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	15.00	1.20

PASSIVE SPACING:

No.	Z depth	Spacing
1	13.00	3.60

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

G5

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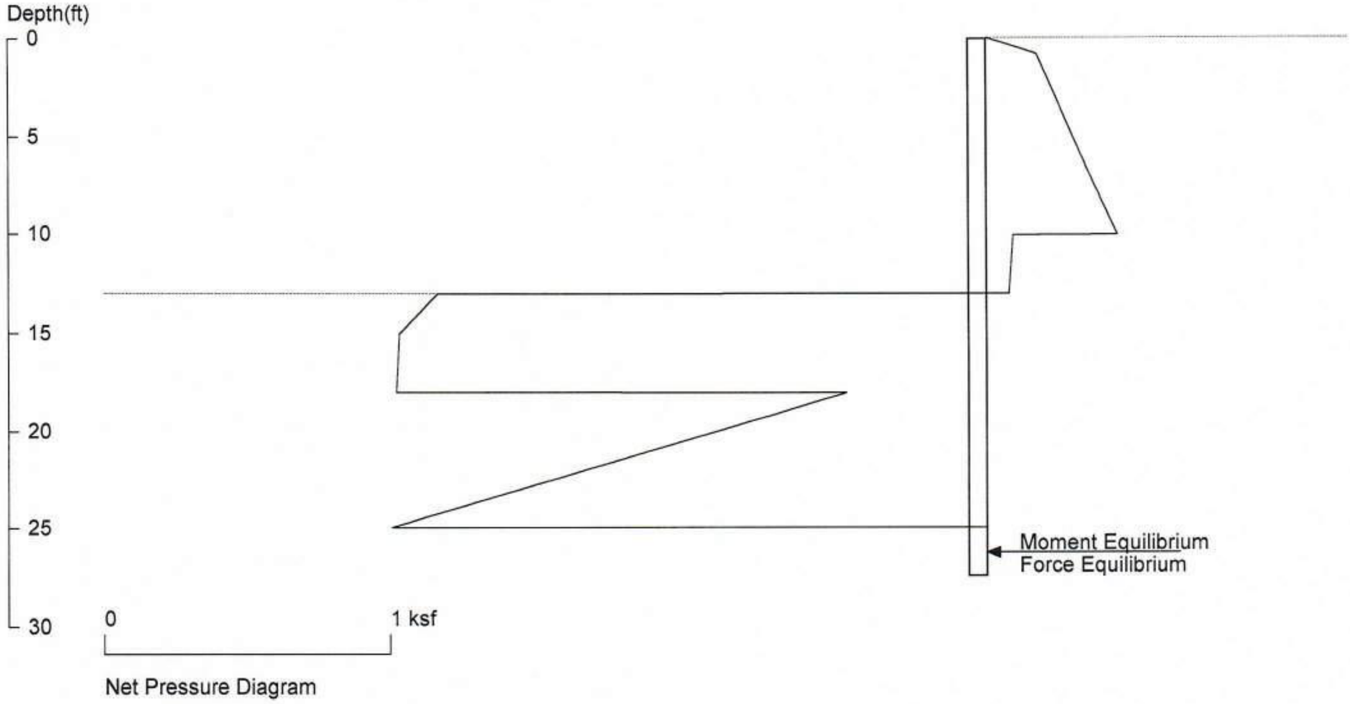

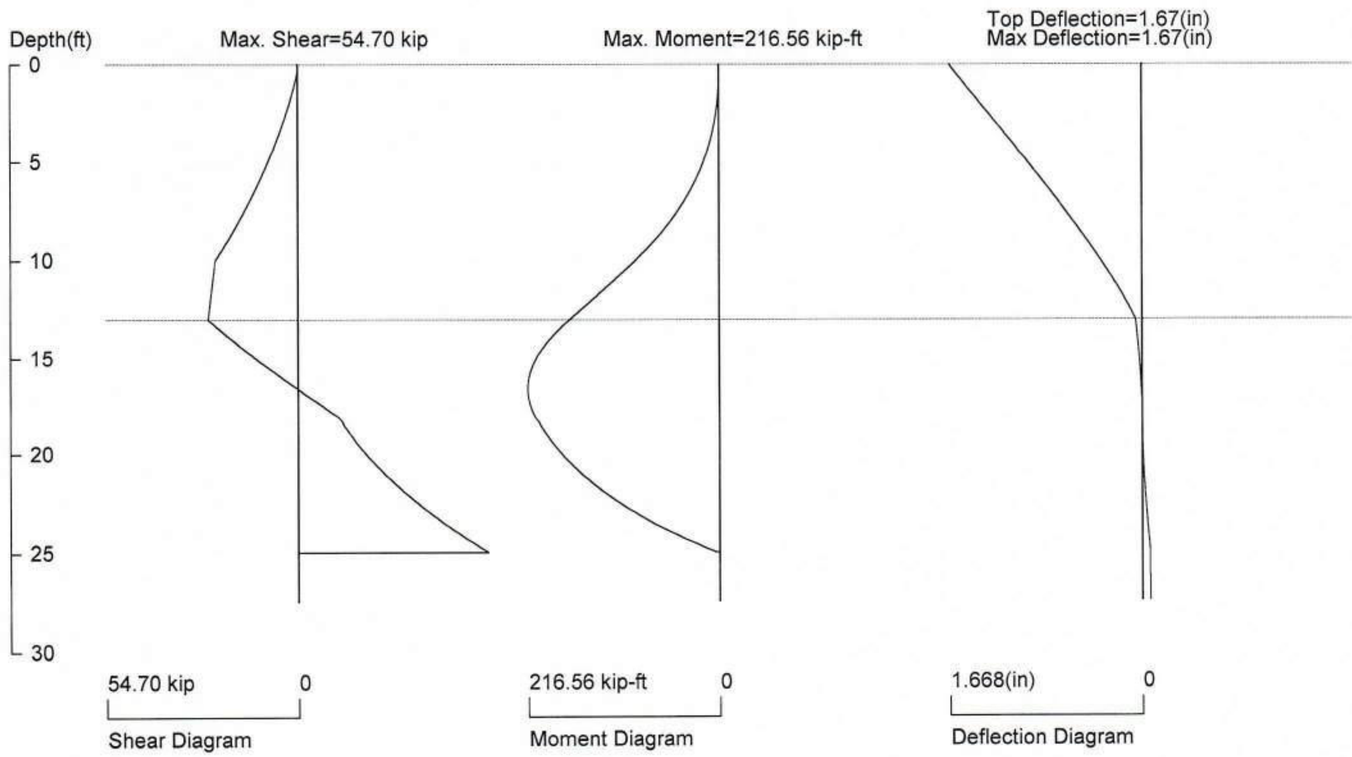

PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 8.0 foot or meter

User Input Pile, HP14x73: E (ksi)=29000.0, I (in4)/pile=729.0

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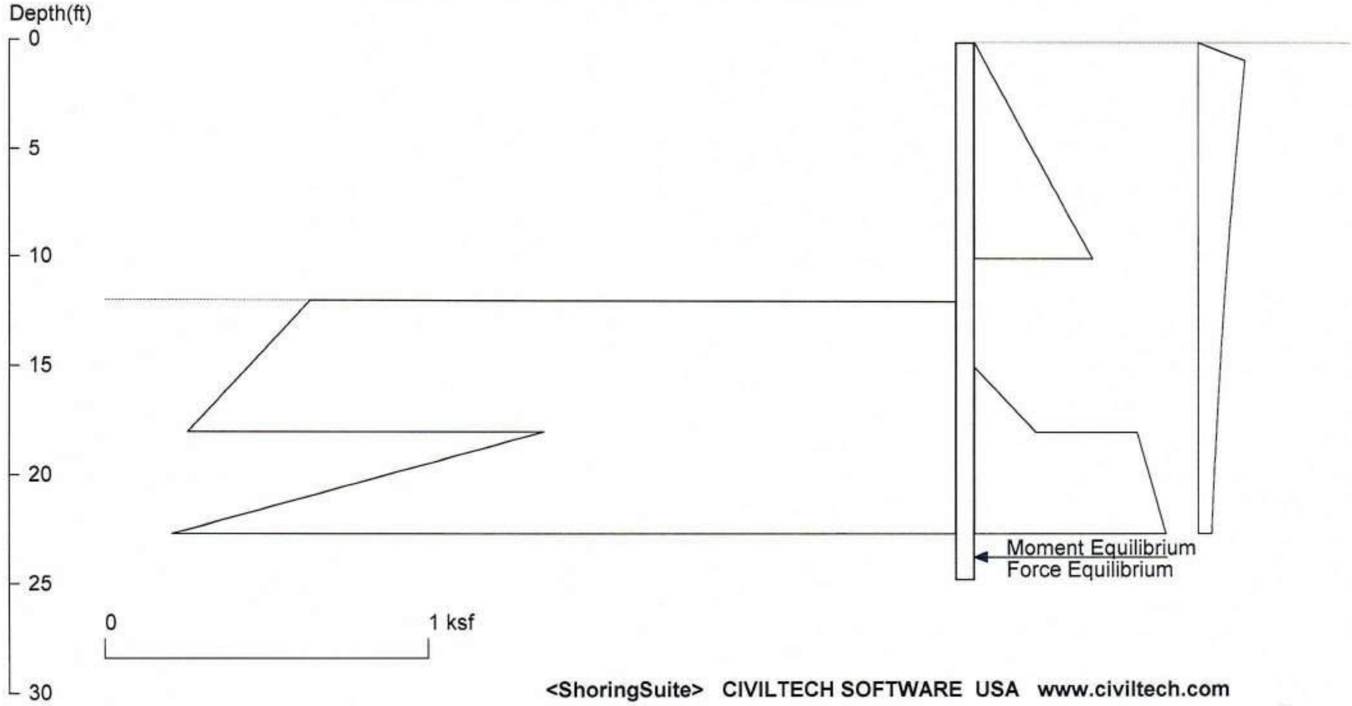
H1



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Wall Height=12.0 Pile Diameter=1.2 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=10.69 Min. Pile Length=22.69
MOMENT IN PILE: Max. Moment=186.68 per Pile Spacing=8.0 at Depth=15.35

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
15	0	18	0.189	0.063
18	0.501	35	0.824	0.019
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446
13.60	0.073	14.40	0.070	-0.00429

H2

14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276
22.40	0.043	24.00	0.039	-0.00249
24.00	0.039	25.60	0.035	-0.00224

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
12	2	18	2.378	0.063
18	1.274	35	5.456	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	12.00	1.20

PASSIVE SPACING:

No.	Z depth	Spacing
1	12.00	3.60

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

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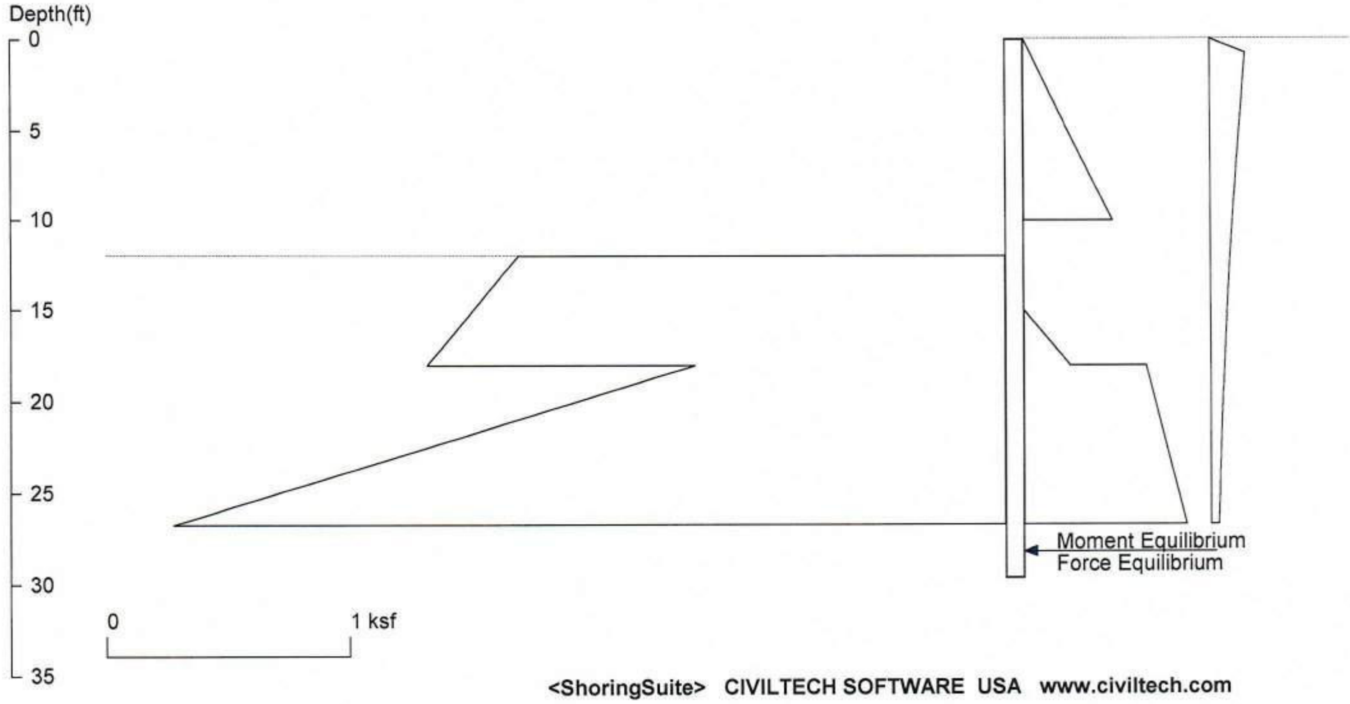
H3



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Wall Height=12.0 Pile Diameter=1.2 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=14.73 Min. Pile Length=26.73
MOMENT IN PILE: Max. Moment=207.30 per Pile Spacing=8.0 at Depth=16.95

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
15	0	18	0.189	0.063
18	0.501	35	0.824	0.019
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446
13.60	0.073	14.40	0.070	-0.00429

H4

14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276
22.40	0.043	24.00	0.039	-0.00249
24.00	0.039	25.60	0.035	-0.00224
25.60	0.035	27.20	0.032	-0.00202
27.20	0.032	28.80	0.029	-0.00181
28.80	0.029	30.40	0.027	-0.00163

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
12	2	18	2.378	0.063
18	1.274	35	5.456	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	12.00	1.20

PASSIVE SPACING:

No.	Z depth	Spacing
1	12.00	3.60

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

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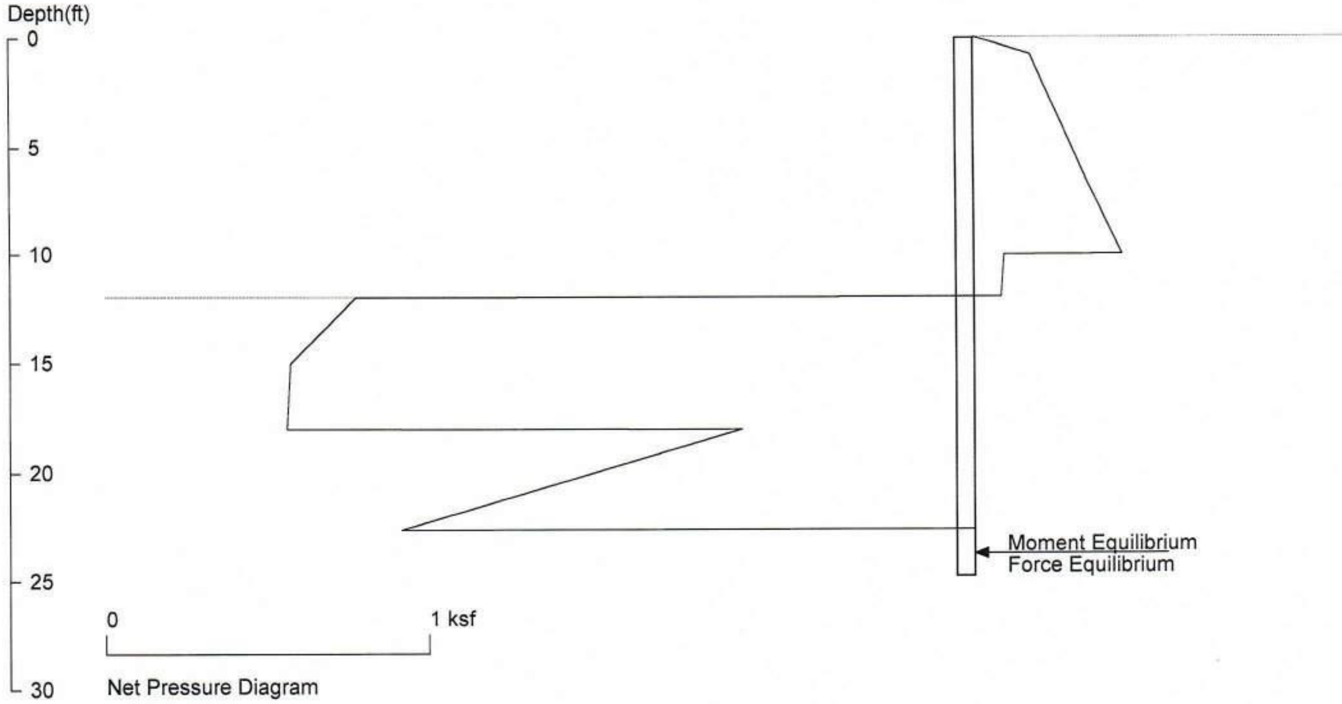
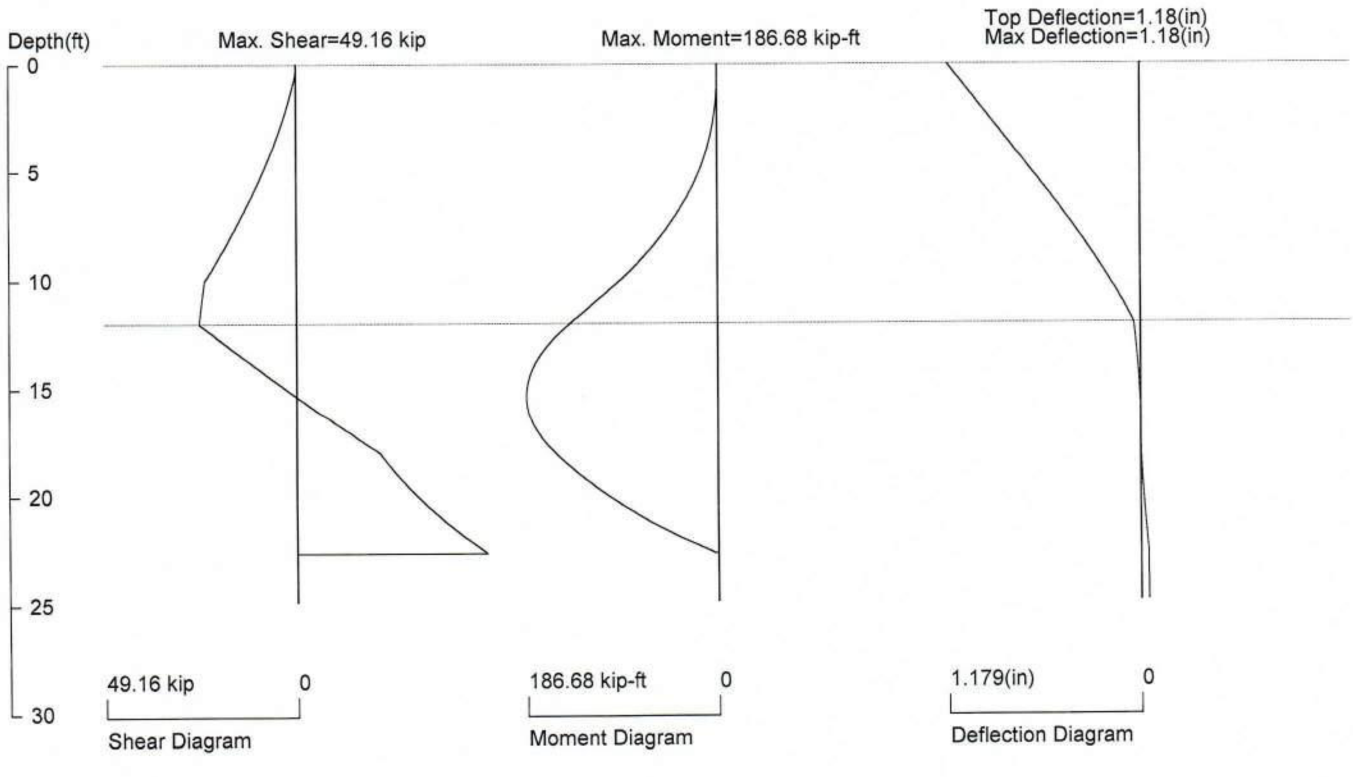
H5





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 8.0 foot or meter

User Input Pile, HP14X73: E (ksi)=29000.0, I (in4)/pile=729.0

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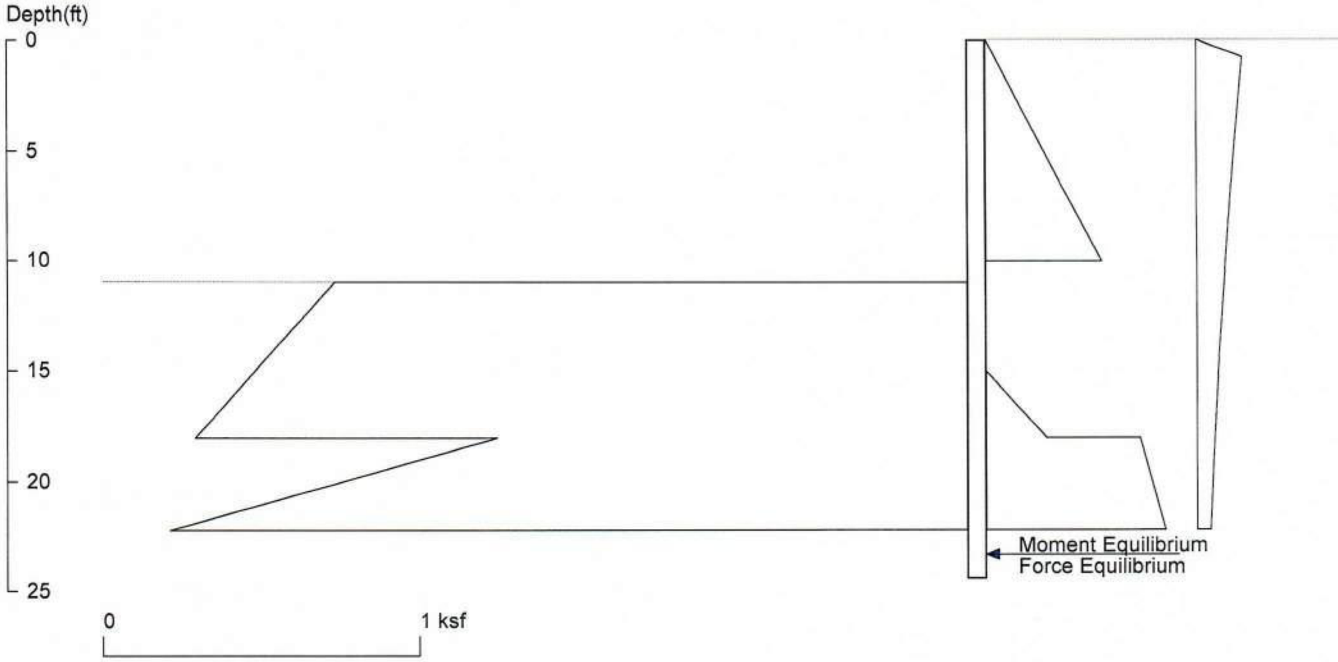

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Wall Height=11.0 Pile Diameter=1.0 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=11.21 Min. Pile Length=22.21
MOMENT IN PILE: Max. Moment=167.57 per Pile Spacing=8.0 at Depth=14.87

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
15	0	18	0.189	0.063
18	0.484	35	0.807	0.019
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446
13.60	0.073	14.40	0.070	-0.00429

14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276
22.40	0.043	24.00	0.039	-0.00249
24.00	0.039	25.60	0.035	-0.00224

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
11	2	18	2.441	0.063
18	1.486	35	5.668	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	11.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	11.00	3.00

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

J3

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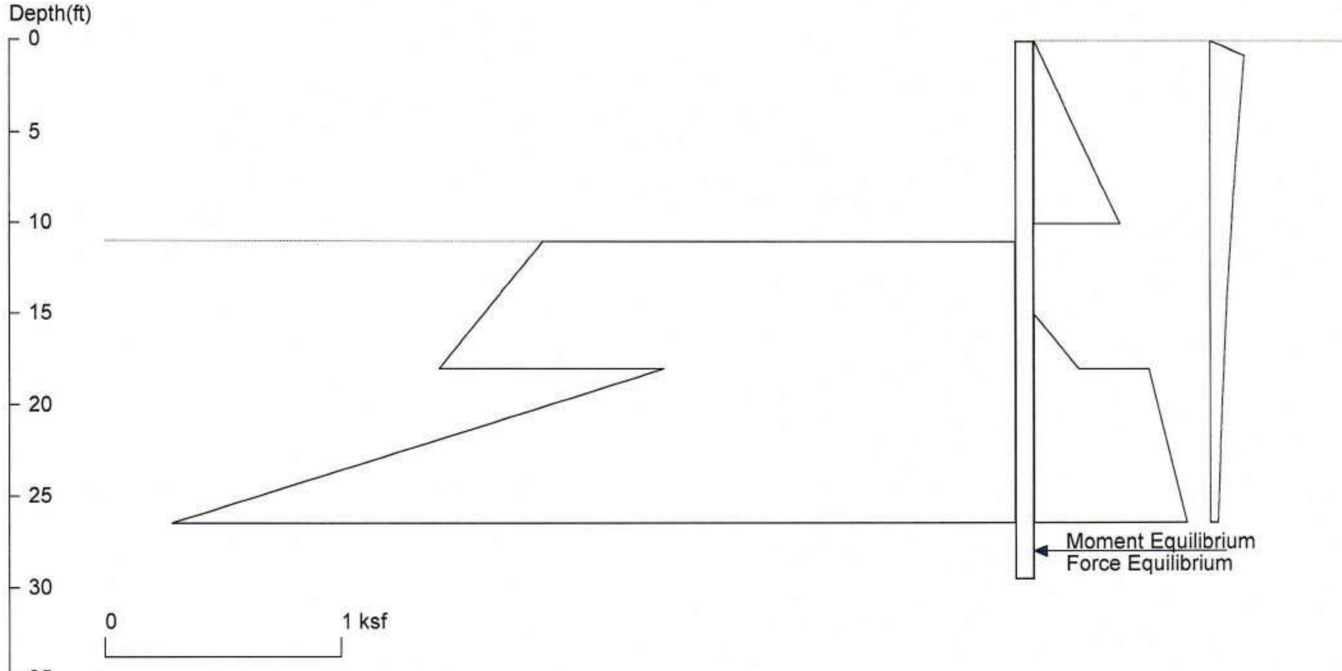
Maine Medical Center - Portland, ME



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Wall Height=11.0 Pile Diameter=1.0 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=15.49 Min. Pile Length=26.49
MOMENT IN PILE: Max. Moment=190.69 per Pile Spacing=8.0 at Depth=16.71

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
15	0	18	0.189	0.063
18	0.484	35	0.807	0.019
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446
13.60	0.073	14.40	0.070	-0.00429

J4

14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276
22.40	0.043	24.00	0.039	-0.00249
24.00	0.039	25.60	0.035	-0.00224
25.60	0.035	27.20	0.032	-0.00202
27.20	0.032	28.80	0.029	-0.00181
28.80	0.029	30.40	0.027	-0.00163

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
11	2	18	2.441	0.063
18	1.486	35	5.668	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	11.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	11.00	3.00

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

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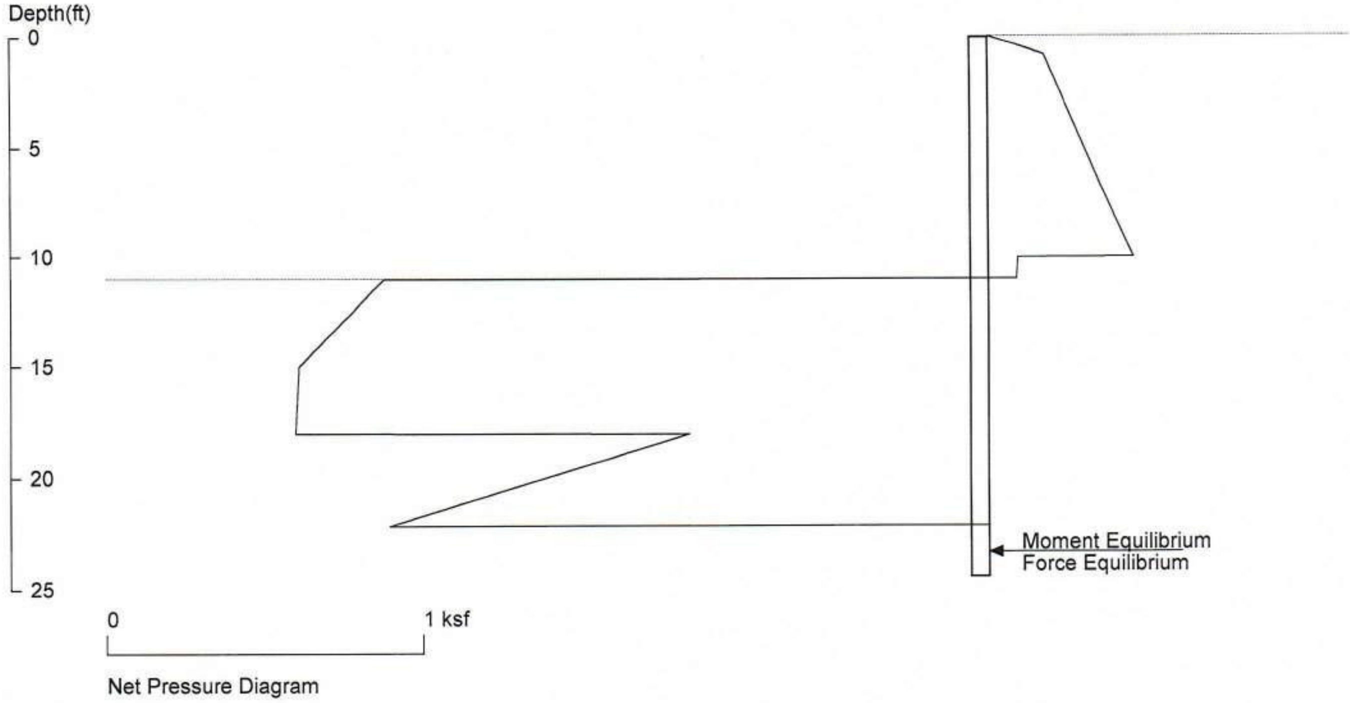
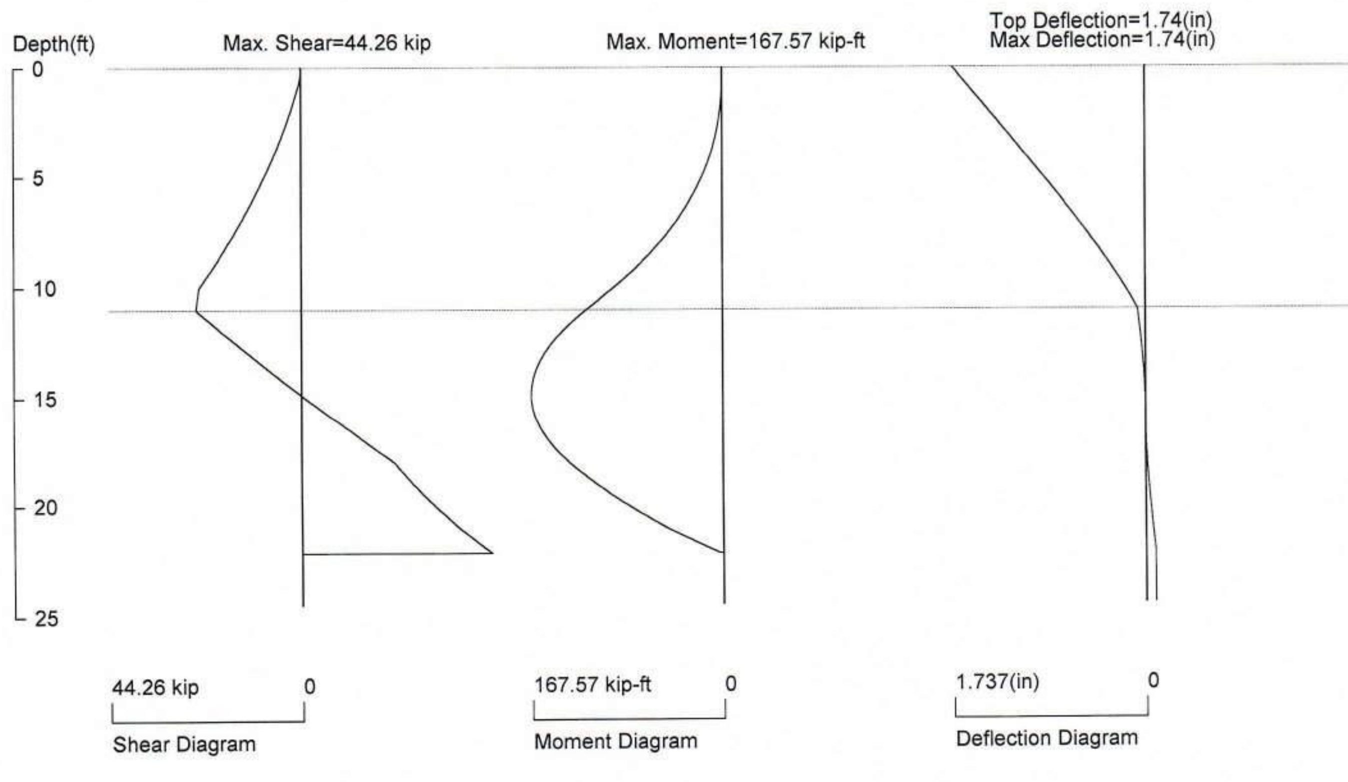
J5





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 8.0 foot or meter

User Input Pile, HP12x53: E (ksi)=29000.0, I (in4)/pile=393.0

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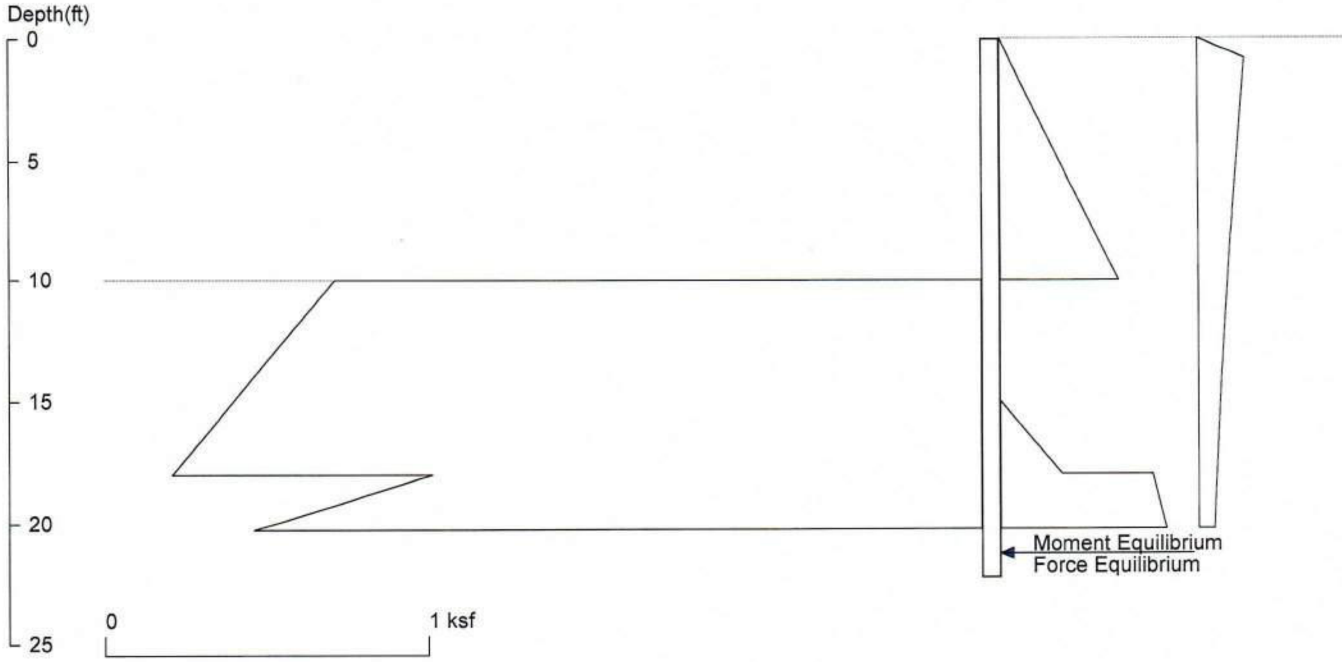

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Wall Height=10.0 Pile Diameter=1.0 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=10.24 Min. Pile Length=20.24
MOMENT IN PILE: Max. Moment=140.92 per Pile Spacing=8.0 at Depth=13.76

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
15	0	18	0.189	0.063
18	0.468	35	0.791	0.019
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446
13.60	0.073	14.40	0.070	-0.00429

K2

14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
10	2	18	2.504	0.063
18	1.699	35	5.881	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	10.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	10.00	3.00

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

K3

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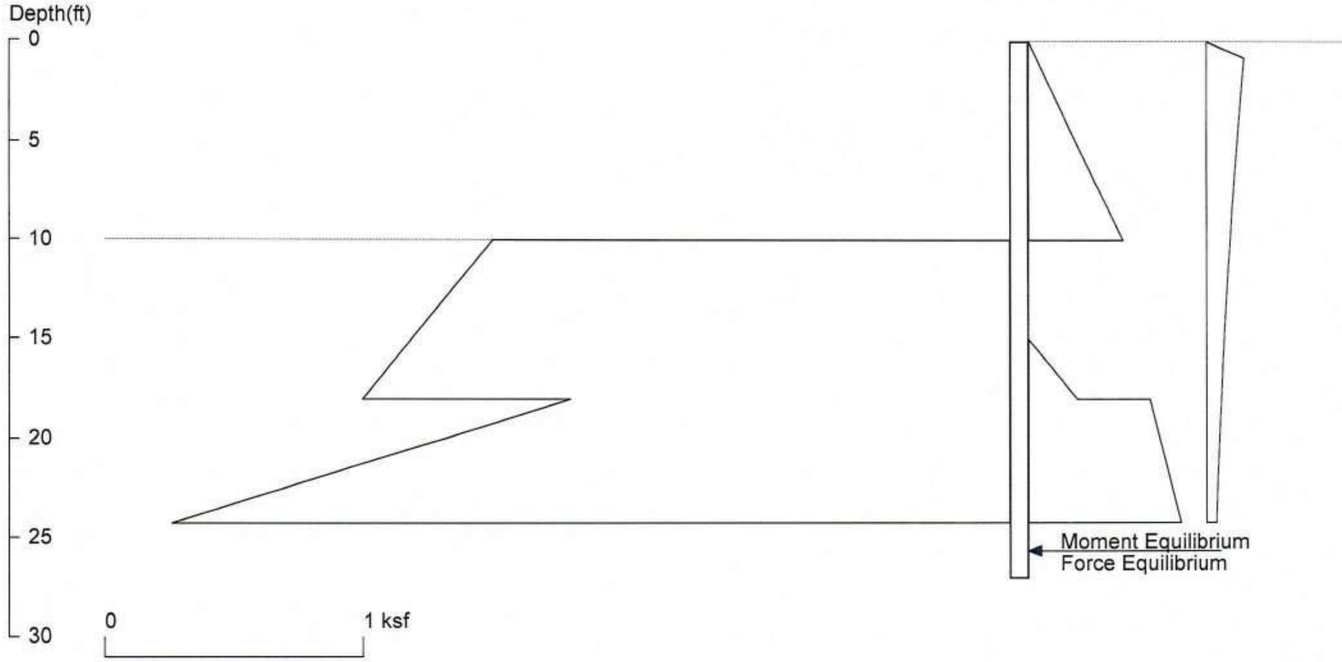

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Wall Height=10.0 Pile Diameter=1.0 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=14.27 Min. Pile Length=24.27
MOMENT IN PILE: Max. Moment=162.77 per Pile Spacing=8.0 at Depth=15.53

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
15	0	18	0.189	0.063
18	0.468	35	0.791	0.019
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446
13.60	0.073	14.40	0.070	-0.00429

K4

14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276
22.40	0.043	24.00	0.039	-0.00249
24.00	0.039	25.60	0.035	-0.00224
25.60	0.035	27.20	0.032	-0.00202

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
10	2	18	2.504	0.063
18	1.699	35	5.881	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	10.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	10.00	3.00

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

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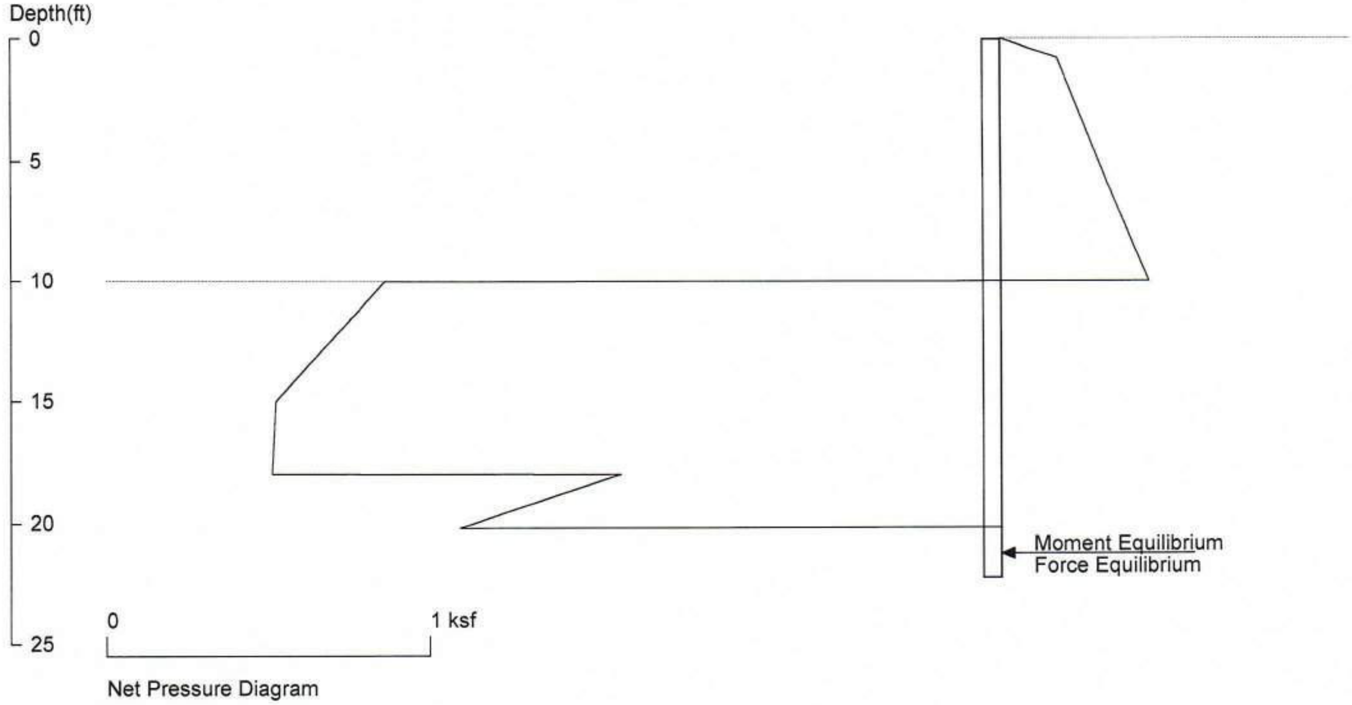
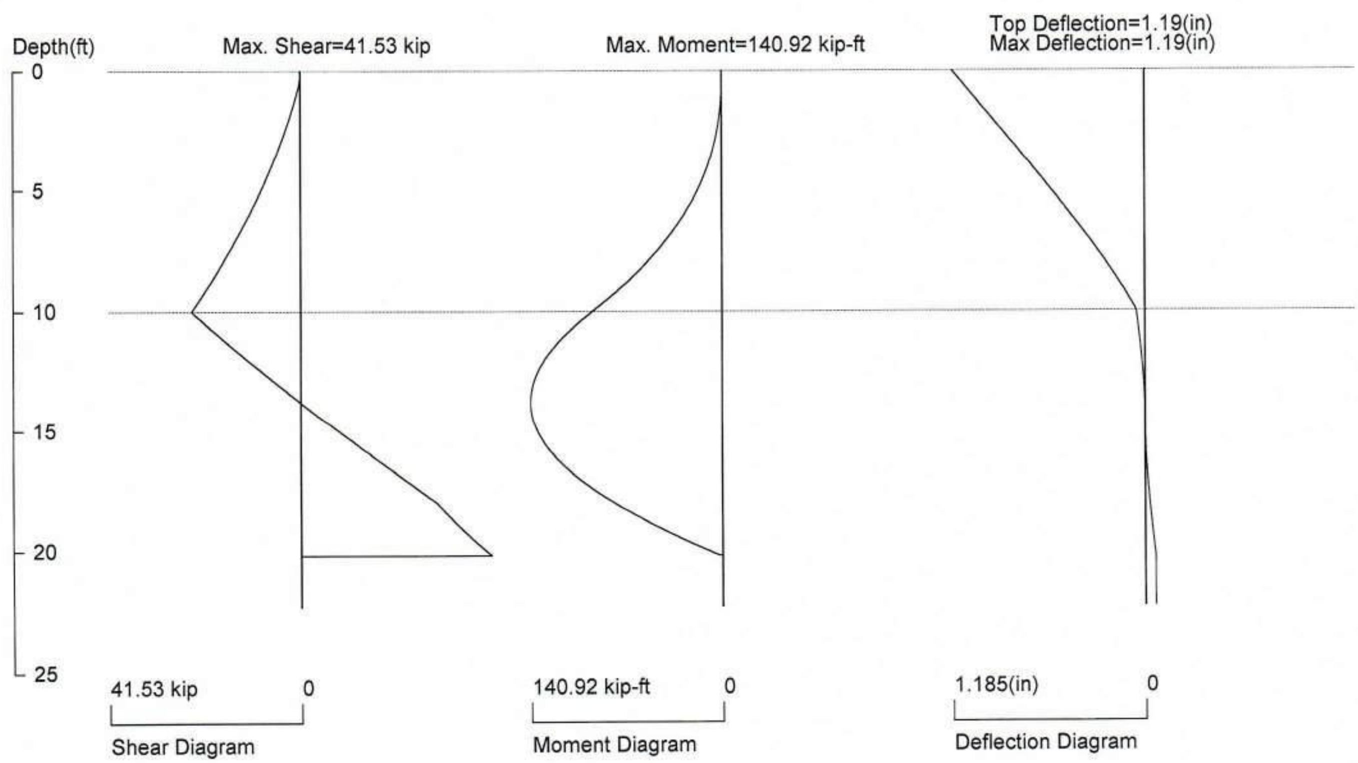
K5





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 8.0 foot or meter

User Input Pile, HP12x53: E (ksi)=29000.0, I (in4)/pile=393.0

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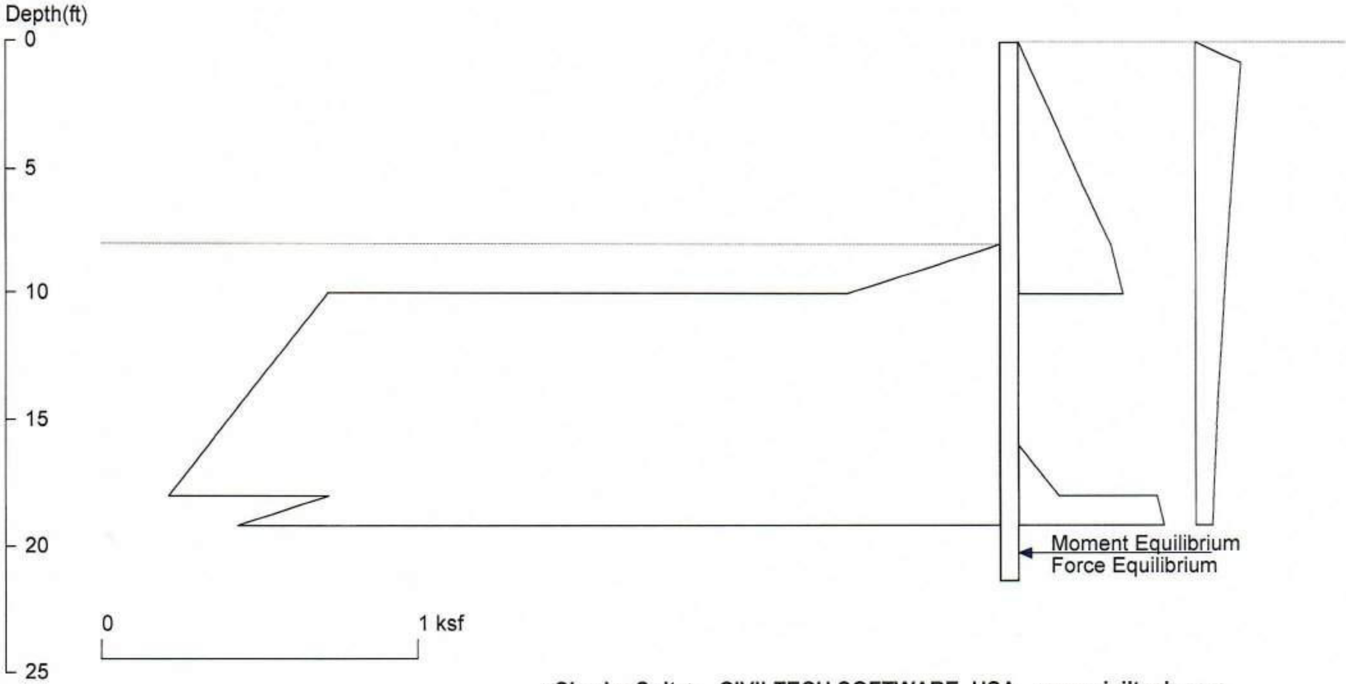

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Wall Height=8.0 Pile Diameter=0.8 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=11.17 Min. Pile Length=19.17
MOMENT IN PILE: Max. Moment=113.65 per Pile Spacing=8.0 at Depth=12.99

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	8	0.291	0.0364
8	0.291	10	0.329	0.019
16	0	18	0.126	0.063
18	0.436	35	0.759	0.019
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446

L2

13.60	0.073	14.40	0.070	-0.00429
14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
8	0	10	0.478	0.239
10	2.125	18	2.629	0.063
18	2.123	35	6.305	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	8.00	0.83

PASSIVE SPACING:

No.	Z depth	Spacing
1	8.00	2.49

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

L3

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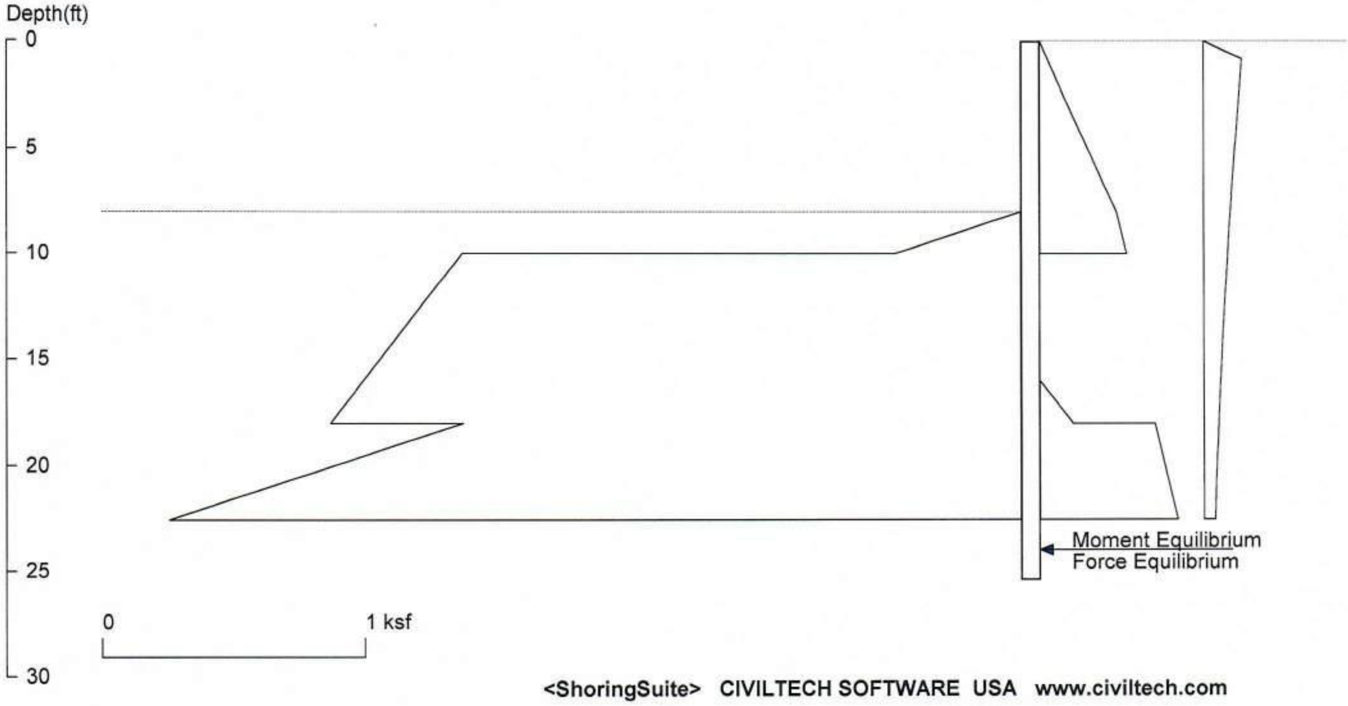

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Wall Height=8.0 Pile Diameter=0.8 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=14.55 Min. Pile Length=22.55
MOMENT IN PILE: Max. Moment=127.79 per Pile Spacing=8.0 at Depth=14.53

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	8	0.291	0.0364
8	0.291	10	0.329	0.019
16	0	18	0.126	0.063
18	0.436	35	0.759	0.019
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446

L4

13.60	0.073	14.40	0.070	-0.00429
14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276
22.40	0.043	24.00	0.039	-0.00249
24.00	0.039	25.60	0.035	-0.00224

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
8	0	10	0.478	0.239
10	2.125	18	2.629	0.063
18	2.123	35	6.305	0.246

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	8.00	0.83

PASSIVE SPACING:

No.	Z depth	Spacing
1	8.00	2.49

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

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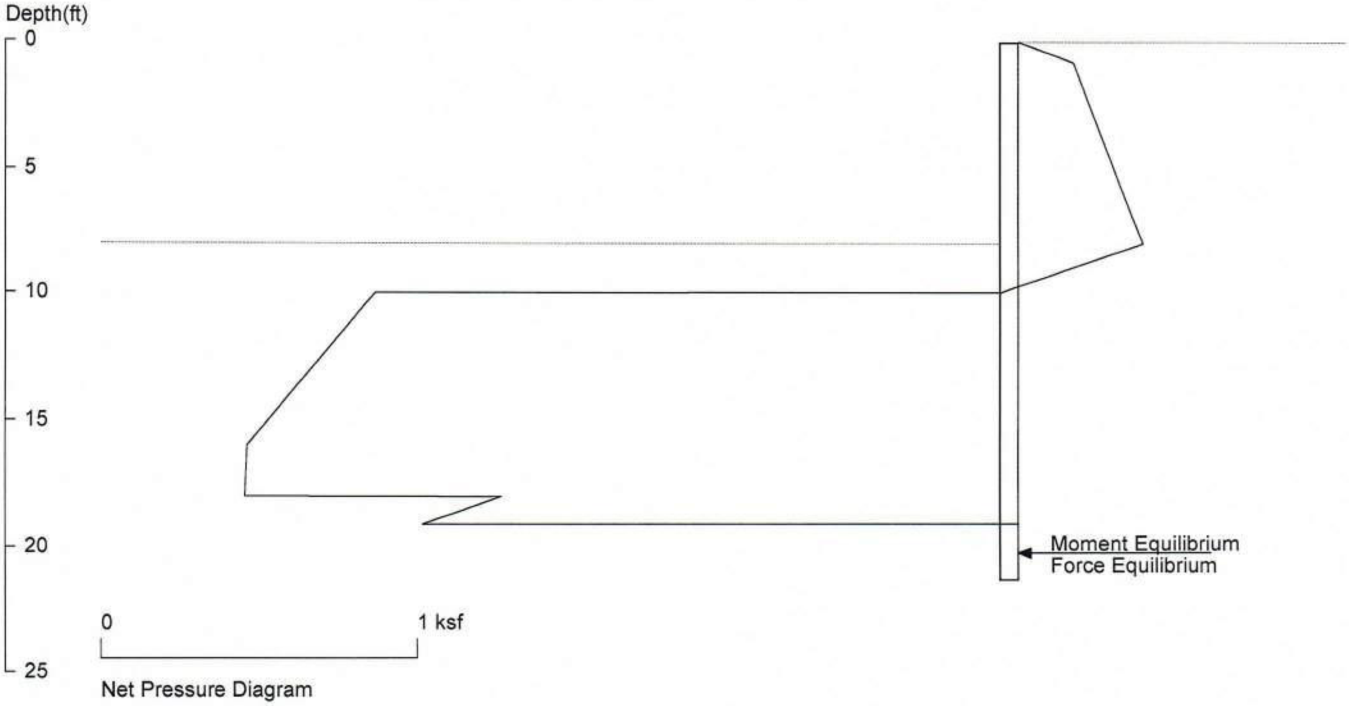

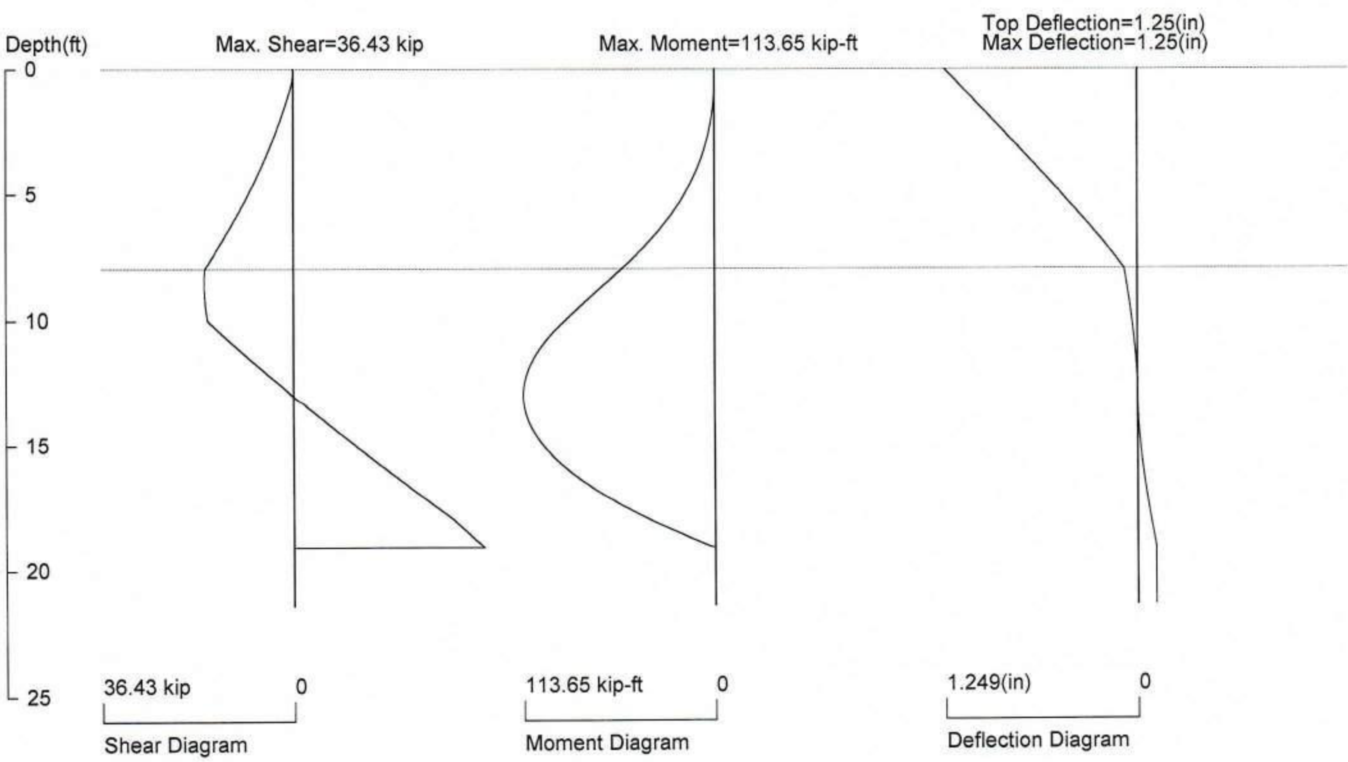

PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 8.0 foot or meter

User Input Pile, HP10x42: E (ksi)=29000.0, I (in4)/pile=210.0

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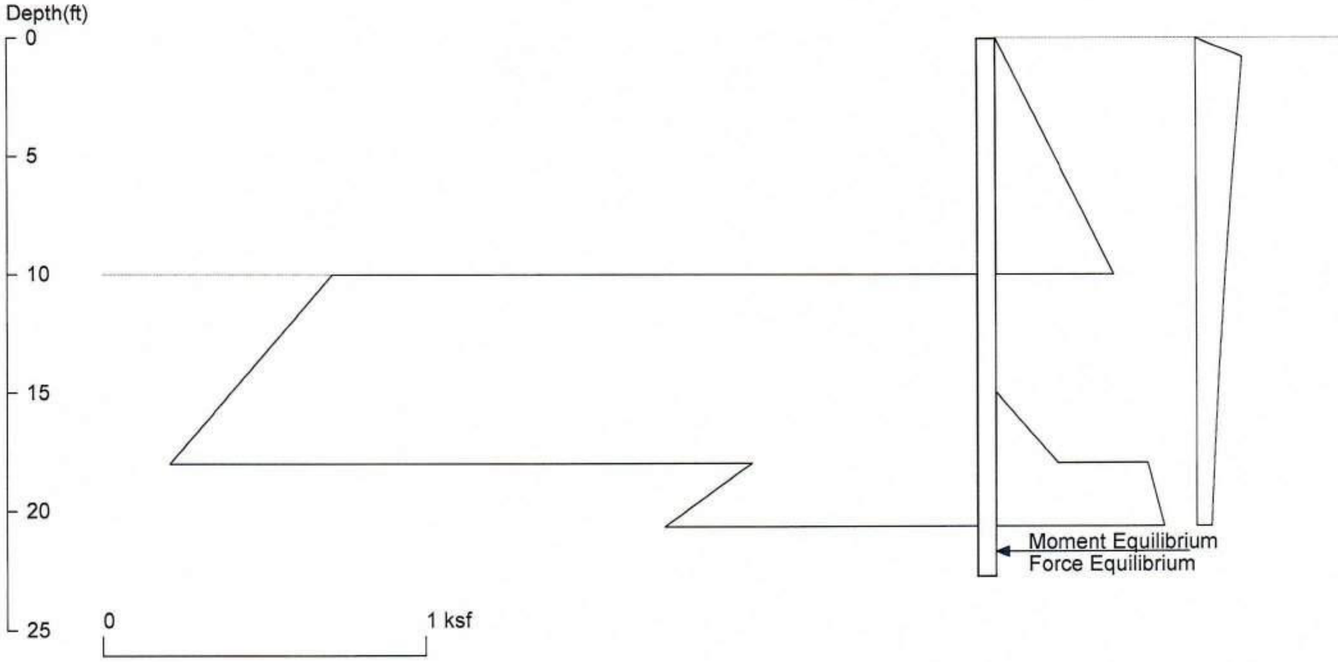
M1



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Wall Height=10.0 Pile Diameter=1.0 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=10.67 Min. Pile Length=20.67
MOMENT IN PILE: Max. Moment=142.98 per Pile Spacing=8.0 at Depth=13.87

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
15	0	18	0.189	0.063
18	0.468	35	0.791	0.019
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446
13.60	0.073	14.40	0.070	-0.00429

M2

14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276
22.40	0.043	24.00	0.039	-0.00249

PASSIVE PRESSURES:

Z1	P1	Z2	P2	Slope
10	2	18	2.504	0.063
18	0.697	35	2.414	0.101

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	11.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	10.00	3.00

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

M3

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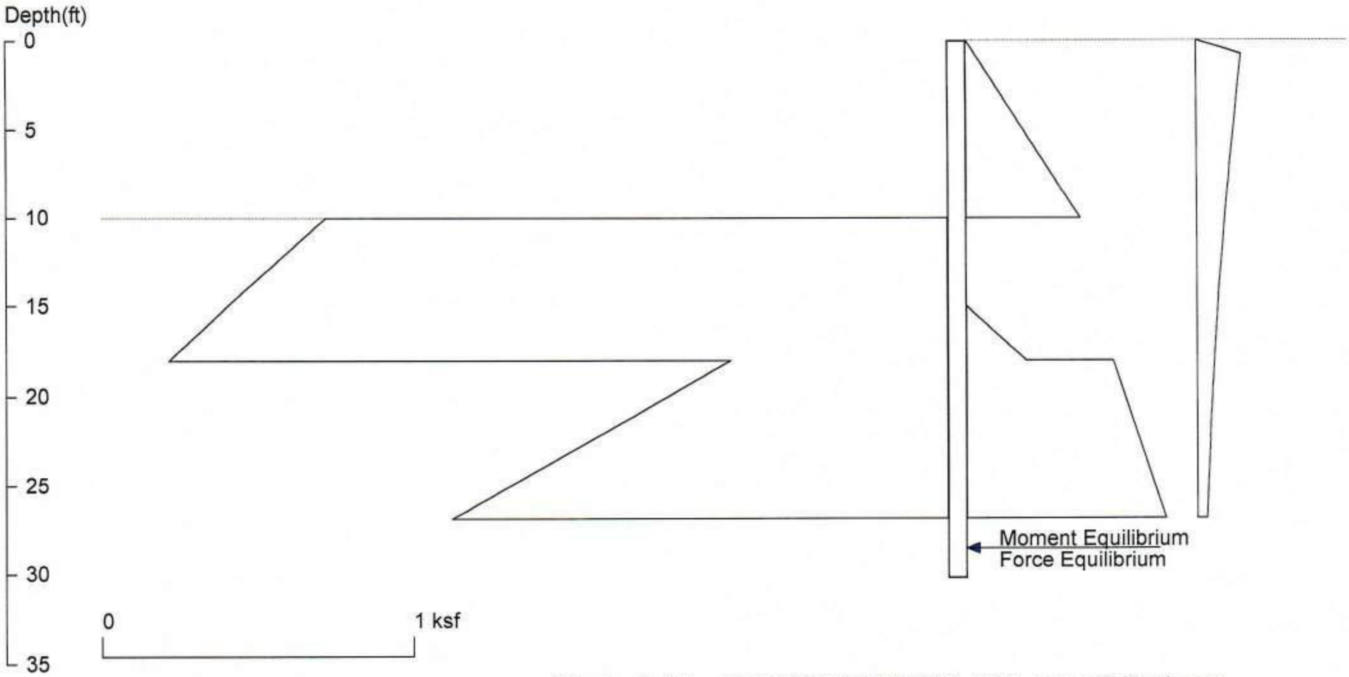

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Wall Height=10.0 Pile Diameter=1.0 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=16.89 Min. Pile Length=26.89
MOMENT IN PILE: Max. Moment=165.93 per Pile Spacing=8.0 at Depth=15.68

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Soil	Load	*	
0	0	10	0.364	0.0364
15	0	18	0.189	0.063
18	0.468	35	0.791	0.019
*	Sur-	charg		
0.000	0.000	0.800	0.145	0.181137
0.800	0.145	1.600	0.140	-0.00634
1.600	0.140	2.400	0.135	-0.00630
2.400	0.135	3.200	0.130	-0.00625
3.200	0.130	4.000	0.125	-0.00618
4.000	0.125	4.800	0.120	-0.00610
4.800	0.120	5.600	0.115	-0.00600
5.600	0.115	6.400	0.110	-0.00588
6.400	0.110	7.200	0.106	-0.00575
7.200	0.106	8.000	0.101	-0.00562
8.000	0.101	8.800	0.097	-0.00547
8.800	0.097	9.600	0.093	-0.00531
9.600	0.093	10.40	0.089	-0.00515
10.40	0.089	11.20	0.085	-0.00498
11.20	0.085	12.00	0.081	-0.00481
12.00	0.081	12.80	0.077	-0.00464
12.80	0.077	13.60	0.073	-0.00446
13.60	0.073	14.40	0.070	-0.00429

M4

14.40	0.070	15.20	0.067	-0.00411
15.20	0.067	16.00	0.064	-0.00394
16.00	0.064	17.60	0.058	-0.00369
17.60	0.058	19.20	0.052	-0.00336
19.20	0.052	20.80	0.047	-0.00305
20.80	0.047	22.40	0.043	-0.00276
22.40	0.043	24.00	0.039	-0.00249
24.00	0.039	25.60	0.035	-0.00224
25.60	0.035	27.20	0.032	-0.00202
27.20	0.032	28.80	0.029	-0.00181
28.80	0.029	30.40	0.027	-0.00163

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
10	2	18	2.504	0.063
18	0.697	35	2.414	0.101

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	11.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	10.00	3.00

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

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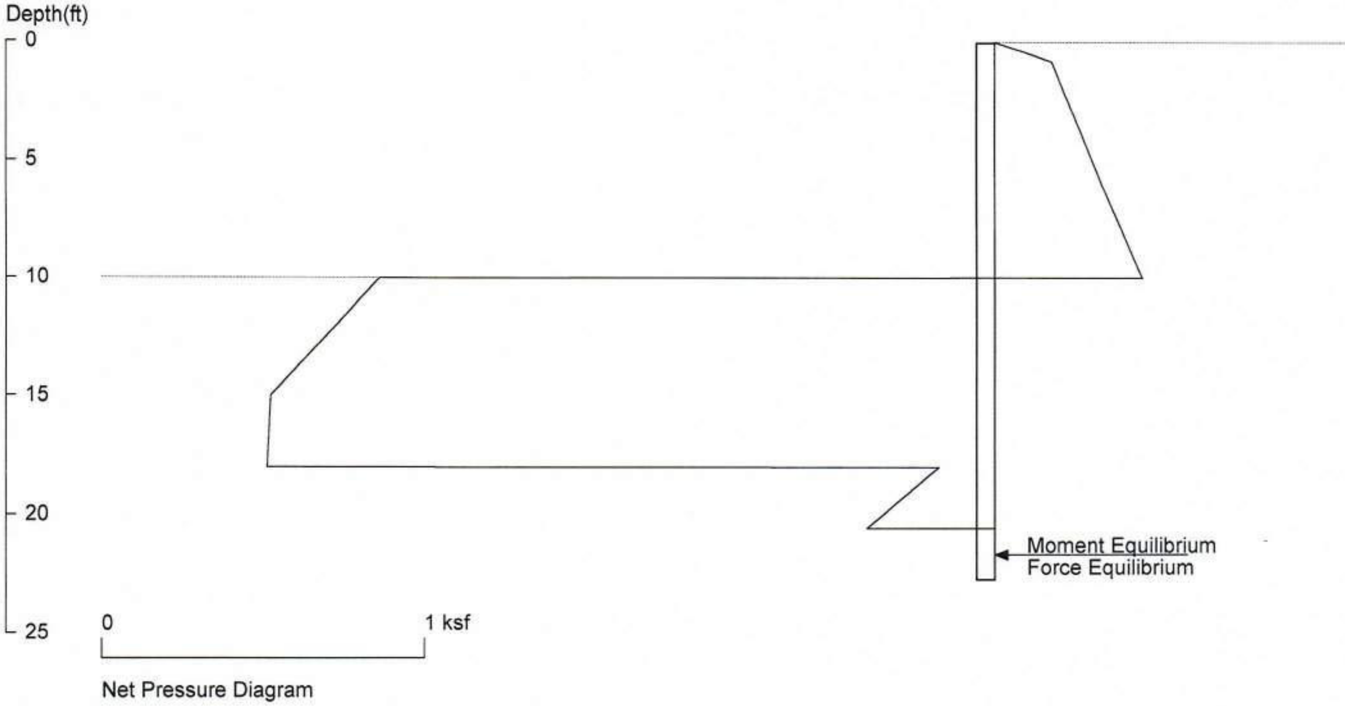
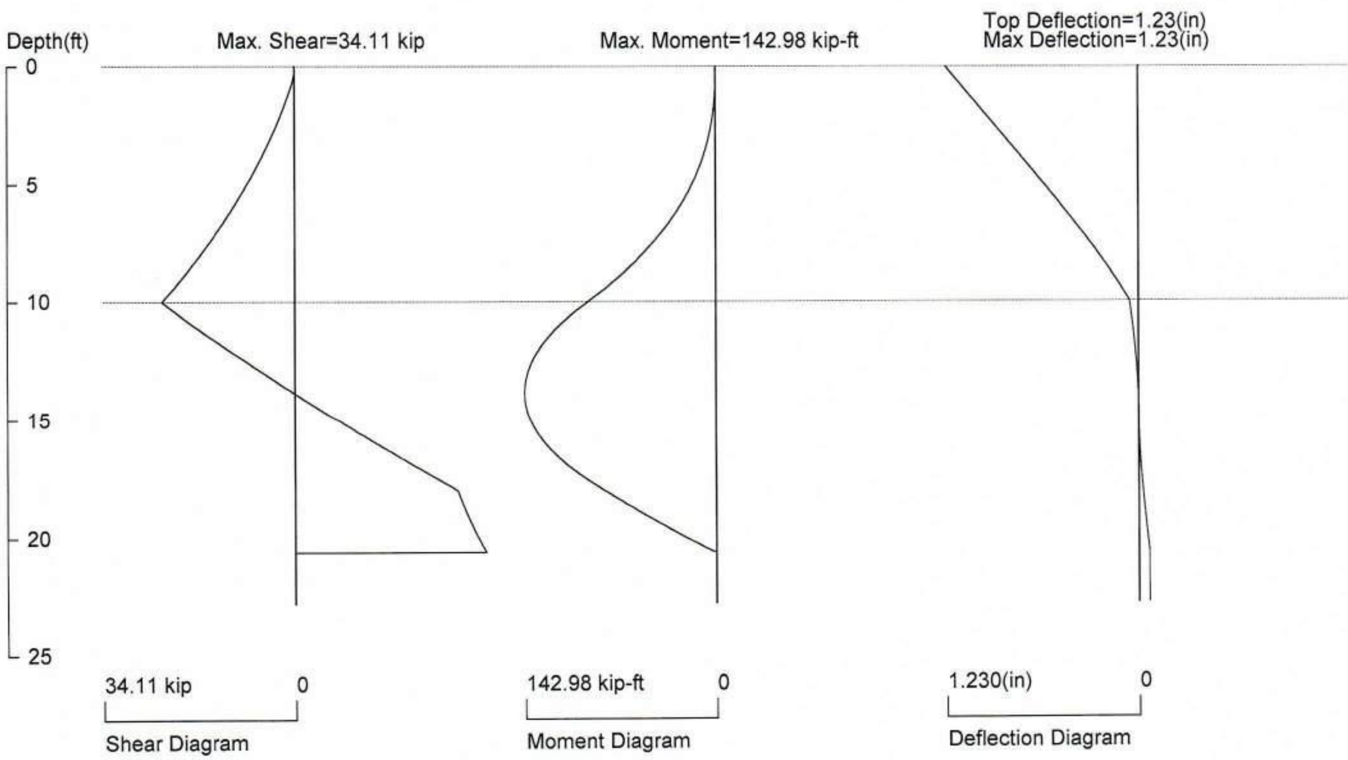
M5





PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 8.0 foot or meter

User Input Pile, HP12x53: E (ksi)=29000.0, I (in4)/pile=393.0

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