March 03, 2023

Amy Palmer
Merryman Barnes Architects
4713 N Albina Ave Suite 304
Portland, OR 97217

Re: Oregon Zoo Art Pole Relocation

Dear Amy:

Attached please find calculation sheets 1 through 16, dated 3/3/2023, which verify the structural adequacy of the Oregon Zoo Art Pole Relocation project, as shown on drawings S603 dated 3/2/2023. Design is based on the requirements of the 2022 Oregon Structural Specialty Code, based on the 2018 International Building Code.

If you have any questions or need further information, please call me.

Sincerely,

Cameron Hansen
KPFF Design Engineer

Attachments

Project No. 10022200940

Stuart Finney, PE SE
Digitally signed by Stuart Finney, PE SE
DN: C=US, E=stuart.finney@kpff.com, O=KPFF, CN="Stuart Finney, PE SE"
Date: 2023.03.07 04:39:55+04'00'

kpff Portland, Oregon	Project Oregon Zoo Pole Relocation	By CMH	Sheet No. 1
	Location Portland, OR	Date 3/3/23	
	Client Mengeren Barnes Architects	Revised	Job No.
		Date	

Art Pole Properties

Max. Fixture Height: 25'-0"

Effective Wind Area: 5 ft² (Assumed)

Pole Properties: • I.D. = 2.5" (2½" Std. Pipe)

W = 5.8 plf

Center of Art Height = 23'-0" (Assumed)

Pole Weight = 5.8 plf (23') ≈ 134 lb

Art Weight = 100 lb (Assumed)

Total Weight = 234 lb

Light Pole Properties

Max Pole + Fixture Height = 14'-0"

Effective Wind Area = 3.5 ft² (Assumed)

Pole Properties: Same as Art Pole

T.O. Pole Height = 12'-6"

Pole Weight = 5.8 plf (12'-6") = 72.5 lb

Fixture Weight = 75 lb (Assumed)

Total Weight = 147.5 lb

Art Pole Properties will control Design

Seismic Loading

$F_p = .4 a_p S_{DS} W_p / (R_p/I_p)(1+2z/h)$

$a_p = 2\frac{1}{2}$
$R_p = 3$
} ASCE 7-16, Tbl. 13.5-1 : Signs/Billboards

$S_{DS} = .714$ - ATC Hazard Tool

$I_p = 1.0$

$z/h = 1.0$

$W_p = 234$ lb

$F_{p/h} = .714 W_p = \underline{167 \text{ lb}}$

$F_{p,min} = .35 S_{DS} I_p W_p = 50 \text{ lb}$ ✓

$F_{p,max} = 1.6"$ " $= 267 \text{ lb}$ ✓

$F_{p,v} = \pm .2 S_{DS} W_p = \underline{33.5 \text{ lb}}$

Wind Loading

$F = q_z G C_f A_s$ (ASCE 7-16, Ch. 29.3)

$q_z = .00256 K_z K_{zt} K_d K_e V^2 = 20.86 psf$

$K_z = 1.04$

$z = 40'$

Exp.: C

$K_{zt} = 1.0$

$K_d = .85$

$K_e = 1.0$

$V = 96 mph$ (ATC Hazard Tool)

Risk Cat.: II

$G = .85$

$C_f = 1.85$ (ASCE 7-16, Fig. 29.3-1)

$s = 1'$

$h = 23' \rightarrow s/h = .04 \leq .016$

$B = 5' \rightarrow B/s = 5$

$A_s = 5 ft^2$

$F_v = 164 lb$

Art Pole Base Plate Properties

$\emptyset = 12"$

$t = 7/8"$

Bolt Holes: (4) $3/4"\emptyset$ @ $6.5" \times 6.5"$ o.c.

Transfer Plate Properties

$t = 1/2"$

$b = 13"$

$d = 20"$

Bolt Holes: (6) $3/4"\emptyset$ w/ outer @ $12" \times 16"$

Transfer Plate Loading

Loads From Pole:

$V = \max(167\text{lb}, 200\text{lb}_{\text{nominal}}) = 200\text{lb}_{LL}$

$M = \max(164\text{lb}, 167\text{lb}) \times 23' = 3841\text{lbft}_{LL}$

$P = 234\text{lb}_{DL} \pm 33.5\text{lb}_{LL}$

Transfer Plate Check

Case 1: Loading Parallel to Cant. Arms

Bolt Couple Distance = 10"

$M_u = 2.0$ k ft

$R_u = 4.75$ k

Case 2: Loading Perpendicular to Cant. Arms

Bolt Spacing = 16"

$M_u = 2.0$ k ft

$R_u = 3.0$ k

Plate Capacity:

$\phi M_n = .9 F_y Z_x = 26.33$ k ft ✓ ok

$F_y = 36$ ksi

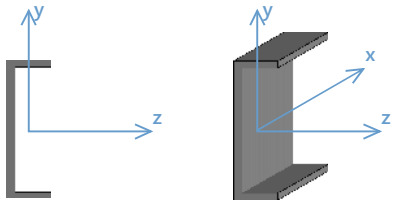
$Z_x = bd^2/4 = .813$

$b = 13"$

$d = 1/2"$

Detail Report: M1

Load Combination: Envelope **Code check:** 0.279 (LC 13)



Input Data

Shape:	C8X18.75	**I Node:**	N1
Member Type:	Beam	**J Node:**	N2
Length (ft):	6.5	**I Release:**	Fixed
Material Type:	Hot Rolled Steel	**J Release:**	Fixed
Design Rule:	Typical	**I Offset:**	N/A
Internal Sections:	97	**J Offset:**	N/A
Design Code:	AISC 15th (360-16): ASD	**T/C Only:**	Both Way

Material Properties

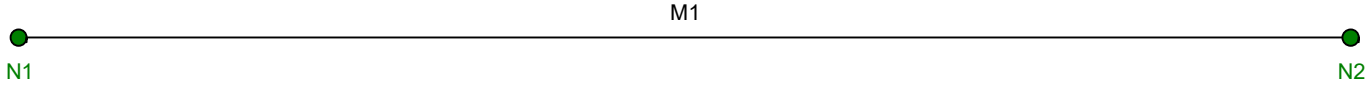
Material:	A992	**Therm. Coeff. (/1E5 F):**	0.65	**F_u (ksi):**	65
E (ksi):	29000	**Density (k/ft^3):**	0.49	**R_t:**	1.1
G (ksi):	11154	**F_y (ksi):**	50		
Nu:	0.3	**R_y:**	1.1		

Shape Properties

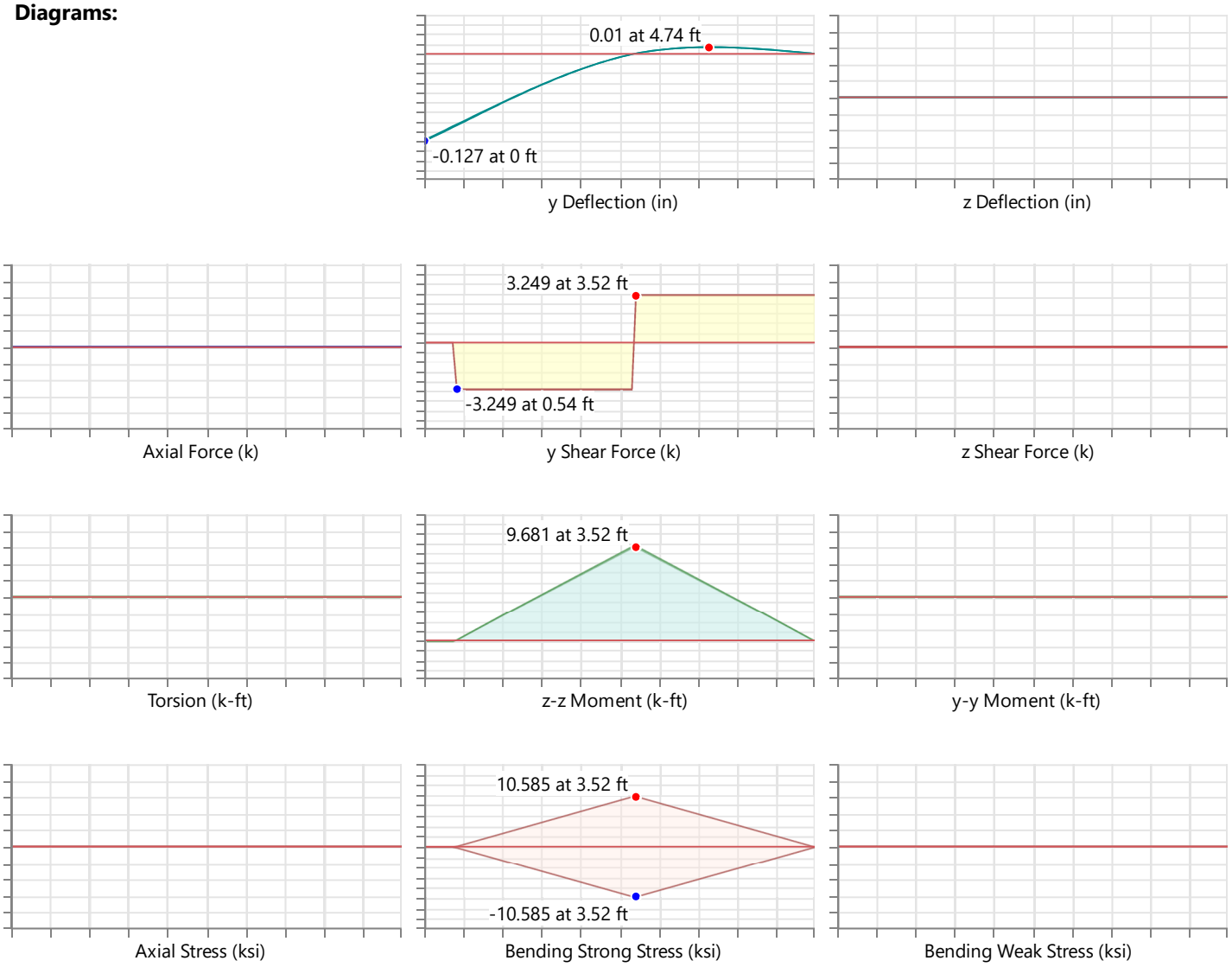
d (in):	8	**I_{zz} (in^4):**	43.9	**J (in^4):**	0.434
b_f (in):	2.53	**Area (in^2):**	5.51	**$\bar{x}$ (in):**	0.565
t_f (in):	0.39	**Z_{yy} (in^3):**	2.17	**e_o (in):**	0.431
t_w (in):	0.487	**Z_{zz} (in^3):**	13.9		
I_{yy} (in^4):	1.97	**C_w (in^6):**	25.1		

Design Properties

$L_{b\ y\text{-}y}$ (ft):	6.5	**$K_{y\text{-}y}$:**	1	**Seismic DR:**	None
$L_{b\ z\text{-}z}$ (ft):	6.5	**$K_{z\text{-}z}$:**	1	**Max Defl Ratio:**	L/661
$L_{comp\ top}$:	Lbyy	**y sway:**	No	**Max Defl Location:**	0
$L_{comp\ bot}$ (ft):	6.5	**z sway:**	No	**Span:**	1
L_{torque} (ft):	6.5	**Function:**	Lateral	**τ_b:**	1



Diagrams:



AISC 15th (360-16): ASD Code Check

Limit State	Gov. LC	Required	Available	Unity Check	Result
Applied Loading - Bending/Axial	13	-	-	-	-
Applied Loading - Shear + Torsion	13	-	-	-	-
Axial Tension Analysis	13	0 k	164.97 k	-	-
Axial Compression Analysis	13	0 k	48.67 k	-	-
Flexural Analysis (Strong Axis)	13	9.681 k-ft	34.681 k-ft	-	-
Flexural Analysis (Weak Axis)	13	0 k-ft	4.002 k-ft	-	-
Shear Analysis (Major Axis y)	13	3.249 k	69.988 k	**0.046**	**PASS**
Shear Analysis (Minor Axis z)	13	0 k	35.45 k	**0**	**PASS**

Bending & Axial Interaction Check (UC Bending Max)	13	-	-	**0.279**	**PASS**

Node Coordinates

	Label	X [ft]	Y [ft]	Z [ft]	Detach From Diaphragm
1	N1	0	0	0	
2	N2	6.5	0	0	
3	N3	3.5	0	0	
4	N4	0.5	0	0	

Node Boundary Conditions

	Node Label	X [k/in]	Y [k/in]	Z [k/in]
1	N3	Reaction	Reaction	Reaction
2	N2	Reaction	Reaction	Reaction

Hot Rolled Steel Properties

	Label	E [ksi]	G [ksi]	Nu	Therm. Coeff. [1e⁵°F⁻¹]	Density [k/ft³]	Yield [ksi]	Ry	Fu [ksi]	Rt
1	A992	29000	11154	0.3	0.65	0.49	50	1.1	65	1.1
2	A36 Gr.36	29000	11154	0.3	0.65	0.49	36	1.5	58	1.2
3	A572 Gr.50	29000	11154	0.3	0.65	0.49	50	1.1	65	1.1
4	A500 Gr.B RND	29000	11154	0.3	0.65	0.527	42	1.4	58	1.3
5	A500 Gr.B RECT	29000	11154	0.3	0.65	0.527	46	1.4	58	1.3
6	A500 Gr.C RND	29000	11154	0.3	0.65	0.527	46	1.4	62	1.3
7	A500 Gr.C RECT	29000	11154	0.3	0.65	0.527	50	1.4	62	1.3
8	A53 Gr.B	29000	11154	0.3	0.65	0.49	35	1.6	60	1.2
9	A1085	29000	11154	0.3	0.65	0.49	50	1.4	65	1.3
10	A913 Gr.65	29000	11154	0.3	0.65	0.49	65	1.1	80	1.1

Member Primary Data

	Label	I Node	J Node	Section/Shape	Type	Design List	Material	Design Rule
1	M1	N1	N2	C8X18.75	Beam	Channel	A992	Typical

Node Reactions

	LC	Node Label	X [k]	Y [k]	Z [k]	MX [k-ft]	MY [k-ft]	MZ [k-ft]
1	1	N3	0	0.454	0	LOCKED	0	0
2	1	N2	0	-0.227	0	0	0	0
3	1	Totals:	0	0.227	0			
4	1	COG (ft):	X: 0.5	Y: 0	Z: 0			
5	13	N3	0	6.499	0	LOCKED	0	0
6	13	N2	0	-3.249	0	0	0	0
7	13	Totals:	0	3.249	0			
8	13	COG (ft):	X: 0.5	Y: 0	Z: 0			
9	14	N3	0	6.402	0	LOCKED	0	0
10	14	N2	0	-3.201	0	0	0	0
11	14	Totals:	0	3.201	0			
12	14	COG (ft):	X: 0.5	Y: 0	Z: 0			

Node Displacements

	LC	Node Label	X [in]	Y [in]	Z [in]	X Rotation [rad]	Y Rotation [rad]	Z Rotation [rad]
1	1	N1	0	-0.009	0	0	0	2.468e-4
2	1	N2	0	0	0	0	0	-4.184e-5
3	1	N3	0	0	0	0	0	1.025e-4
4	1	N4	0	-0.007	0	0	0	2.468e-4

Node Displacements (Continued)

	LC	Node Label	X [in]	Y [in]	Z [in]	X Rotation [rad]	Y Rotation [rad]	Z Rotation [rad]
5	13	N1	0	-0.127	0	0	0	3.535e-3
6	13	N2	0	0	0	0	0	-5.994e-4
7	13	N3	0	0	0	0	0	1.468e-3
8	13	N4	0	-0.106	0	0	0	3.535e-3
9	14	N1	0	-0.125	0	0	0	3.483e-3
10	14	N2	0	0	0	0	0	-5.904e-4
11	14	N3	0	0	0	0	0	1.446e-3
12	14	N4	0	-0.104	0	0	0	3.483e-3

Node Loads and Enforced Displacements (BLC 1 : Dead)

	Node Label	L, D, M	Direction	Magnitude [(k, k-ft), (in, rad), (k*s²/ft, k*s²*ft)]
1	N4	L	Y	-0.162

Node Loads and Enforced Displacements (BLC 3 : Seismic)

	Node Label	L, D, M	Direction	Magnitude [(k, k-ft), (in, rad), (k*s²/ft, k*s²*ft)]	Inactive
1	N4	L	Y	-0.034	
2	N4	L	Y	-3.021	
3	N4	L	Y	3.021	Inactive
4	N4	L	Y	0.034	Inactive
5	N4	L	MZ	1.921	Inactive
6	N4	L	MZ	-1.921	Inactive

Maximum Member Section Forces

	LC	Member Label		Axial[k]	Loc[ft]	y Shear[k]	Loc[ft]	z Shear[k]	Loc[ft]	Torque[k-ft]	Loc[ft]	y-y Moment[k-ft]	Loc[ft]	z-z Moment[k-ft]	Loc[ft]
1	13	M1	max	0	6.5	3.249	6.5	0	6.5	0	6.5	0	6.5	9.681	3.521
2			min	0	0	-3.249	0.542	0	0	0	0	0	0	0	0
3	14	M1	max	0	6.5	3.201	6.5	0	6.5	0	6.5	0	6.5	9.536	3.521
4			min	0	0	-3.201	0.542	0	0	0	0	0	0	0	0

Beam Deflections

	LC	Member Label	Span	Location [ft]	y' [in]	(n) L'/y' Ratio
1	1	M1	1	-0.068	0	NC
2			2	-0.068	0	NC
3	13	M1	1	0	-0.127	661
4			2	4.74	0.01	3772
5	14	M1	1	0	-0.125	672
6			2	4.74	0.009	3829

AISC 15TH (360-16): ASD Member Steel Code Checks

	LC	Member	Shape	UC Max	Loc[ft]	Shear UC	Loc[ft]	Dir	Pnc/om [k]	Pnt/om [k]	Mnyy/om [k-ft]	Mnzz/om [k-ft]	Cb	Eqn
1	13	M1	C8X18.75	0.279	3.521	0.046	6.5	y	48.67	164.97	4.002	34.681	1.395	H1-1b
2	14	M1	C8X18.75	0.275	3.521	0.046	6.5	y	48.67	164.97	4.002	34.681	1.395	H1-1b

Cont: Beam Reactions:

Pole: $V = 6.5k$

Leg: $V = 3.25k$

Pole:

Studs: (2) 5/8" Threaded Studs

$\phi R_n = 2(.75)A_s F_u = 27.61k$ ✓ok

$A_s = \pi(5/8)^2/4 = .307$

$F_u = 60$ ksi

Leg:

L 3x3x1/4

$\phi P_n = .9 F_{cr} A_g = 44.15k$ ✓ok

$L/r = 32.4 \leq 134 = 4.71\sqrt{E/F_y}$

$L_c = 2.5' = 30"$

$r = .926"$

$F_{cr} = (.658^{F_y/F_e})F_y = 34.06$ ksi

$F_e = 272.7$

$A_g = 1.44 in^2$

Connector Channel (At Col Pipe-Channel)

$V = 6k$

Weld: $l = 2(6.75")$

$\phi R_n = 1.392Dl = 75k$ √ok

$D = 4$

Channel:

Try C 6x8.2x6.75"

Web:

$\phi V_n = .75(.6)F_y A_s = 22 \; k$ √ok

$F_y = 36 ksi$

$A_s = 6.75(.2) = 1.35 in^2$

Flanges:

$V_c = 6k/2 = 3k$

$\phi V_n = .75(.6)(36)(A_s) = 37.5k$ √ok

$A_s = 6.75(.343) = 2.06 in^2$

Eccentric loading on welds

$P = 6k$

$e = 2.16 + 3/16" = 2.447 \rightarrow 2.5" \rightarrow a = 2.5/6.75 = .37 \rightarrow .4$

$k = 6/6.75 = .888 \rightarrow .9$

$\rightarrow C = 2.83$

$D_{min} = 6/[.75(2.83)(6.75)] = .419$ √ok

Reactions:

O-P : $R = 3k/3 = 1k$ /bolt

I-P : $R = 4.75k/2 = 2.375k$ /bolt

Channel Flange

$T = R = 2.38$

$V = 2.38\ k$

$M = P_b = 2.38(1.25) = 2.97\ k\text{-in}$

$t = .39"$

Capacity

$\phi M_n = .9 F_y Z_x = 6.16\ k\text{-in}$ ✓ok

$F_y = 36\ ksi$

$Z_x = bd^2/4 = .19\ in^3$

$d = t = .39"$

$b = 5"$ (Bolt spacing)

$\phi V_n = .75(.6)(.39)(5)(1)(36) = 31.59\ k$ ✓ok

Loading Capacity of GL Decking

Deck: GL 6 3/4 x 48 horizontal

Max Span = 18'-6"

Fixity: Pin-Pin

Design Loads:

Self weight: $35_{pcf}(6.75")(48")/144 = 78.75\ plf_{DL}$

Decking Top: $10\ psf(4') = 40\ plf_{DL}$

Live Loading: $60\ psf(4') = 240\ plf_{LL}$

Max Demand w/ (E) Conditions:

$V = (78.75+40+240)(18.5')/2 = 3318.44\ lb$

$M = (78.75+40+240)(18.5')^2/8 = 15347.77\ lb\text{-}ft = 184173.24\ lb\text{-}in$

$f_v = 3V/2bd = \underline{15.36\ psi}$

$b = 48"$

$d = 6.75"$

$f_b = 6M/bd^2 = \underline{505.28\ psi}$

Decking Capacity:

$F_v = 230\ psi(1.0)(1.0)(1.0) = \underline{230\ psi}$ ✓ok

$F_b = 1450\ psi(1)(1)(1)(1)(0.858)(1.07)(1)(1) = \underline{1331.187\ psi}$ ✓ok

New Point Load on Deck:

$P = .7(3.25k) = 2.275k$ (ASD)

Decking Capacity Check

$V = (78.75 + 40 + .75(240) + .75(100))(18.5')/2 + 227.5/2 = 4595\ lb$

$M = " \quad "(18.5)^2/8 + 227.5(18.5)/4 = 16558\ lb/ft$

$f_v = 21.27\ psi$ ✓ok

$f_b = 390.27\ psi$ ✓ok (Less than deck worst case loading)

Screw Withdrawal Check

Fast: (2) ½" Dia. x 4½" Lag Screws

$W' = W C_D C_M C_t C_{eg} C_{tn} = 378 \text{ lb/in}$

$C_D = 1$

$C_M = 1$

$C_t = 1$

$C_{eg} =$

$W = 378 \text{ lb/in}$

$G = .5 \quad (DF)$

$W'_T = 378 \text{ lb/in} \; (2)(4.5") = 3402 \text{ lb} \quad (ASD)$

$\rightarrow 3402(3.32)(.65)(1) = 7341.52 \text{ lb} \quad (LRFD)$ ✓ok