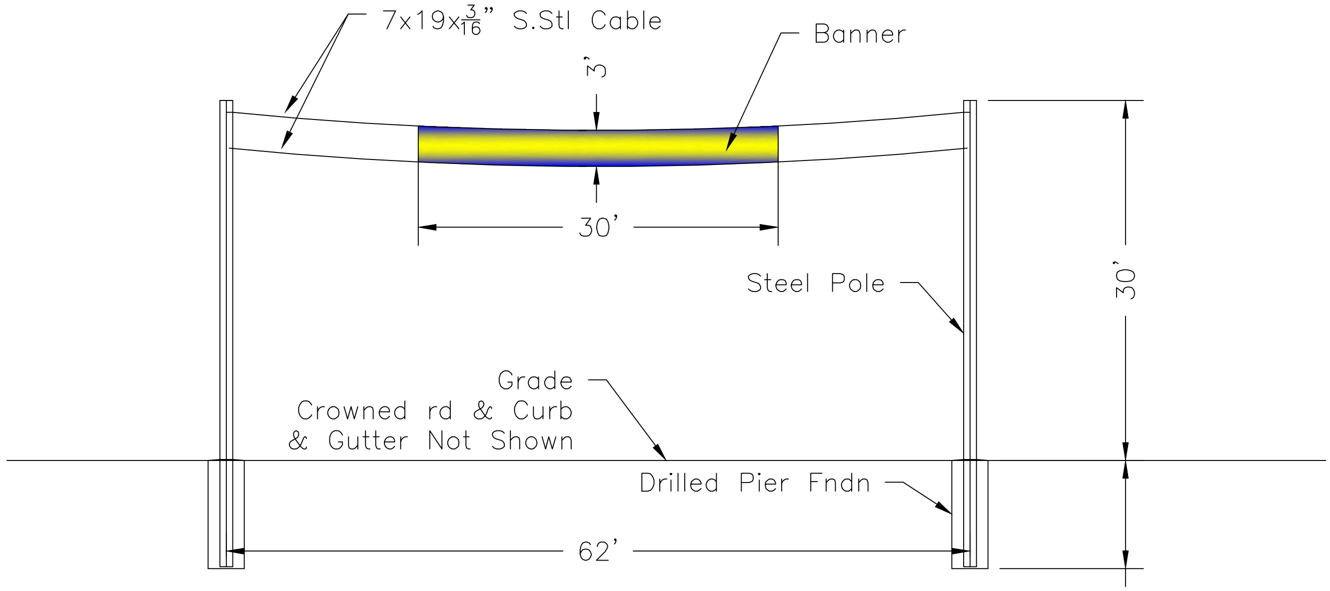
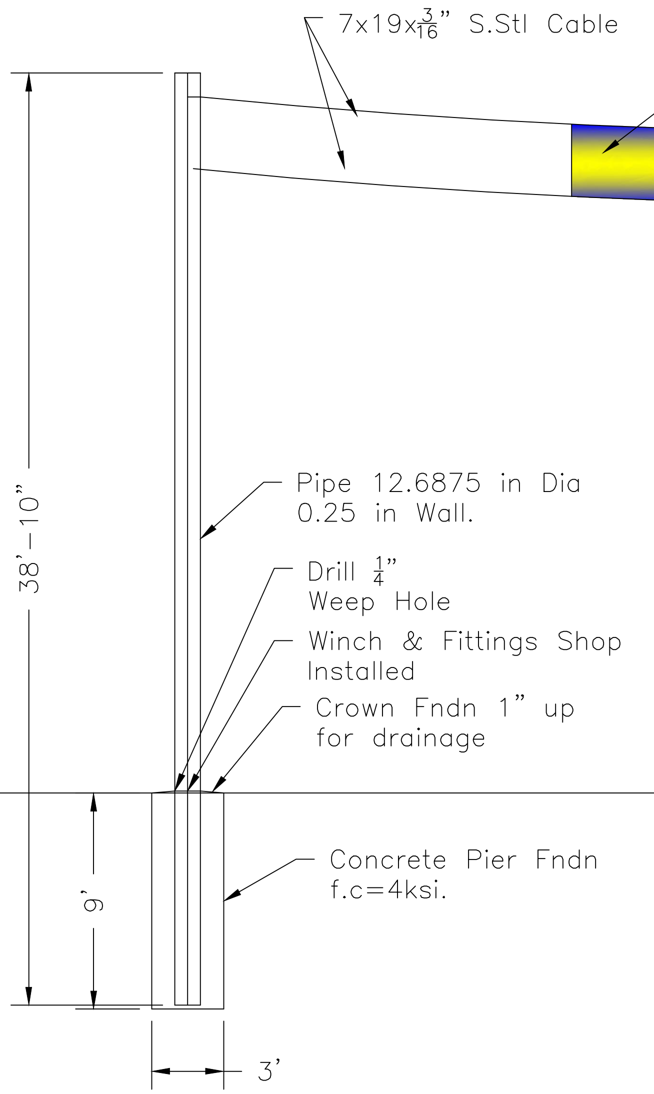


Elevation



Elevation Detail

Load Conditions and Reactions
Wind 115 MPH Exp B
Seismic Classification D
Lateral Force At Base 3.4 Kips
Over Turning Moment 100.8 Ft Kip
Vertical Load -1.5 Kips

Material: Steel API 5L X65 St'l
Concrete f'c=4000 psi
Flag: 3'x30' PVC Polyester
Code Requirement: ASCE7-10
Wind Load Based on 115 MPH
Exp. B

Val Kelly
Associated Foods
Logan, UT

Colonial Flag

9390 So 300 West Sandy, UT
84070
800 782-0500

G&A
ENG. SERVICES INC.
SALT LAKE CITY, UTAH

G&A Engineering Services, Inc.
3270 East Coronet Dr.
Salt Lake City, UT 84124
Phone: 801 272-1622
Fax: 801 272-1688

Sign Cloth Tension Calculations for Simple Span with Uniform Loads.

Sign Cloth Span — $l := 30ft$

Sign Cloth Length Stretched — L to be determined

Sign Cloth Sag — f to be determined

Sign Cloth Cross Sectional Area per Inch — $A = 0.16 \cdot in^2$

Sign Cloth Modulus of Elasticity — $E := 400000psi$

Sign Cloth Load per lin ft — $q := q_w \cdot 12in$ — $q = 20.14 \cdot \frac{lbf}{ft}$

Distance Between Tie Downs — $d := 3ft$

Calculate f

$$f := l \cdot \left[\frac{(3 \cdot q \cdot l)}{64 \cdot E \cdot A}\right]^{\frac{1}{3}} \qquad f = 27.42 \cdot in$$

$$L := l \cdot \left[1 + \left(\frac{8}{3}\right) \cdot \left(\frac{f}{l}\right)^2\right] \qquad L = 365.57 \cdot in$$

$$T := \frac{\left(q \cdot l^2\right)}{8f} \cdot \left[1 + 16 \cdot \left(\frac{f}{l}\right)^2\right]^{.5} \qquad T = 1036.47 \cdot lbf$$

$$\sigma_{ten} := \frac{T}{12 \cdot A} \qquad \sigma_{ten} = 539.2 \cdot psi$$

Tensile Load per Inch — $\sigma_{ten} \cdot A = 86.37 \cdot lbf$

Tensile Strength Fabric 150 lbf / in

$$\Delta L := \frac{(T \cdot L)}{E \cdot A} \qquad \Delta L = 5.91 \cdot in$$

$$\Delta f := \frac{\Delta L}{\frac{16}{15} \cdot \left(\frac{f}{l}\right) \cdot 5 - 24 \cdot \left(\frac{f}{L}\right)^2} \qquad \Delta f = 21.8 \cdot in$$

$$\alpha := atan\left[4 \cdot \frac{(f + \Delta f)}{l}\right] \qquad \alpha = 28.68 \cdot deg$$

$$V := T \cdot \sin(\alpha) \qquad V = 497.37 \cdot lbf$$

$$H := T \cdot \cos(\alpha) \qquad H = 909.33 \cdot lbf$$

CAL-WIRE STRANDIN COMPANY

6 X 7 CLASS

6 x 7 GALVANIZED			6 X 7 BRIGHT			6 X 7 BRIGHT		
IMPROVED PLOW STEEL *			IMPROVED PLOW STEEL *			IMPROVED PLOW STEEL *		
FIBER CORE, POLY CORE			STRAND CORE			FIBER CORE, POLY CORE		
DIAMETER IN INCHES	APPROX WEIGHT PER FOOT	NOMINAL BREAKING STRENGTH IN TONS	DIAMETER IN INCHES	APPROX WEIGHT PER FOOT	NOMINAL BREAKING STRENGTH IN TONS	DIAMETER IN INCHES	APPROX WEIGHT PER FOOT	NOMINAL BREAKING STRENGTH IN TONS
1/4	0.094	2.38	3/16	0.062	1.61	3/16	0.056	1.5
5/16	0.15	3.69	1/4	0.10	2.84	1/4	0.094	2.64
3/8	0.21	5.27	5/16	0.16	4.41	5/16	0.15	4.10
7/16	0.29	7.14	3/8	0.23	6.30	3/8	0.21	5.86
1/2	0.38	9.27	7/16	0.32	8.52	7/16	0.29	7.93
9/16	0.48	11.7	1/2	0.42	11.1	1/2	0.38	10.3
5/8	0.59	14.3	9/16	0.53	14.0	9/16	0.48	13.0
3/4	0.84	20.4	5/8	0.65	17.1	5/8	0.59	15.9
7/8	1.15	27.6	3/4	0.92	24.4	3/4	0.84	22.7
1	1.50	35.7	7/8	1.27	33.0	7/8	1.15	30.7
1 1/8	1.90	44.8	1	1.65	42.7	1	1.50	39.7
1 1/4	2.34	54.9	1 1/8	2.09	53.5	1 1/8	1.90	49.8
1 3/8	2.84	65.8	1 1/4	2.57	65.6	1 1/4	2.34	61.0
1 1/2	3.38	77.6	1 3/8	3.12	78.6	1 3/8	2.84	73.1
			1 1/2	3.72	92.7	1 1/2	3.38	86.2

***EIPS ROPES AVAILABLE CALL FOR QUOTES AND INFORMATION**
ALL ROPES PER RR-W-410-D

HOME

Loads On Top & Bot Cable

$$P_v := \frac{d}{2} \cdot \frac{V}{ft}$$

$$P_v = 746.06 \cdot lbf$$

(Edge of Panel)

$$P_h := \frac{d}{2} \cdot \frac{H}{ft}$$

$$P_h = 1364 \cdot lbf$$

Find Take up Cables with load Capacity to Handle T*d/2

$$\frac{T}{2} \cdot \frac{d}{ft} = 1554.7 \cdot lbf$$

DESIGN LOADS:

WIND LOAD   Shape Factor $C_q := .85$

115 MPH EXPOSURE "C" $w_w := C_q \cdot 33.86 \cdot \frac{lbf}{ft^2}$ Ice on Pole $d_i := 0.0 \cdot in$

DESIGN PARAMETERS:

ALLOWABLE STRESSES

Steel

SHELL

$f_{yshell} := 65000 \cdot psi$

$f_{bshell} := .6 \cdot f_{yshell}$

FLANGE

$f_{yflng} := 65000 \cdot psi$

$f_{bflng} := .6 \cdot f_{yflng}$

MODULUS OF ELASTICITY

Steel $E_{stl} := 29 \cdot 10^6 \cdot psi$

ELEVATION WIND COEFFICIENTS

$C_{e15} := 0.70$

$C_{e20} := 0.70$

$C_{e25} := 0.70$

$C_{e30} := 0.70$

$C_{e40} := 0.76$

$C_{e60} := 0.85$

$C_{e80} := 0.93$

$C_{e100} := 0.99$

Tapered Pole

Two SECTIONS

DIAMETERS

$d := 12.6875 \cdot in$ $d_1 := 12.6875 \cdot in$ $d_2 := 12.6875 \cdot in$

WALL THICKNESS

$t := 0.25 \cdot in$ $t_1 := 0.25 \cdot in$ $t_2 := 0.25 \cdot in$

SECTION LENGTHS

$L := 15 \cdot ft$ $L_1 := 15 \cdot ft$ $L_2 := 0 \cdot ft$

Flags Exposed Areas.

$A_3 := 3 \cdot ft^2$ Exposed Area to Match Load calculated on Drag Force Calculation

HEIGHT OF Pole: $H := 30 \cdot ft$

Loads on Pole

Pole Section 1

$$P := w_w \cdot \left(2 \cdot d_i + \frac{d + d_1}{2}\right) \cdot C_{e15} \cdot L$$

$$P = 319.51 \cdot lbf$$

Pole Section 2

$$P_1 := w_w \cdot \left[2 \cdot d_i + \frac{\left(d_1 + d_2\right)}{2}\right] \cdot C_{e30} \cdot L_1$$

$$P_1 = 319.51 \cdot lbf$$

Elevation of Load

$$a := 7.5 \cdot ft$$

$$a_1 := 22.5 \cdot ft$$

Cable Load

$$P_3 := 1600 lbf$$

$$P_3 = 1600 \cdot lbf$$

$$P_4 := 1600 lbf$$

$$P_4 = 1600 \cdot lbf$$

Elevation of Load

$$a_3 := 30 \cdot ft$$

Elevation of Load

$$a_4 := 27 \cdot ft$$

Moment of Inertia:

$$I := .049087 \cdot \left[d^4 - (d - 2 \cdot t)^4\right]$$

$$I_1 := .049087 \cdot \left[{d_1}^4 - \left(d_1 - 2t_1\right)^4\right]$$

Area of cross-section:

$$A := \frac{\pi \cdot \left[d^2 - (d - 2t)^2\right]}{4}$$

$$A_1 := \frac{\pi \cdot \left[{d_1}^2 - \left(d_1 - 2t_1\right)^2\right]}{4}$$

$$S := \frac{I}{d} \cdot 2$$

$$S_1 := \frac{I_1}{d_1} \cdot 2$$

Now compute the deflection and stress at points along the beam:

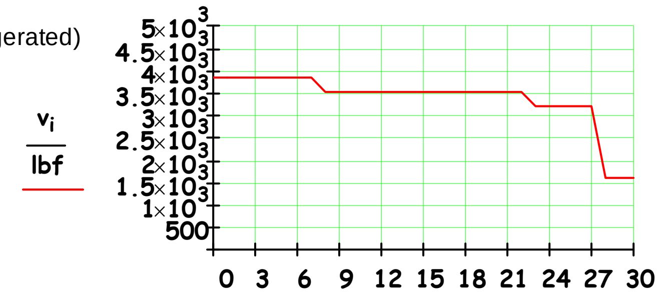
Points along the beam: $i := 0 .. \frac{H}{ft}$ $\quad x_i := i \cdot \frac{H}{\frac{H}{ft}}$

Reactions:

$R_1 := P_1 + P + P_2 + P_3 + P_4 + P_5 \qquad R_1 = 3839.03 \cdot lbf$

Shear Diagram

Side view of beam
(vertical dimension greatly exaggerated)



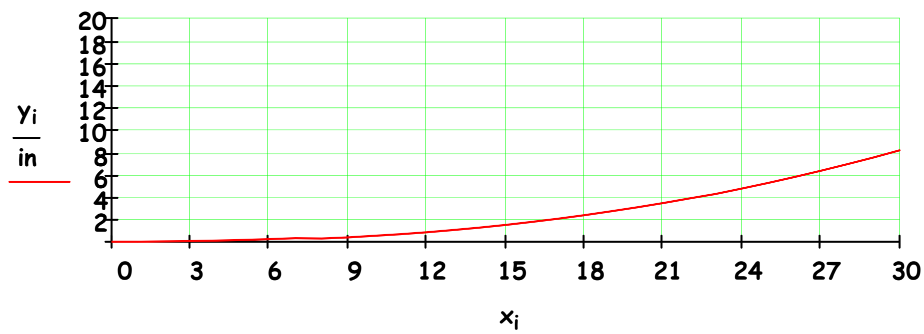
Shear Stress

$v_{max} := R_1$

$\sigma_{shear} := \frac{v_{max}}{A} \qquad \sigma_{shear} = 393.01 \cdot psi$

Deflection:

$y_{\frac{H}{ft}} = 14.3 \cdot in$



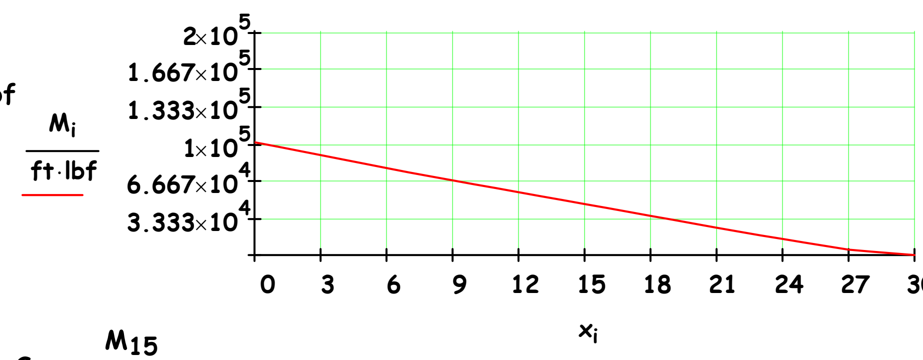
Stress and bending moment:

Moment diagram for beam

$M_0 = 100785.42 \cdot ft \cdot lbf$

$M_5 = 81590.28 \cdot ft \cdot lbf$

$M_{25} = 11200 \cdot ft \cdot lbf$



STRESS AT BOTTOM OF EACH SECTION

$S_0 := \frac{M_0}{S} \qquad S_{15} := \frac{M_{15}}{S_1}$

$S_0 = 40602.6 \cdot psi \qquad S_{15} = 18369.03 \cdot psi$

$\frac{S_0}{f_{bshell}} = 1.04$ <1.0 $\qquad \frac{S_{15}}{f_{bshell}} = 0.47$ <1.0

Drilled Shaft Foundation for Sign & Signal Structures

SUBJECT Street Banner Pier Foundation
DESIGNED BY JCG DATE 7/21/14
CHECKED BY JCG DATE 7/21/14

Input

SoilType := [Sand (selected) / Clay]

WaterElevation := [Below Bottom of Shaft (selected) / Above Top of Shaft]

$\gamma_{soil.dry} := \mathbf{110} \cdot pcf$ *dry soil density* $\gamma_{water} := 62.4 \cdot pcf$ *water density*

$\gamma_{soil} := \gamma_{soil.dry} - \text{if}(\text{WaterElevation} = \text{"Above Top of Shaft"}, \gamma_{water}, 0 \cdot pcf) = 110 \cdot pcf$

$\gamma_{soil} = 110 \cdot pcf$

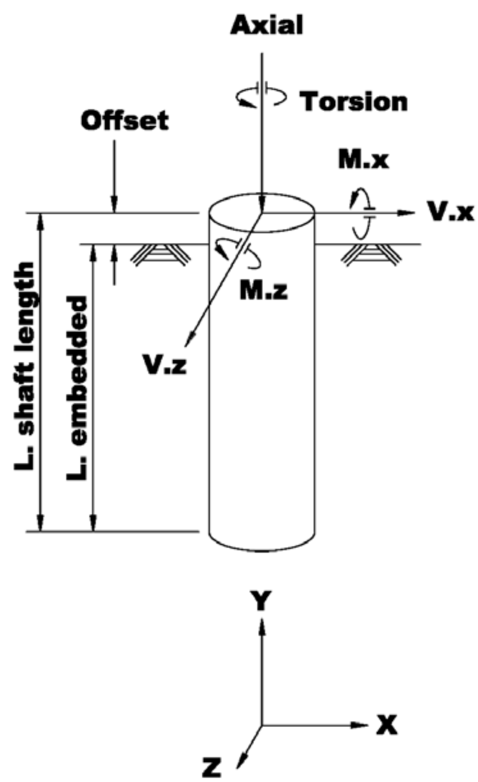
$b := 3 \cdot ft$ *shaft diameter* $\text{Offset} := \mathbf{0.0} \cdot ft$ *groundline to top of foundation*

$\phi_{soil} := 30 \cdot deg$ *soil friction angle (sand)* $c_{soil} := 2.0 \cdot \frac{kip}{ft^2}$ *soil shear strength (clay)*

Applied Loads

$M_x := 100.8 \cdot kip \cdot ft$ $V_x := 3.9 \cdot kip$ $\text{Torsion} := .05 \cdot kip \cdot ft$

$M_z := 0 \cdot kip \cdot ft$ $V_z := 0 \cdot kip$ $\text{Axial} := 1.5 \cdot kip$



Shaft Depth Required to Resist Overturning

$SF_{ot} := \mathbf{2}$ *Safety Factor against Overturning* SM Vol-9 13.6

$M_{total} := (SF_{ot}) \cdot \sqrt{M_x^2 + M_z^2}$ $P_{total} := (SF_{ot}) \cdot \sqrt{V_x^2 + V_z^2}$

$M_{total} = 201.6 \cdot kip \cdot ft$ $P_{total} = 7.8 \cdot kip$

*short free-head pile in **cohesionless soil** using Broms method*

$K_p := \tan\left(45 \cdot deg + \frac{\phi_{soil}}{2}\right)^2$ $e_{sand} := \text{Offset}$

Guess value $L_{otSand} := 8 \cdot ft$

Given $\frac{\gamma_{soil} \cdot b \cdot L_{otSand}^3 \cdot K_p}{2} - P_{total} \cdot (e_{sand} + L_{otSand}) - M_{total} = 0 \cdot kip \cdot ft$

$\text{Temp} := \text{Find}(L_{otSand})$ $L_{otSand} := \text{Temp}$ $L_{otSand} = 8.12 \cdot ft$

(round up to next foot) $L_{otSand} := \text{ceil}\left(\frac{L_{otSand}}{ft}\right) \cdot ft$ $L_{otSand} = 9\ ft$

short free-head pile in __cohesive soil__ using Modified Broms method for L < 3b (see reference file for derivation)

$c_{soil} := if(c_{soil} = 0 \cdot ksf, 0.1 \cdot ksf, c_{soil})$ $\quad Slope := 8 \cdot \frac{c_{soil}}{3 \cdot b}$ $\quad e_{clay} := \frac{M_{total}}{P_{total}} + Offset$

$nforce(M,N) := \left[Slope \cdot (2 \cdot M + N) + 2 \cdot c_{soil}\right] \cdot N \cdot \frac{b}{2}$ $\quad mforce(M) := \left(2 \cdot c_{soil} + M \cdot Slope\right) \cdot M \cdot \frac{b}{2}$

$$m\_arm(M) := e_{clay} + \frac{M}{3} \cdot \frac{2 \cdot \left(M \cdot Slope + c_{soil}\right) + c_{soil}}{M \cdot Slope + 2 \cdot c_{soil}}$$

$$n\_arm(M,N) := e_{clay} + M + \frac{N}{3} \cdot \frac{2 \cdot \left(N \cdot Slope + M \cdot Slope + c_{soil}\right) + \left(M \cdot Slope + c_{soil}\right)}{Slope \cdot (2 \cdot M + N) + 2 \cdot c_{soil}}$$

Guess value $\quad M := 4.0 \cdot ft \quad N := 4.0 \cdot ft$

Given $\quad P_{total} + nforce(M,N) = mforce(M) \quad mforce(M) \cdot m\_arm(M) = nforce(M,N) \cdot n\_arm(M,N)$

$\begin{pmatrix} M \\ N \end{pmatrix} := Find(M,N) \quad L_{ot1Clay} := M + N \quad L_{ot1Clay} = 6.74 \cdot ft$

(round up to next foot) $\quad L_{ot1Clay} := ceil\left(\frac{L_{ot1Clay}}{ft}\right) \cdot ft \quad L_{ot1Clay} = 7 \cdot ft$

short free-head pile in __cohesive soil__ using Regular Broms method for L > 3b

$f_{clay} := \frac{P_{total}}{9 \cdot c_{soil} \cdot b} \quad M_{maxtemp} := P_{total} \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f_{clay}\right) \quad g := \sqrt{\frac{M_{maxtemp}}{2.25 \cdot c_{soil} \cdot b}}$

$L_{ot2Clay} := \left(1.5 \cdot b + f_{clay} + g\right) \quad L_{ot2Clay} = 8.84\, ft$

(round up to next foot) $\quad L_{ot2Clay} := ceil\left(\frac{L_{ot2Clay}}{ft}\right) \cdot ft \quad L_{ot2Clay} = 9 \cdot ft$

$L_{otClay} := if\left(L_{ot1Clay} < 3 \cdot b, L_{ot1Clay}, L_{ot2Clay}\right) \quad L_{otClay} = 7 \cdot ft$

(If $L_{ot} < 3b$, use Modified Broms method)

$L_{reqdOT} := if\left(SoilType = "Sand", L_{otSand}, L_{otClay}\right) \quad L_{reqdOT} = 9\, ft$

Shaft Depth Required to Resist Torsion

$SF_{tor} := \mathbf{1.3}$ *Safety Factor against Torsion*
1.0 for Mast Arm signal structures
1.3 for Overhead Cantilever sign structures *SM Vol-9 13.6*

$\omega_{fdot} := 1.5$ *load transfer ratio* *SM Vol-9 13.6* $\mu := \tan(\phi_{soil})$ *coefficient of friction between shaft and soil* $\mu = 0.58$

$\gamma_{concrete} := 150 \cdot pcf$ $\gamma_{concrete} := \gamma_{concrete} - \text{if}(\text{WaterElevation} = \text{"Above Top of Shaft"}, \gamma_{water}, 0 \cdot pcf) = 150 \cdot pcf$

$\gamma_{concrete} = 150 \cdot pcf$

$\text{CohesionFactor} := 0.55$ $f_{se} := \text{CohesionFactor} \cdot c_{soil}$

short free-head pile in ***cohesionless soil***

Guess value $L_{torSand} := L_{reqdOT}$

Given

$$\text{Torsion} = \frac{\left[\pi \cdot b \cdot (L_{torSand}) \cdot \gamma_{soil} \cdot \left(\frac{L_{torSand}}{2}\right) \cdot (\omega_{fdot}) \cdot \frac{b}{2} + \pi \cdot \left(\frac{b}{2}\right)^2 \cdot L_{torSand} \cdot (\gamma_{concrete}) \cdot \frac{b}{3} \cdot \mu\right]}{SF_{tor}}$$

$\text{Temp} := \text{Find}(L_{torSand})$ $L_{torSand} := \text{Temp}$ $L_{torSand} = 0.1\,ft$

(round up to next foot) $L_{torSand} := \text{ceil}\left(\frac{L_{torSand}}{ft}\right) \cdot ft$ $L_{torSand} = 1\,ft$

short free-head pile in ***cohesive soil***

Guess value $L_{torClay} := L_{reqdOT}$

Given $\left[f_{se} \cdot (\pi \cdot b) \cdot (L_{torClay} - 1.5 \cdot ft) \cdot \frac{b}{2}\right] + \left[f_{se} \cdot \pi \cdot \left(\frac{b}{2}\right)^2 \cdot \left(\frac{b}{3}\right)\right] = \text{Torsion} \cdot SF_{tor}$

$\text{Temp} := \text{Find}(L_{torClay})$ $L_{torClay} := \text{Temp}$ $L_{torClay} = 1\,ft$

(round up to next foot) $L_{torClay} := \text{ceil}\left(\frac{L_{torClay}}{ft}\right) \cdot ft$ $L_{torClay} = 2\,ft$

$L_{reqdTor} := \text{if}(\text{SoilType} = \text{"Sand"}, L_{torSand}, L_{torClay})$ $L_{reqdTor} = 1\,ft$

$L_{embedded} := \text{if}(L_{reqdTor} > L_{reqdOT}, L_{reqdTor}, L_{reqdOT})$ $L_{embedded} = 9\,ft$

$L_{shaft.length} := L_{embedded} + \text{Offset}$ $L_{shaft.length} = 9\,ft$

Unfactored Maximum Moment in Shaft

*short free-head pile in **cohesionless soil** using Broms method*

$$f_{sand} := \sqrt{\frac{2 \cdot \frac{P_{total}}{SF_{ot}}}{3 \cdot \gamma_{soil} \cdot b \cdot K_p}} \qquad f_{sand} = 1.62\,ft$$

$$M_{maxSand} := \frac{P_{total}}{SF_{ot}} \cdot \left(e_{sand} + f_{sand}\right) - \frac{\frac{P_{total}}{SF_{ot}} \cdot f_{sand}}{3} + \frac{M_{total}}{SF_{ot}} \qquad M_{maxSand} = 105 \cdot kip \cdot ft$$

*short free-head pile in **cohesive soil** using Modified Broms method for L < 3b (see reference file for derivation)*

Guess value $f_{mod} := 4.0 \cdot ft$

Given

$$\frac{P_{total}}{SF_{ot}} = \frac{f_{mod} \cdot b}{2} \cdot \left(2 \cdot c_{soil} + f_{mod} \cdot Slope\right)$$

$$f_{mod} := Find\left(f_{mod}\right) \qquad f_{mod} = 0.53\,ft$$

$$M_{modBroms} := \frac{P_{total}}{SF_{ot}} \cdot \left(e_{clay} + f_{mod}\right) - \frac{c_{soil} \cdot b \cdot f_{mod}^{\ 2}}{2} - \frac{b \cdot f_{mod}^{\ 3} \cdot Slope}{6} \qquad M_{modBroms} = 101.9 \cdot kip \cdot ft$$

*short free-head pile in **cohesive soil** using Regular Broms method for L > 3b*

$$M_{Broms} := \frac{P_{total}}{SF_{ot}} \cdot \left(e_{clay} + 1.5 \cdot b + 0.5 \cdot f_{clay}\right) \qquad M_{Broms} = 118.6 \cdot kip \cdot ft$$

$$M_{maxClay} := if\left(L_{ot1Clay} < 3 \cdot b, M_{modBroms}, M_{Broms}\right) \qquad M_{maxClay} = 101.9 \cdot kip \cdot ft$$

(If $L_{ot} < 3b$, use Modified Broms method)

$$M_{max} := if\left(SoilType = \text{"Sand"}, M_{maxSand}, M_{maxClay}\right)$$

(this is a Service moment) $M_{max} = 105 \cdot kip \cdot ft$