WAYPOINT ENGINEERING

21-074108 REV 01 SD

STRUCTURAL CALCULATIONS

Sellwood Moreland Steeple

SE Lambert St & SE Milwaukie Ave
Portland, OR 97202
22465

Prepared For:

Steelhead Architecture

5210 SE 26th Ave
Portland, OR 97202

REGISTERED PROFESSIONAL ENGINEER
81013PE
OREGON
12-09-2013
JARED N FISCHER
EXPIRES: 12-31-2023

DATE LOG

Date:	March 10, 2023
Revision(s):	

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DESIGN CRITERIA

SECTION A

NARRATIVE

Waypoint Engineering was retained in limited capacity to perform the following work for this project including:

- Structural analysis of building vertical and lateral force resisting systems.
- Lateral analysis utilizing steel cantilever column on reinforced concrete footings.
- Gravity analysis including existing wood structure on reinforced concrete footings.

REFERENCES

- 2022 Oregon Structural Specialty Code (OSSC)
- ASCE/SEI 7-16 American Society of Civil Engineers, ASCE Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE)

GRAVITY DESIGN DATA

Dead Load:	
Steeple	10 psf
Roof Snow Load:	
Ground Snow Load, Pg:	9 psf (SEAO)
Flat-Roof Snow Load, Pf:	25 psf (ASCE 7.3)
Snow Exposure Factor, Ce:	1.0 (ASCE Table 7.3-1)
Importance Factor, Is:	1.0 (ASCE Table 1.5-2)
Thermal Factor, Ct:	1.0 (ASCE Table 7.3-2)
Slope Factor, Cs:	1.0 (ASCE 7.4 And Table 7.4-1)
Deflection Limits:	
Snow or Wind Load	L/120

WIND DESIGN DATA

Basic Design Wind Speed, V:	98 Mph (IBC 1609.3.1)
Nominal Design Wind Speed, Vasd =V√0.6:	76 Mph (IBC Equation 16-33)
Risk Category:	II (ASCE Table 1.5-1)
Wind Exposure:	Surface Roughness B (ASCE 26.7.2) (N/S And E/W Directions) Exposure B (ASCE 26.7.3) (N/S And E/W Directions)
Internal Pressure Coefficients, GCpi:	±0.18 (Partially Open) (ASCE Table 26.13-1)
Component And Cladding Wind Pressures, P:	47 psf (Nominal Load, ASCE 30.3)

SEISMIC DESIGN DATA

Risk Category:	II (ASCE Table 1.5-1)
Seismic Importance Factor, Ie:	1.00 (ASCE Table 1.5-2)
Mapped Spectral Response Acceleration Parameters, Ss/S1:	0.89/0.39
Site Class:	C – Very Dense Soil and Soft Rock (ASCE 20.3 And Table 20.3-1)
Design Spectral Response Acceleration Parameters, Sds /Sd1:	0.71/0.39
Seismic Design Category:	D (ASCE 11.6)
Basic Seismic Force-Resisting System(S):	Steel Ordinary Cantilever Column System (N/S And E/W Directions) (ASCE Table 12.2-1)
Design Base Shear(S):	
Steeple	2.91 Kips
Seismic Response Coefficient(S), Cs:	0.568 (ASCE 12.8.1.1)
Response Modification Coefficient(S), R:	1.25 (N/S And E/W Directions) (ASCE Table 12.2-1)
Analysis Procedure Used:	Equivalent Lateral Force (ELF) Procedure (ASCE 12.8)

GEOTECHNICAL DESIGN DATA

Foundations:	
Allowable Soil Pressure, D+SL:	2,500 psf (Geotechnical Report)
Allowable Soil Pressure, D+L+E/1.4:	3,325 psf (Geotechnical Report)
Coefficient of Friction:	0.35 (Geotechnical Report)
Lateral Bearing Pressure: (Passive Soil Resistance)	250 psf/ft (Geotechnical Report)
Retaining Walls:	
Lateral Soil Load, Active Pressures:	35 psf/ft (Geotechnical Report)
Lateral Soil Load, At-Rest Pressures:	58 psf/ft (Geotechnical Report)
Earthquake Lateral Pressure:	20h (Uniform Distribution)

LATERAL DESIGN

SECTION B

Steeple:

Siding	2.90 psf
Sheathing	1.70 psf
2x4 at 16" OC	1.10 psf
3x6 at 16" OC	2.70 psf
Miscellaneous	1.60 psf
Total:	**10.00 psf**

WIND:

$$q_z = 0.002560\ K_z K_{zt} K_d V^2 \quad (26.10-1)$$

$$q_z = 0.00256(0.67)(1.0)(1.0)(98\ mph)^2$$

$$q_z = 16.47\ PSF$$

$$F = q_z G C_f A_f \quad (29.4-1)$$

$$= (16.47\ PSF)(0.85)(0.85)\ A_f$$

$$= 11.2\ PSF \times A_f$$

$h = 34'-0"$

$D = 7'-0"$

$h/D = 34'/7' = 4.85$

$1 < 4.85 < 7$

$C_f = 0.8$ (FIGURE 29.4-1)

SEISMIC:

SURFACE AREA OF A CONE (LATERAL)

$$L = \pi r \sqrt{r^2 + h^2}$$

$$= \pi \frac{9.5'}{2} \sqrt{\left(\frac{9.5}{2}\right)^2 + (34')^2}$$

$$= 512.3\ ft^2$$

10 PSF STEEPLE WEIGHT

$W = 10\ PSF \times 512.3\ FT^2 = 5,123\ LBS$

STEEL ORDINARY CANTILEVER COLUMN

$R = 1\frac{1}{4}$ (TABLE 12.2-1)

$\Omega = 1\frac{1}{4}$

$C_d = 1\frac{1}{4}$

$$V = C_s W \quad (12.1-1)$$

$$= 0.568 \times 5,123\ LBS$$

$$= 2,910\ LBS \sim 2.91\ KIPS$$

$$C_s = \frac{S_{DS}}{R/I_e} \quad (12.8-2)$$

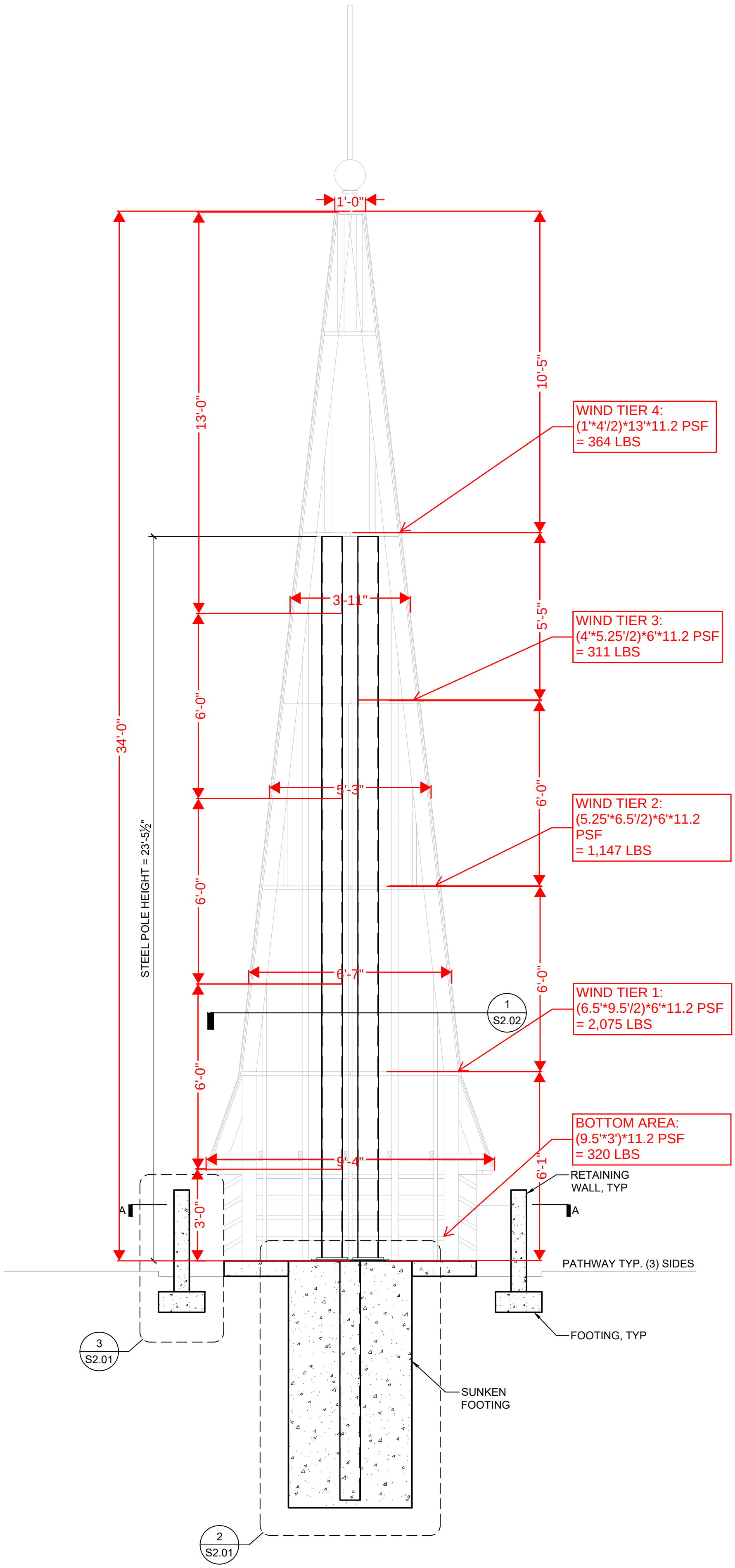
$$= \frac{0.71}{1\frac{1}{4}/1}$$

$$= 0.568$$

WAYPOINT ENGINEERING

PROJECT: 22465 - Sellwood Moreland Steeple
SUBJECT: Steeple Wind Loading

DATE: 03/10/2023
DESIGN: CD
PAGE:



MAX WIND AT TIER 1:

WIND = 2,075 LBS (WORST CASE)

(S) LS50 CLIP : 730 LBS ALLOWABLE WIND

$$\underbrace{(4)\,730 \text{ LBS} = 2920 \text{ LBS}}_{\text{CONNECTION CAPACITY}} > \underbrace{2{,}075 \text{ LBS}}_{\text{APPLIED LOAD AT CONNECTION}}$$

BASE WELD CHECK:

HSS 8x8x1/4 WORK-ABLE FLAT = 6 7/8"

ASD : $\frac{R_n}{\Omega} = (0.928 \text{ kip/in})\, D\ell$ (AISC 8-2b)

$= (0.928 \text{ kip/in})(4)(6\ 7/8")$

$= 25.52$ kip per side

MAX MOMENT AT COLUMN BASE = 25.418 K-FT

$25.418 \text{ K-FT} \,/\, \left(\frac{8"}{12"}\right) = 38.127 \text{ K}$

(2) 25.52 KIPS = 51.04 KIPS AVAILABLE CAPACITY

38.127 KIPS < 51.04 KIPS ∴ CONNECTION HAS ADEQUATE CAPACITY

Steel Column

DESCRIPTION: C1 - Steeple interior steel pole loading at tiers (ASD)

Code References

Calculations per AISC 360-16, IBC 2021, ASCE 7-16
Load Combinations Used : ASCE 7-16

General Information

Steel Section Name : **HSS8x8x1/4**
Analysis Method : Allowable Strength
Steel Stress Grade , A500, Grade C, Fy = 50 ksi, Carbon Steel
Fy : Steel Yield 50.0 ksi
E : Elastic Bending Modulus 19,000.0 ksi

Overall Column Height 23.50 ft
Top & Bottom Fixity Top Free, Bottom Fixed
Brace condition for deflection (buckling) along columns :
X-X (width) axis :
Unbraced Length for buckling ABOUT Y-Y Axis = 23.50 ft, K = 2.1
Y-Y (depth) axis :
Unbraced Length for buckling ABOUT X-X Axis = 23.50 ft, K = 2.1

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 606.11 lbs * Dead Load Factor
BENDING LOADS . . .
Wind Tier 4 - Trapizoid: (1'*4'/2)*13'*11.2psf: Lat. Point Load at 23.50 ft creating Mx-x, W = 0.3640 k
Wind Tier 3 - Trapizoid: (4'*5.25'/2)*6'*11.2psf: Lat. Point Load at 18.250 ft creating Mx-x, W = 0.3110 k
Wind Tier 2 - Trapizoid: (5.2'*6.5'/2)*6'*11.2psf: Lat. Point Load at 12.0 ft creating Mx-x, W = 1.147 k
Wind Tier 1 - Trapizoid: (6.5'*9.5'/2)*6'*11.2psf: Lat. Point Load at 6.0 ft creating Mx-x, W = 2.075 k
Wind Tier 1 - Bottom Area: (9.5'*3')*11.2psf: Lat. Point Load at 6.0 ft creating Mx-x, W = 0.320 k
Base Shear: Lat. Point Load at 0.10 ft creating Mx-x, E = 2.910 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = **0.6307** : 1

Load Combination	+D+0.60W	
Location of max.above base	0.0	ft
At maximum location values are . . .		
Pa : Axial	0.6061	k
Pn / Omega : Allowable	16.461	k
Ma-x : Applied	-25.418	k-ft
Mn-x / Omega : Allowable	41.513	k-ft
Ma-y : Applied	0.0	k-ft
Mn-y / Omega : Allowable	41.513	k-ft

PASS Maximum Shear Stress Rati **0.04140** : 1

Load Combination	+D+0.60W	
Location of max.above base	0.0	ft
At maximum location values are . . .		
Va : Applied	2.530	k
Vn / Omega : Allowable	61.119	k

Maximum Load Reactions . .

Top along X-X	0.0 k
Bottom along X-X	0.0 k
Top along Y-Y	0.0 k
Bottom along Y-Y	4.217 k

Maximum Load Deflections . . .

Along Y-Y 6.422 in at 23.50ft above base
for load combination : W Only

Along X-X 0.0 in at 0.0ft above base
for load combination :

Load Combination Results

Load Combination	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Cbx	Cby	KxLx/Ry	KyLy/Rx	Maximum Shear Ratios: Stress Ratio	Status	Location
D Only	0.037	PASS	0.00 ft	2.76	1.00	188.00	188.00	0.000	PASS	0.00 ft
+D+0.60W	0.631	PASS	0.00 ft	2.76	1.00	188.00	188.00	0.041	PASS	0.00 ft
+D+0.450W	0.478	PASS	0.00 ft	2.76	1.00	188.00	188.00	0.031	PASS	0.00 ft
+0.60D+0.60W	0.623	PASS	0.00 ft	2.76	1.00	188.00	188.00	0.041	PASS	0.00 ft
+D+0.70E	0.037	PASS	0.16 ft	2.76	1.00	188.00	188.00	0.033	PASS	0.00 ft
+D+0.5250E	0.037	PASS	0.16 ft	2.76	1.00	188.00	188.00	0.025	PASS	0.00 ft
+0.60D+0.70E	0.022	PASS	0.16 ft	2.76	1.00	188.00	188.00	0.033	PASS	0.00 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction (k) @ Base	X-X Axis Reaction (k) @ Top	Y-Y Axis Reaction @ Base	Y-Y Axis Reaction @ Top	Mx - End Moments (k-ft) @ Base	Mx - End Moments (k-ft) @ Top	My - End Moments @ Base	My - End Moments @ Top
D Only	0.606								
+D+0.60W	0.606			2.530		-25.418			

Steel Column

DESCRIPTION: C1 - Steeple interior steel pole loading at tiers (ASD)

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	Axial Reaction @ Base	X-X Axis Reaction k @ Base	X-X Axis Reaction @ Top	Y-Y Axis Reaction @ Base	Y-Y Axis Reaction @ Top	Mx - End Moments k-ft @ Base	Mx - End Moments @ Top	My - End Moments @ Base	My - End Moments @ Top
+D+0.450W	0.606			1.898		-19.064			
+0.60D+0.60W	0.364			2.530		-25.418			
+D+0.70E	0.606			2.037		-0.204			
+D+0.5250E	0.606			1.528		-0.153			
+0.60D+0.70E	0.364			2.037		-0.204			
W Only				4.217		-42.364			
E Only				2.910		-0.291			

Extreme Reactions

Item	Extreme Value	Axial Reaction @ Base	X-X Axis Reaction k @ Base	X-X Axis Reaction @ Top	Y-Y Axis Reaction @ Base	Y-Y Axis Reaction @ Top	Mx - End Moments k-ft @ Base	Mx - End Moments @ Top	My - End Moments @ Base	My - End Moments @ Top
Axial @ Base	Maximum	0.606								
"	Minimum				4.217		-42.364			
Reaction, X-X Axis Base	Maximum	0.606								
"	Minimum	0.606								
Reaction, Y-Y Axis Base	Maximum				4.217		-42.364			
"	Minimum	0.606								
Reaction, X-X Axis Top	Maximum	0.606								
"	Minimum	0.606								
Reaction, Y-Y Axis Top	Maximum	0.606								
"	Minimum	0.606								
Moment, X-X Axis Base	Maximum	0.606								
"	Minimum		-42.364		4.217		-42.364			
Moment, Y-Y Axis Base	Maximum	0.606								
"	Minimum	0.606								
Moment, X-X Axis Top	Maximum	0.606								
"	Minimum	0.606								
Moment, Y-Y Axis Top	Maximum	0.606								
"	Minimum	0.606								

Maximum Deflections for Load Combinations

Load Combination	Max. X-X Deflection	Distance	Max. Y-Y Deflection	Distance
D Only	0.0000 in	0.000 ft	0.000 in	0.000 ft
+D+0.60W	0.0000 in	0.000 ft	3.853 in	23.500 ft
+D+0.450W	0.0000 in	0.000 ft	2.890 in	23.500 ft
+0.60D+0.60W	0.0000 in	0.000 ft	3.853 in	23.500 ft
+D+0.70E	0.0000 in	0.000 ft	0.000 in	23.500 ft
+D+0.5250E	0.0000 in	0.000 ft	0.000 in	23.500 ft
+0.60D+0.70E	0.0000 in	0.000 ft	0.000 in	23.500 ft
W Only	0.0000 in	0.000 ft	6.422 in	23.500 ft
E Only	0.0000 in	0.000 ft	0.001 in	23.342 ft

Steel Section Properties : HSS8x8x1/4

Depth	=	8.000 in	I xx	=	70.70 in^4	J	=	111.000 in^4
Design Thick	=	0.233 in	S xx	=	17.70 in^3			
Width	=	8.000 in	R xx	=	3.150 in			
Wall Thick	=	0.250 in	Zx	=	20.500 in^3			
Area	=	7.100 in^2	I yy	=	70.700 in^4	C	=	28.100 in^3
Weight	=	25.792 plf	S yy	=	17.700 in^3			
			R yy	=	3.150 in			

Ycg	=	0.000 in

Waypoint Engineering
700 Washington Street
Suite 605
Vancouver, WA 98660
360.635.6611

Project Title: Sellwood Moreland Steeple
Engineer: CD
Project ID: 22465
Project Descr:

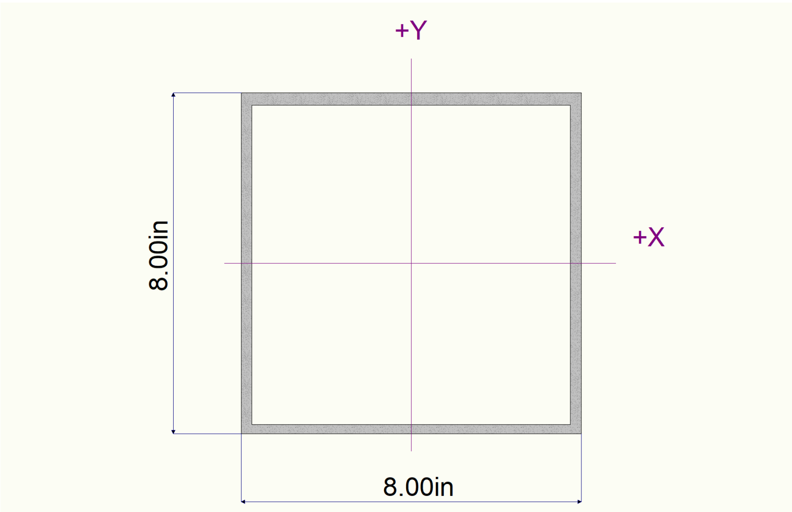
Steel Column

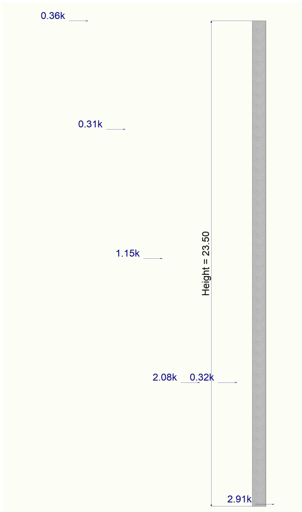
Project File: 22465 - Lateral.ec6

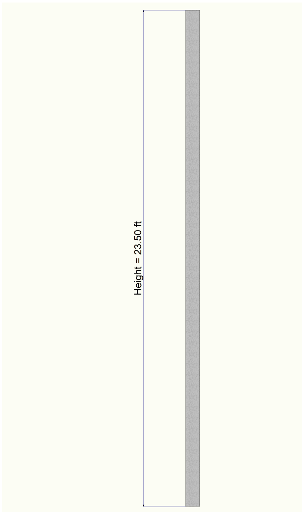
LIC# : KW-06015354, Build:20.23.2.14 Waypoint Engineering, Inc. (c) ENERCALC INC 1983-2022

DESCRIPTION: C1 - Steeple interior steel pole loading at tiers (ASD)

Sketches







Pole Footing Embedded in Soil

DESCRIPTION: F1 - Footing for steeple steel pole

Code References

Calculations per IBC 2021 1807.3, ASCE 7-16
Load Combinations Used : ASCE 7-16

General Information

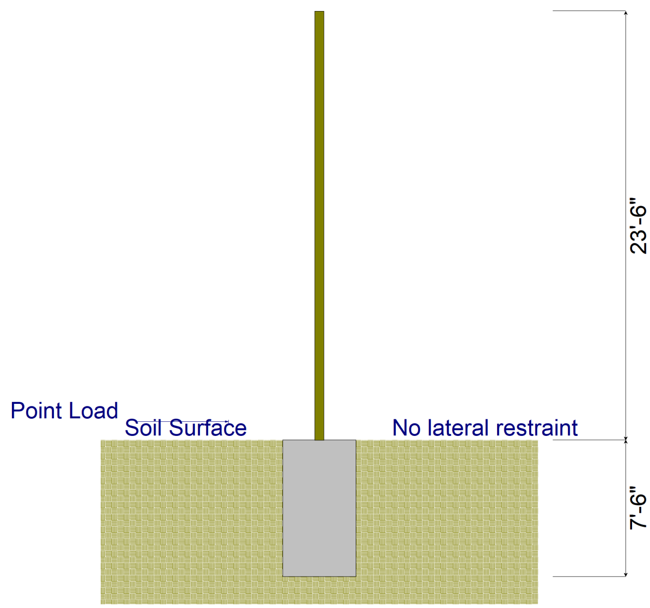
Pole Footing Shape	Circular
Pole Footing Diameter	48.0 in
Find Lateral Pressure for Given Depth	
No Lateral Restraint at Ground Surface	
Allow Passive	250.0 pcf
Max Passive	250.0 psf
Embedment Depth of Footing	7.50 ft

Controlling Values

Governing Load Combination	+0.60W
Lateral Load	2.563 k
Moment	2.563 k-ft

NO Ground Surface Restraint

Pressures at 1/3 Depth	
Actual	**229.0** psf
Allowable	**250.0** psf
Footing Base Area	12.566 ft^2
Maximum Soil Pressure	0.0 ksf



Applied Loads

Lateral Concentrated Load (k)		Lateral Distributed Loads (klf)	Vertical Load (k)
D : Dead Load	k	k/ft	k
Lr : Roof Live	k	k/ft	k
L : Live	k	k/ft	k
S : Snow	k	k/ft	k
W : Wind	4.271 k	k/ft	k
E : Earthquake	2.910 k	k/ft	k
H : Lateral Earth	k	k/ft	k
Load distance above ground surface	1.0 ft	TOP of Load above ground surface 23.50 ft	
		BOTTOM of Load above ground surface ft	

Load Combination Results

	Forces @ Ground Surface		Pressure at 1/3 Depth		Soil Increase
Load Combination	Loads - (k)	Moments - (ft-k)	Actual - (psf)	Allow - (psf)	Factor
	0.000	0.000	1.0	250.0	1.000
+0.60W	2.563	2.563	229.0	250.0	1.000
-0.60W	2.563	2.563	229.0	250.0	1.000
+0.450W	1.922	1.922	173.0	250.0	1.000
-0.450W	1.922	1.922	173.0	250.0	1.000
E Only * 0.70	2.037	2.037	183.0	250.0	1.000
E Only * 0.5250	1.528	1.528	137.0	250.0	1.000

SIMPSON Strong-Tie®

Anchor Designer™
Software
Version 3.1.2301.3

Company:	Waypoint Engineering	Date:	10/21/2022
Engineer:	CD	Page:	1/5
Project:	22465 - Sellwood Moreland Steeple		
Address:	700 Washington Street, Suite #605, 700 Washington Stre		
Phone:			
E-mail:			

1.Project information

Customer company:
Customer contact name:
Customer e-mail:
Comment:

Project description:
Location:
Fastening description:

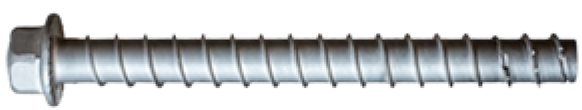
2. Input Data & Anchor Parameters

General
Design method:ACI 318-14
Units: Imperial units

Anchor Information:
Anchor type: Concrete screw
Material: Stainless Steel
Diameter (inch): 0.500
Nominal Embedment depth (inch): 3.500
Effective Embedment depth, h_{ef} (inch): 2.080
Code report: IAPMO UES ER-493
Anchor category: 1
Anchor ductility: Yes
h_{min} (inch): 5.42
c_{ac} (inch): 5.92
C_{min} (inch): 1.75
S_{min} (inch): 3.67

Base Material
Concrete: Normal-weight
Concrete thickness, h (inch): 6.00
State: Cracked
Compressive strength, f'_c (psi): 2500
$\Psi_{c,V}$: 1.0
Reinforcement condition: B tension, B shear
Supplemental edge reinforcement: Not applicable
Reinforcement provided at corners: No
Ignore concrete breakout in tension: No
Ignore concrete breakout in shear: No
Ignore 6do requirement: Not applicable
Build-up grout pad: No

Recommended Anchor
Anchor Name: Titen HD® Stainless Steel - 1/2"Ø SS Titen HD, hnom:3.5" (89mm)
Code Report: IAPMO UES ER-493



Load and Geometry
Load factor source: ACI 318 Section 5.3
Load combination: not set
Seismic design: Yes
Anchors subjected to sustained tension: Not applicable
Ductility section for tension: 17.2.3.4.3 (d) is satisfied
Ductility section for shear: 17.2.3.5.3 (c) is satisfied
Ω_0 factor: not set
Apply entire shear load at front row: No
Anchors only resisting wind and/or seismic loads: Yes

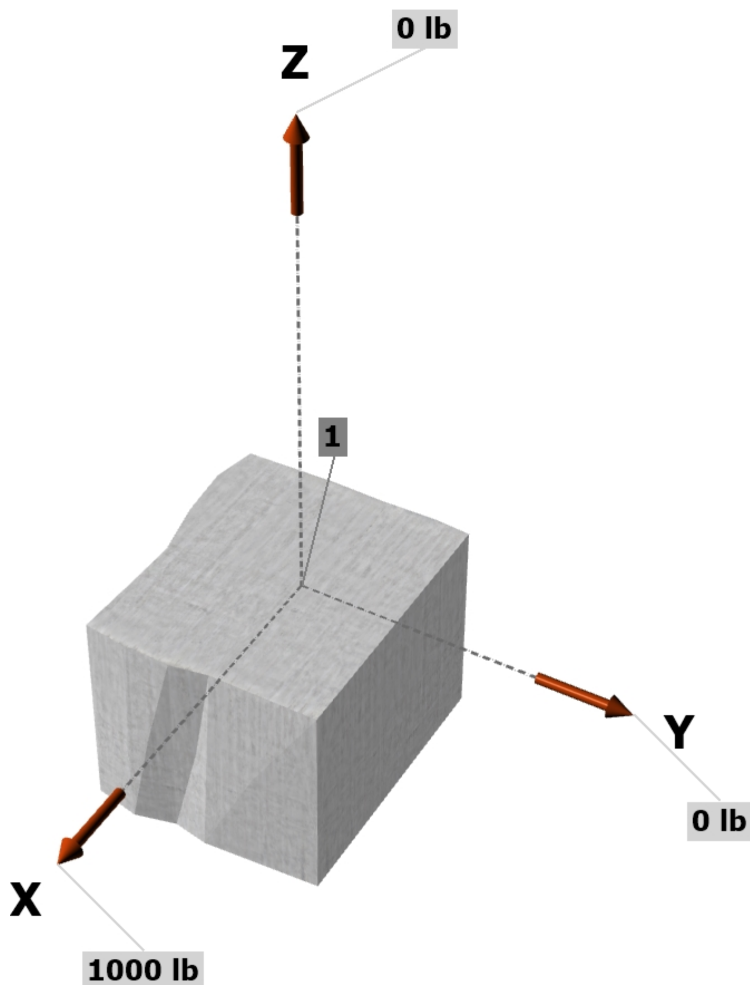
1000 lbs is an arbitrary higher value than required.

Seismic Loading:
2,910 lbs (base shear) / (2*PI*4.75')
= 97.5 plf *1.5' (sill plate anchor spacing)
= 146.25 lbs per sill plate anchor
= 146*1.25 = 182.8 lbs << 1000 lbs

Strength level loads:

N_{ua} [lb]: 0
V_{uax} [lb]: 1000
V_{uay} [lb]: 0

<Figure 1>



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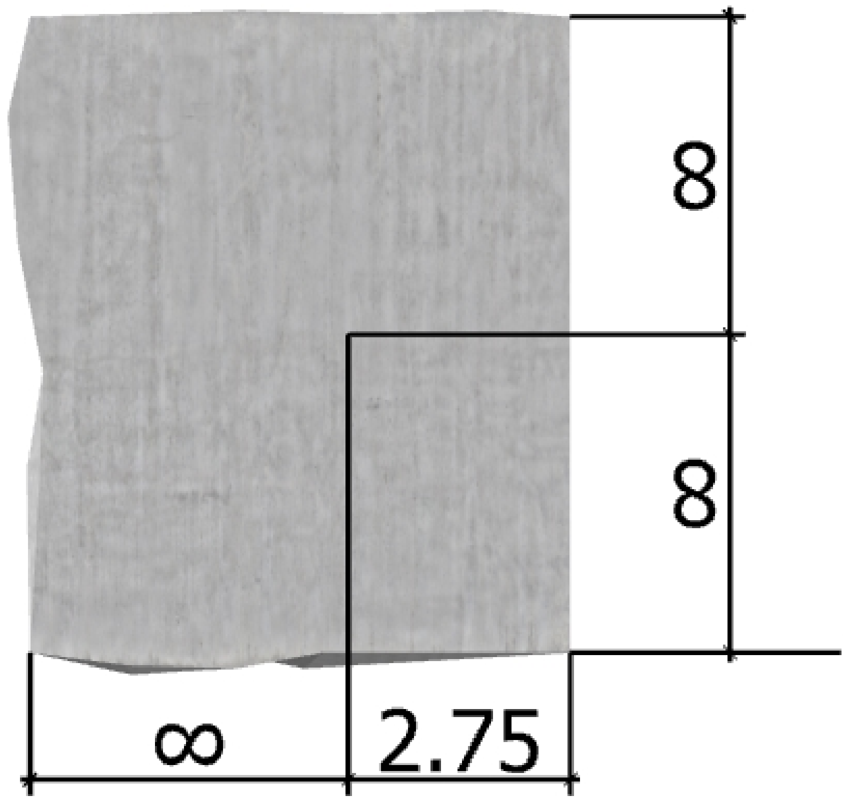

3. Resulting Anchor Forces

Anchor	Tension load, N_{ua} (lb)	Shear load x, V_{uax} (lb)	Shear load y, V_{uay} (lb)	Shear load combined, $\sqrt{(V_{uax})^2+(V_{uay})^2}$ (lb)
1	0.0	1000.0	0.0	1000.0
Sum	0.0	1000.0	0.0	1000.0

Maximum concrete compression strain (‰): 0.00
Maximum concrete compression stress (psi): 0
Resultant tension force (lb): 0
Resultant compression force (lb): 0
Eccentricity of resultant tension forces in x-axis, e'_{Nx} (inch): 0.00
Eccentricity of resultant tension forces in y-axis, e'_{Ny} (inch): 0.00
Eccentricity of resultant shear forces in x-axis, e'_{Vx} (inch): 0.00
Eccentricity of resultant shear forces in y-axis, e'_{Vy} (inch): 0.00

8. Steel Strength of Anchor in Shear (Sec. 17.5.1)

V_{sa} (lb)	ϕ_{grout}	ϕ	$\phi_{grout}\phi V_{sa}$ (lb)
5821	1.0	0.65	3784

9. Concrete Breakout Strength of Anchor in Shear (Sec. 17.5.2)

Shear parallel to edge in y-direction:

$V_{bx} = \min|7(l_e / d_a)^{0.2}\sqrt{d_a}\lambda_a\sqrt{f'_c}c_{a1}^{1.5}; 9\lambda_a\sqrt{f'_c}c_{a1}^{1.5}|$ (Eq. 17.5.2.2a & Eq. 17.5.2.2b)

l_e (in)	d_a (in)	λ_a	f'_c (psi)	c_{a1} (in)	V_{bx} (lb)
2.08	0.500	1.00	2500	2.75	1501

$\phi V_{cby} = \phi\ (2)(A_{Vc} / A_{Vco})\Psi_{ed,V}\Psi_{c,V}\Psi_{h,V}V_{bx}$ (Sec. 17.3.1, 17.5.2.1(c) & Eq. 17.5.2.1a)

A_{Vc} (in²)	A_{Vco} (in²)	$\Psi_{ed,V}$	$\Psi_{c,V}$	$\Psi_{h,V}$	V_{bx} (lb)	ϕ	ϕV_{cby} (lb)
34.03	34.03	1.000	1.000	1.000	1501	0.70	2101

10. Concrete Pryout Strength of Anchor in Shear (Sec. 17.5.3)

$\phi V_{cp} = \phi k_{cp}N_{cb} = \phi k_{cp}(A_{Nc} / A_{Nco})\Psi_{ed,N}\Psi_{c,N}\Psi_{cp,N}N_b$ (Sec. 17.3.1 & Eq. 17.5.3.1a)

k_{cp}	A_{Nc} (in²)	A_{Nco} (in²)	$\Psi_{ed,N}$	$\Psi_{c,N}$	$\Psi_{cp,N}$	N_b (lb)	ϕ	ϕV_{cp} (lb)
1.0	36.63	38.94	0.964	1.000	1.000	2550	0.70	1619

11. Results

Interaction of Tensile and Shear Forces (Sec. 17.6)

Shear	Factored Load, V_{ua} (lb)	Design Strength, ϕV_n (lb)	Ratio	Status

Steel	1000	3784	0.26	Pass
|| Concrete breakout y+	1000	2101	0.48	Pass
Pryout	**1000**	**1619**	**0.62**	**Pass (Governs)**

1/2"Ø SS Titen HD, hnom:3.5" (89mm) meets the selected design criteria.

12. Warnings

- Per designer input, ductility requirements for tension have been determined to be satisfied – designer to verify.

- Per designer input, ductility requirements for shear have been determined to be satisfied – designer to verify.

- Designer must exercise own judgement to determine if this design is suitable.

- Refer to manufacturer’s product literature for hole cleaning and installation instructions.