

## 15' VERTICAL WOOD SHEETING PIT DESIGN

### DEFINE UNITS:

$$kip := 1000 \cdot lbf \quad deg := \frac{\pi}{180} \cdot rad \quad pcf := \frac{lbf}{ft^3}$$

### 1. SOIL PROPERTIES:

Angle of Internal Friction	$\phi := 30 \cdot deg$
Weight of Soil, Saturated	$\gamma_s := 125 \cdot pcf$
Weight of Soil	$\gamma := 115 \cdot pcf$
Water of Weight	$\gamma_w := 62.4 \cdot pcf$
Weight of Soil, Submerged	$\gamma' := \gamma_s - \gamma_w \quad \gamma' = 62.6 \text{ pcf}$
Coefficient of Active Pressure	Coefficient of Passive Pressure
$Ka_1 := \frac{1 - \sin(\phi)}{1 + \sin(\phi)} = 0.333$	$Kp_1 := \frac{1 + \sin(\phi)}{1 - \sin(\phi)} = 3.000$

### 2. SOIL LOADING:

Depth of Excavation	$He_1 := 15.00 \cdot ft$
Height of Water above Subgrade	$Hw := 0.00 \cdot ft$
Uniform Surcharge	$Q_1 := 3 \cdot ft \cdot \gamma = 345 \text{ psf}$
Lateral Surcharge Pressure	$Ps_1 := Ka_1 \cdot Q_1 = 115 \text{ psf}$
Lateral Soil Pressure	$Pc_1 := 0.8 \cdot Ka_1 \cdot \gamma \cdot He_1 = 460 \text{ psf}$
Maximum Lateral Pressure	$Pm_1 := Ps_1 + Pc_1 = 575 \text{ psf}$
Lateral Passive Soil Pressure	$Pp_1 := (Kp_1 - Ka_1) \cdot \gamma = 307 \frac{psf}{ft}$

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### 3. WOOD & TIMBER PROPERTIES: (SOUTHERN PINE, DENSE STRUCTURAL)

$$F_{bw} := 1750 \cdot \text{psi} \cdot 133.33\%$$

$$F_{bw} = 2333 \text{ psi}$$

$$F_{vw} := 175 \cdot \text{psi} \cdot 133.33\%$$

$$F_{vw} = 233 \text{ psi} \quad (\text{LUMBER})$$

$$F_{vt} := 165 \cdot \text{psi} \cdot 133.33\%$$

$$F_{vt} = 220 \text{ psi} \quad (\text{TIMBER})$$

$$F_c := 1100 \cdot \text{psi}$$

$$F_c = 1100 \text{ psi} \quad (\text{PARALLEL})$$

$$E_w := 1600000 \cdot \text{psi}$$

$$E_w = 1600000 \text{ psi}$$

The above allowable stresses include 1/3 overstress for temporary use.

### 4. CALCULATE SHEETING LOADS:

$$He_1 = 15 \text{ ft}$$

$$A_1 := 2.50 \cdot \text{ft}$$

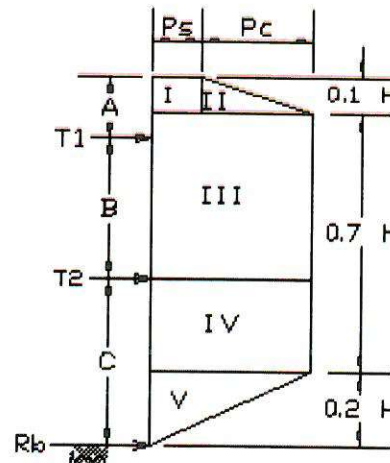
$$B_1 := 6.50 \cdot \text{ft}$$

$$C_1 := He_1 - A_1 - B_1 = 6.00 \text{ ft}$$

$$Ps_1 = 115 \text{ psf}$$

$$Pc_1 = 460 \text{ psf}$$

$$Pm_1 = 575 \text{ psf}$$



Sum of Moments above T2:

$$HF_1 := \begin{bmatrix} Ps_1 \cdot 0.1 \cdot He_1 \\ \frac{1}{2} \cdot Pc_1 \cdot 0.1 \cdot He_1 \\ Pm_1 \cdot (A_1 + B_1 - 0.1 \cdot He_1) \end{bmatrix} = \begin{bmatrix} 173 \\ 345 \\ 4313 \end{bmatrix} \text{ plf}$$

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$$X_1 := \begin{bmatrix} A_1 + B_1 - \frac{1}{2} \cdot 0.1 \cdot He_1 \\ A_1 + B_1 - \frac{2}{3} \cdot 0.1 \cdot He_1 \\ \frac{A_1 + B_1 - 0.1 \cdot He_1}{2} \end{bmatrix} = \begin{bmatrix} 8 \\ 8 \\ 4 \end{bmatrix} \text{ ft}$$

$$T_1 := \frac{HF_1 \cdot X_1}{B_1} = 3132 \text{ plf}$$

Sum of Moments above Rb:

$$HF_2 := \begin{bmatrix} Ps_1 \cdot 0.1 \cdot He_1 \\ \frac{1}{2} \cdot Pc_1 \cdot 0.1 \cdot He_1 \\ Pm_1 \cdot 0.7 \cdot He_1 \\ \frac{1}{2} \cdot Pm_1 \cdot 0.2 \cdot He_1 \end{bmatrix} = \begin{bmatrix} 173 \\ 345 \\ 6038 \\ 863 \end{bmatrix} \text{ plf}$$

$$\sum HF_2 = 7418 \text{ plf}$$

$$X_2 := \begin{bmatrix} \left(1 - \frac{1}{2} \cdot 0.1\right) \cdot He_1 \\ \left(1 - \frac{2}{3} \cdot 0.1\right) \cdot He_1 \\ 0.55 \cdot He_1 \\ \frac{2}{3} \cdot 0.2 \cdot He_1 \end{bmatrix} = \begin{bmatrix} 14 \\ 14 \\ 8 \\ 2 \end{bmatrix} \text{ ft}$$

$$T_2 := \frac{HF_2 \cdot X_2 - T_1 \cdot (B_1 + C_1)}{C_1}$$

$$T_2 = 3280 \text{ plf}$$

Sum of Horizontal Forces:

$$Rb_1 := \sum HF_2 - T_1 - T_2 = 1006 \text{ plf}$$

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### 5. DESIGN TIMBER WALE - STRUT:

$$W_1 := \max(T_1, T_2) = 3280 \text{ plf}$$

$$F_c = 1100 \text{ psi}$$

$$L_1 := 13 \cdot \text{ft} \quad L_2 := 8 \text{ ft} + 4 \cdot \text{in} = 8 \text{ ft}$$

$$L_{DES} := L_1 - 2 \cdot 12 \cdot \text{in} - 3 \cdot \text{in} = 10.75 \text{ ft}$$

Center to center  
strut spacing

$$P_1 := \frac{W_1 \cdot L_2}{2} = 13665 \text{ lbf}$$

$$Mx_1 := \frac{W_1 \cdot L_{DES}^2}{8} = 47376 \text{ ft} \cdot \text{lbf}$$

$$L_S := L_1 - 2 \cdot 12 \cdot \text{in} = 11 \text{ ft}$$

Length of strut

TRY  $b_1 := 12 \cdot \text{in}$  Timber width

$d_S := 12 \cdot \text{in}$  Timber depth

$$\frac{L_S}{d_S} = 11.00$$

$$Sx_1 := \frac{b_1 \cdot d_S^2}{6} = 288 \text{ in}^3$$

$$Area_1 := b_1 \cdot d_S = 144 \text{ in}^2$$

$$Ix_1 := \frac{b_1 \cdot d_S^3}{12} = 1728 \text{ in}^4$$

$$Fc' := \begin{cases} \text{if } 0 < \frac{L_S}{d_S} < 10 \\ \end{cases}$$

$$k_1 := 0.671 \cdot \sqrt{\frac{E_w}{F_c}} = 25.59$$

||  $F_c$   
|| else

|| if  $\frac{L_S}{d_S} < k_1$

||  $F_c \cdot \left( 1 - \frac{1}{3} \cdot \left( \frac{\frac{L_S}{d_S}}{k_1} \right)^2 \right)$

|| else

||  $\frac{0.3 \cdot E_w}{\left( \frac{L_S}{d_S} \right)^2}$

$$Fc' = 1032 \text{ psi}$$

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$$fc_1 := \frac{P_1}{Area_1} = 95 \text{ psi}$$

$$fb_1 := \frac{Mx_1}{Sx_1} = 1974 \text{ psi}$$

$$Fc' = 1032 \text{ psi}$$

$$F_{bw} = 2333 \text{ psi}$$

$$\frac{fc_1}{Fc'} + \frac{fb_1}{F_{bw}} = 0.938$$

**CHECK SHEAR:**  $L_V := L_1 - 2 \cdot 12 \cdot \text{in} - 2 \cdot 3 \cdot \text{in} = 11 \text{ ft}$

$$Vx_1 := \frac{W_1 \cdot L_V}{2} \quad Vx_1 = 17218 \text{ lbf}$$

$$f_V := \frac{3 \cdot Vx_1}{2 \cdot b_1 \cdot d_S}$$

$$f_V = 179 \text{ psi}$$

$$F_{vt} = 220 \text{ psi}$$

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### 6. DESIGN LUMBER STRUT:

TRY  $b_1 = 12 \text{ in}$  Lumber width  $d_{S1} := 3 \cdot \text{in}$  Lumber depth

$$L_{S1} := L_2 - 2 \cdot 12 \cdot \text{in} = 6.33 \text{ ft}$$

$$\frac{L_{S1}}{d_{S1}} = 25.33$$

$$Sx_2 := \frac{b_1 \cdot d_{S1}^2}{6} = 18 \text{ in}^3$$

$$Area_2 := b_1 \cdot d_{S1} = 36 \text{ in}^2$$

$$Ix_2 := \frac{b_1 \cdot d_{S1}^3}{12} = 27 \text{ in}^4$$

$$Fc'_1 := \begin{cases} \text{if } 0 < \frac{L_{S1}}{d_{S1}} < 10 \\ F_c \\ \text{else} \\ \text{if } \frac{L_{S1}}{d_{S1}} < k_1 \\ F_c \cdot \left( 1 - \frac{1}{3} \cdot \left( \frac{\frac{L_{S1}}{d_{S1}}}{k_1} \right)^2 \right) \\ \text{else} \\ \frac{0.3 \cdot E_w}{\left( \frac{L_{S1}}{d_{S1}} \right)^2} \end{cases}$$

$$k_1 = 25.59$$

$$Fc'_1 = 741 \text{ psi}$$

$$Pr_2 := Area_2 \cdot Fc'_1 = 26664 \text{ lbf}$$

$$L_{V1} := L_1 - 2 \cdot 12 \cdot \text{in} = 11.00 \text{ ft}$$

$$Pa_2 := \frac{W_1 \cdot L_{V1}}{2} \quad Pa_2 = 18038 \text{ lbf}$$



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### 7. DESIGN WOOD SHEETING:

$$B_1 = 6.50 \text{ ft} \quad Rb_1 = 1006 \text{ plf} \quad F_{bw} = 2333 \text{ psi}$$

$$C_1 = 6.00 \text{ ft} \quad Pm_1 = 575 \text{ psf}$$

**BENDING:**

$$Mx_A := \frac{Pm_1 \cdot 1 \cdot \text{ft} \cdot B_1^2}{8} \quad Mx_A = 3037 \text{ ft} \cdot \text{lb}$$

$$S_{shg} := \frac{Mx_A}{F_{bw}} = 15.62 \text{ in}^3$$

**TRY**  $b_2 := 12 \cdot \text{in}$  **Wood width**  $d_{s2} := 3 \cdot \text{in}$  **Wood depth**

$$Sx_2 := \frac{b_2 \cdot d_{s2}^2}{6} = 18.00 \text{ in}^3 \quad Ix_2 := \frac{b_2 \cdot d_{s2}^3}{12} = 27.00 \text{ in}^4$$

**CHECK SHEAR:**

$$Vx_2 := Rb_1 \cdot 1 \cdot \text{ft} \quad Vx_2 = 1006 \text{ lbf}$$

$$f_v := \frac{3 \cdot Vx_1}{2 \cdot b_1 \cdot d_s} \quad f_v = 179 \text{ psi} \quad F_{vw} = 233 \text{ psi}$$

**PENETRATION:**  $Rb_1 = 1006 \text{ plf}$   $Pp_1 = 307 \frac{\text{psf}}{\text{ft}}$   $SF := 1.15$

$$D_0 := \sqrt{\frac{2 \cdot Rb_1}{Pp_1}} \cdot (SF) \quad D_0 = 2.95 \text{ ft}$$