Project Details

Project Name: Marias Expansion

Location: 30905 County Rd 35, Steamboat Springs, CO 80487, USA

Unique ID: 1P-0-10TOP-XD-84-L-5Hx3W-2339

Dealer: ______________________________

Date: Thu Sep 25 2025

Number of Modules: 15

Number of Poles: 1

Date Sold:

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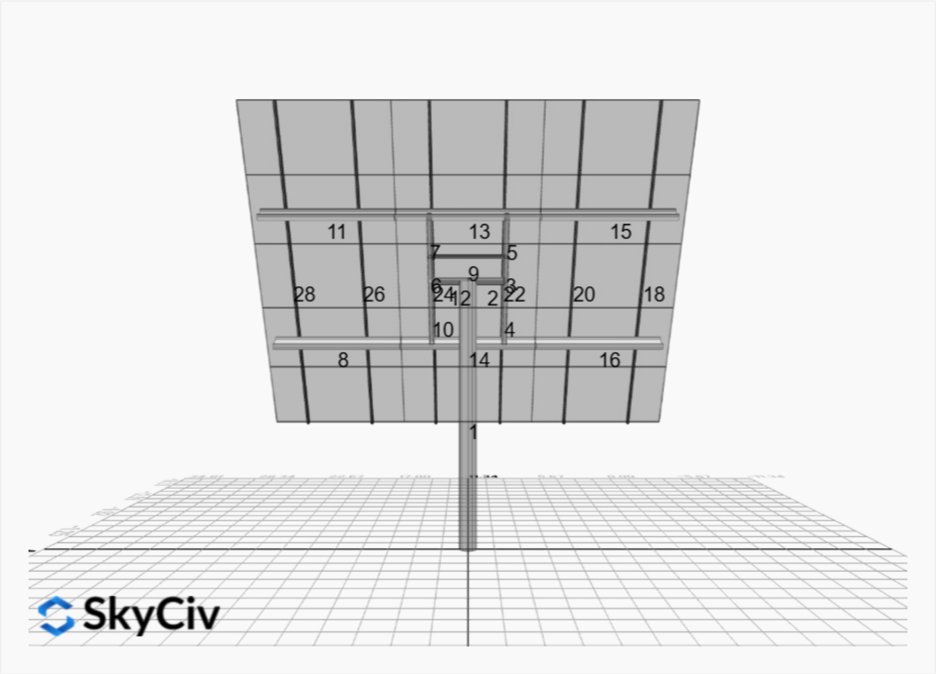


Array Dimensions N/S	18.81 ft
Array Dimensions E/W	22.67 ft
Winter Tilt Angle	62
Front Edge Clearance	6 ft

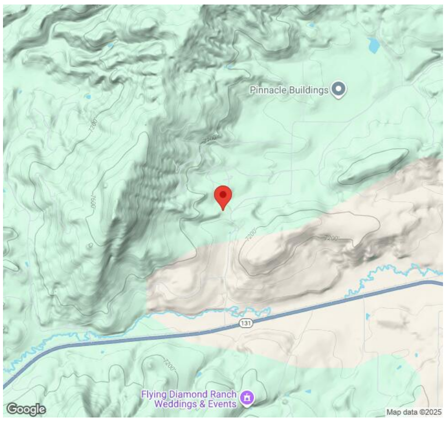
MT Solar Bill of Materials (1P-0-10TOP-XD-84-L-5Hx3W-2339)

Part	Short Description	BOM Qty
MTS-PC-10	10IN Pole Cap Assembly	1
MTS-HF-XD	H-Frame Assembly-XD	1
MTS-XD-Wing-84	84IN XD Wing	4
MTS-CLAMP-ANGLE-4PK	Angle Clamp	3

Rail Bill of Materials

Part	Qty
Rails (226in)	6
Rail Attachment	24
Module Mid Clamp	24
Module End Clamp	12
Ground Lug	3

Site Details:



Site Address: 30905 County Rd 35, Steamboat Springs, CO 80487, USA

Array Specification

Duty Classification:	XD
Module Width:	44.65 in
Module Length:	89.69in
Number of Rows:	5
Number of Columns:	3
Total Number of Modules:	15
Winter Tilt Angle:	62
Front Edge Clearance:	6
Total Array Height at Tilt:	22.61 ft
Total Frame Length:	21.50 ft
Module Info/Notes:	SEG SOLAR 595
Array Dimensions N/S:	18.81 ft
Array Dimensions E/W:	22.67 ft
Rail Length:	225.75 in
Rail Spacing:	3.78 ft

Support Specifications

Pole Size:	10in Pipe Sch 40
Pole Length above Grade:	14.31 ft
Number of Poles:	1
Pole Spacing:	0

Foundation Specifications

Foundation Type:	Square
Foundation Dimensions:	48 x 48 in
Foundation Depth (below grade):	Pile 1: 8.25 ft
Foundation Volume:	4.889 y^3

Site Info

Risk Category:	I
Exposure:	B
Soil Classification:	sand
Site Location:	30905 County Rd 35, Steamboat Springs, CO 80487, USA
Wind Speed:	115 mph
Snow Load:	110 psf

Design Disclaimer

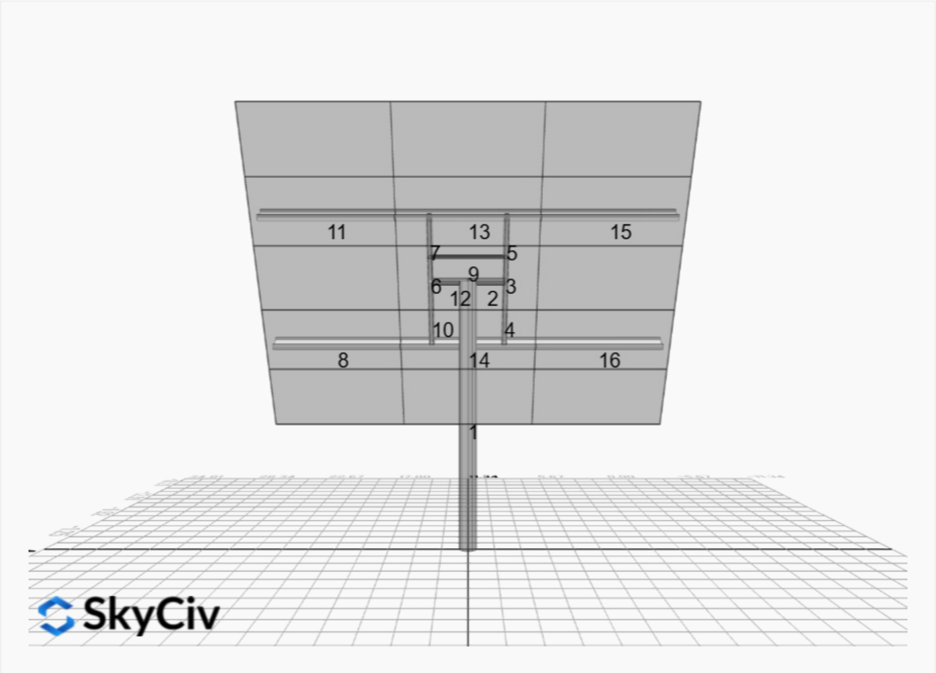
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

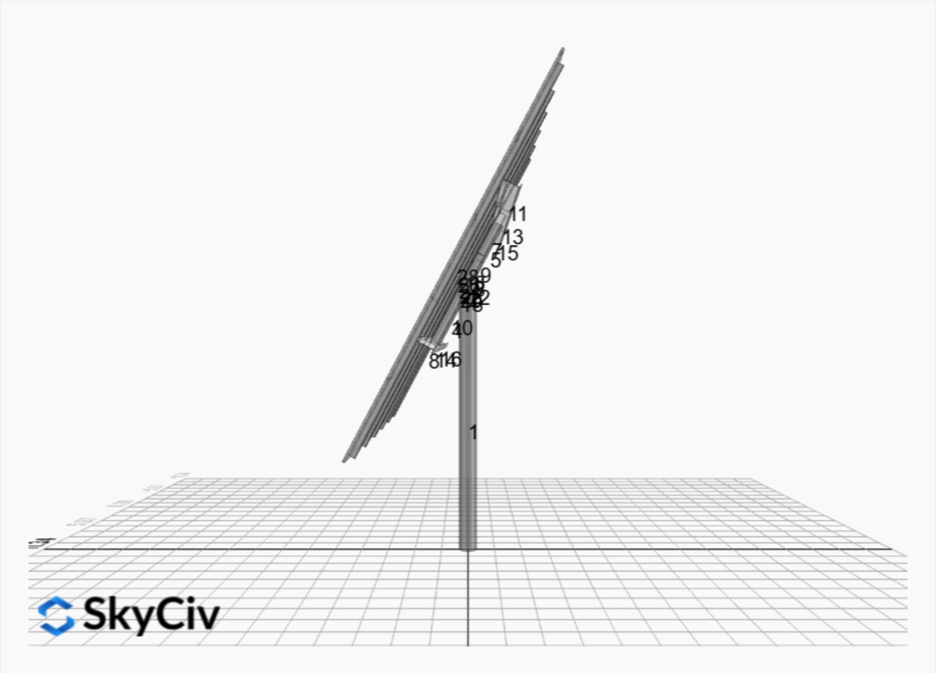
AutoDesigner Input

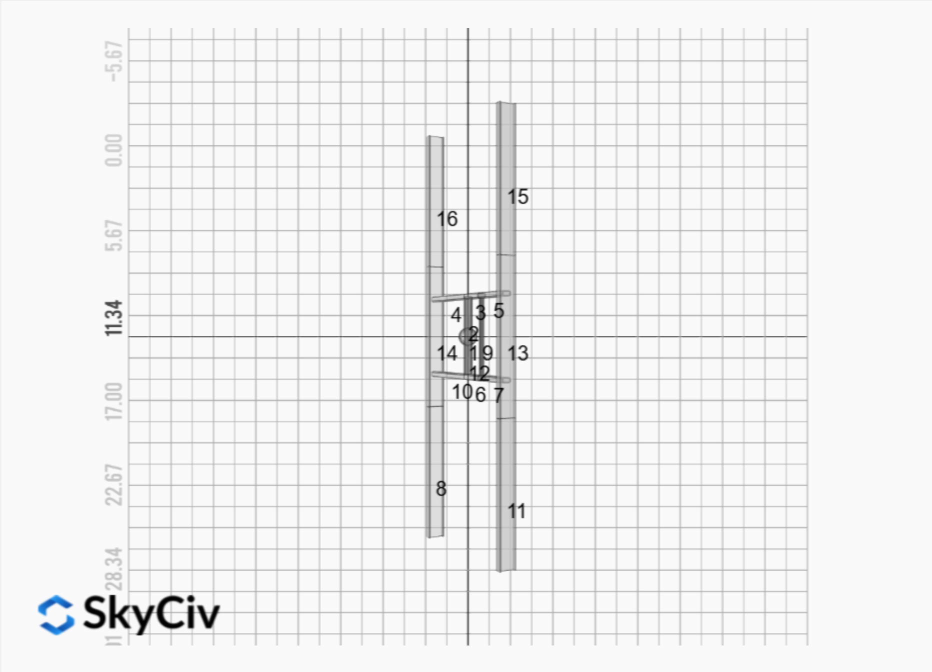
{"product_type":"Beam","designer_name":"Colin ","designer_email":"colin@sunwise-solar.com","designer_phone":"9708190840","project_id":"Marias Expansion","site_address":"30905 County Rd 35, Steamboat Springs, CO 80487, USA","module_info":"SEG SOLAR 595","module_width":44.65,"module_length":89.69,"number_rows":"5","number_columns":3,"pole_mount_section":"4_40","core_pipe_width":65,"core_pipe_section":"2_40","adjuster_section":"2_40","core_beam_height":65,"core_beam_section":"HSS3x2x1/8","main_pipe_section":"2_12GA","pole_spacing":"15","tilt_angle":62,"ground_clearance":6,"risk_category":"I","exposure_category":"B","frame_duty_override":"auto","pole_override":"auto","soil_type":"sand","customer_foundation_override":"48_Square","foundation_type":"Square","foundation_size":48,"check_rails":false,"wind_speed_override":115,"snow_load_override":110,"direct_snow_load":false,"add_angle_brace":false}

Design Notes:

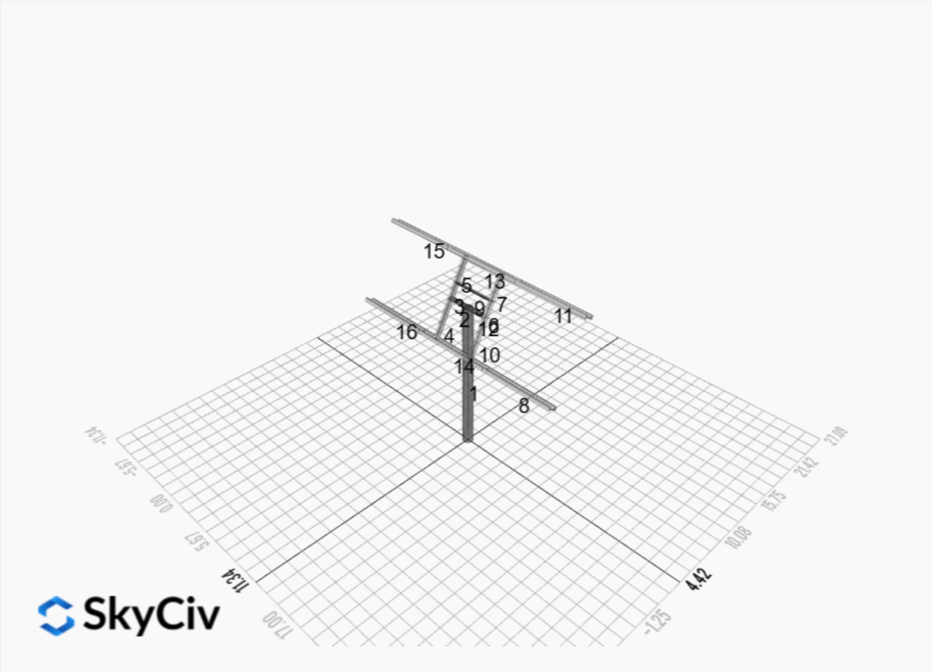
- AISC Deflection checks are set to L/1 due to structure design intent
- Foundation Soil Parameters used in this Autodesign are all estimates, proper geotechnical reports are required to confirm soil profiles
- Wind speeds, snow loads and other site specific results are based on ASCE 7 2016
- Steel frame design checks are based on AISC 360 2016 (LRFD)
- Foundation Design and Sizing is approximate only







-5.67
0.00
5.67
11.34
17.00
22.67
28.34
16
15
4
3
5
2
14
1
9
13
12
10
6
7
8
11



15
5
13
3
9
7
2
16
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11
10
14
1
8
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5.67
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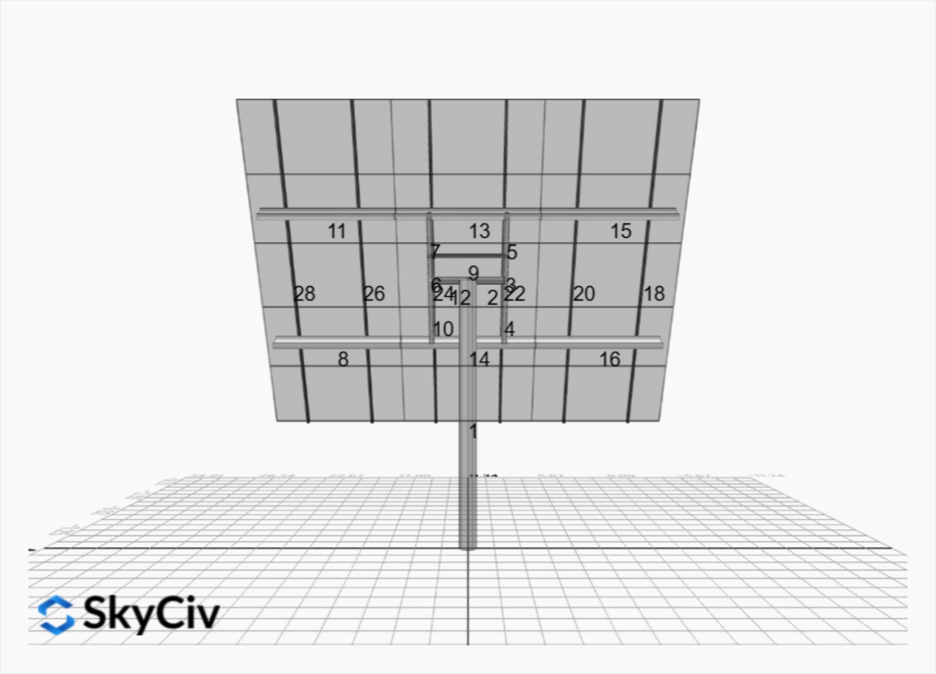
10.08
4.42
-1.25


11
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6
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24
12
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18
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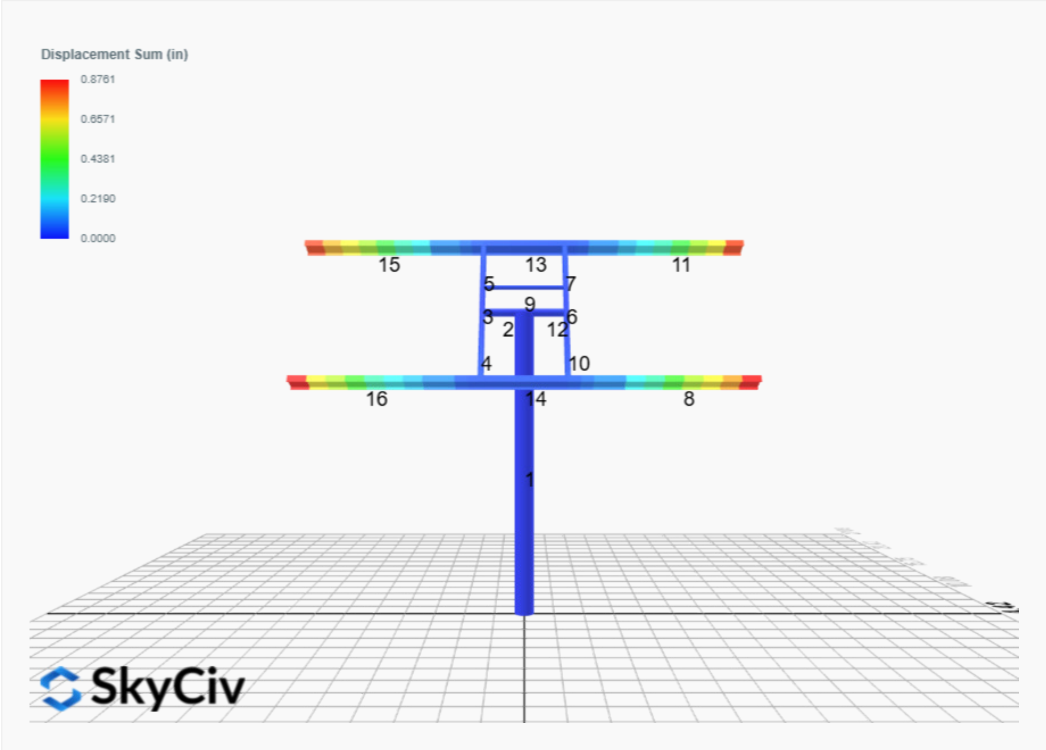
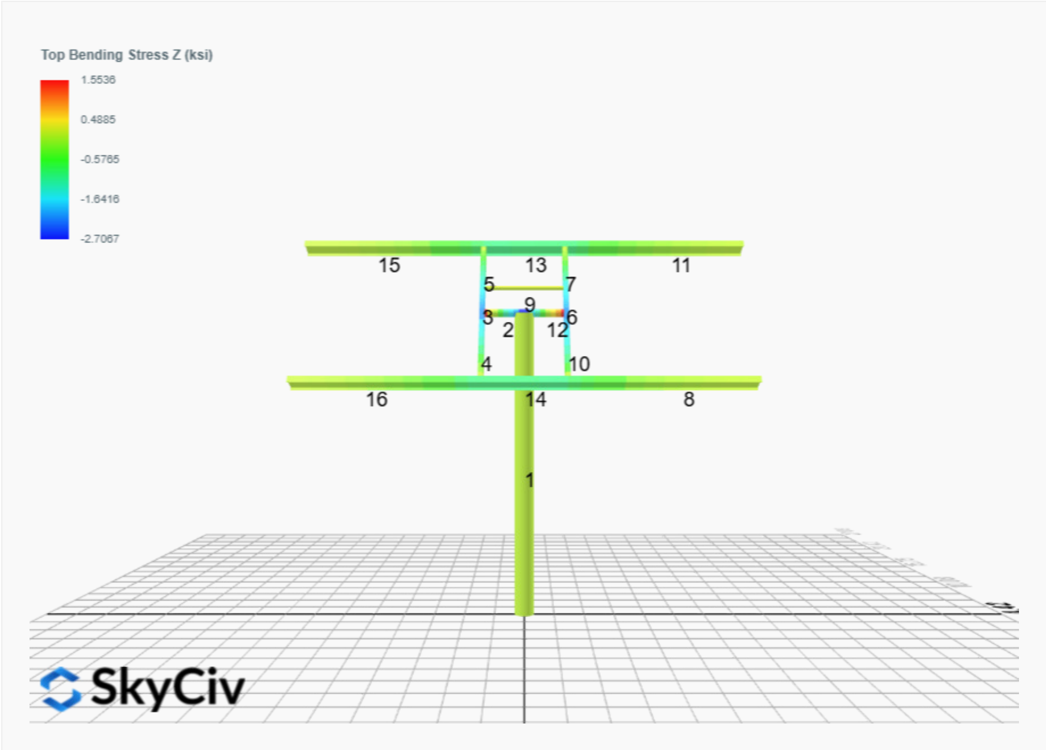
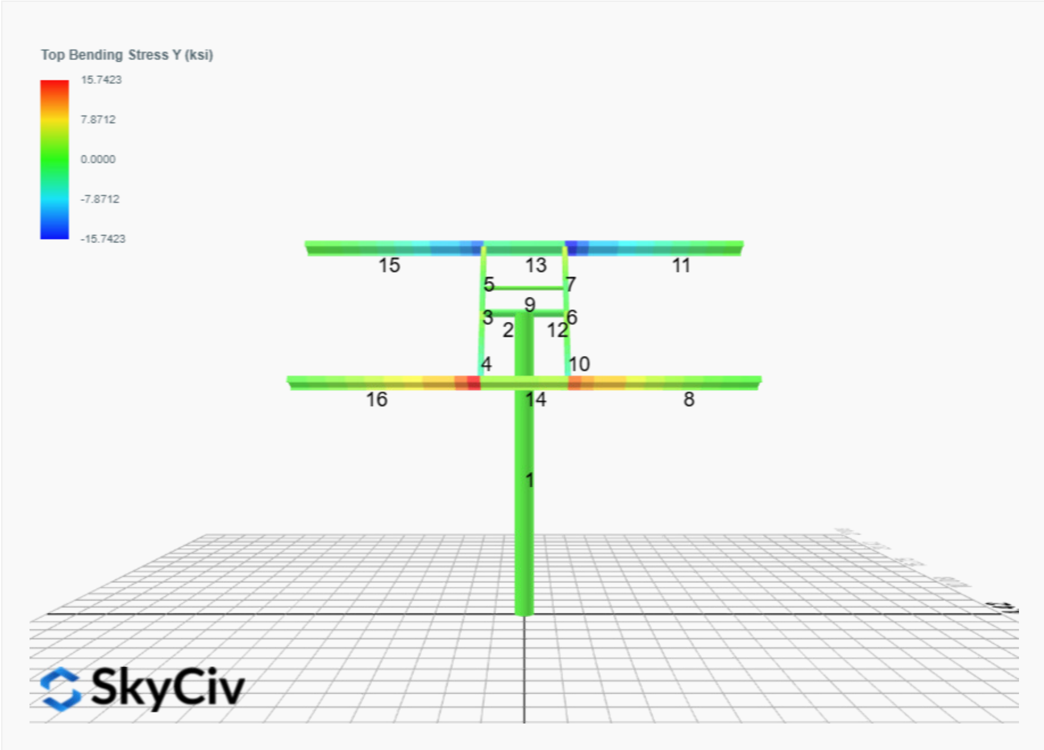
14
16
1
SkyCiv

FEM Results (Envelope Worst Case for each member)






Top Bending Stress Y (ksi)
15.7423
7.8712
0.0000
-7.8712
-15.7423
15
13
11
5
7
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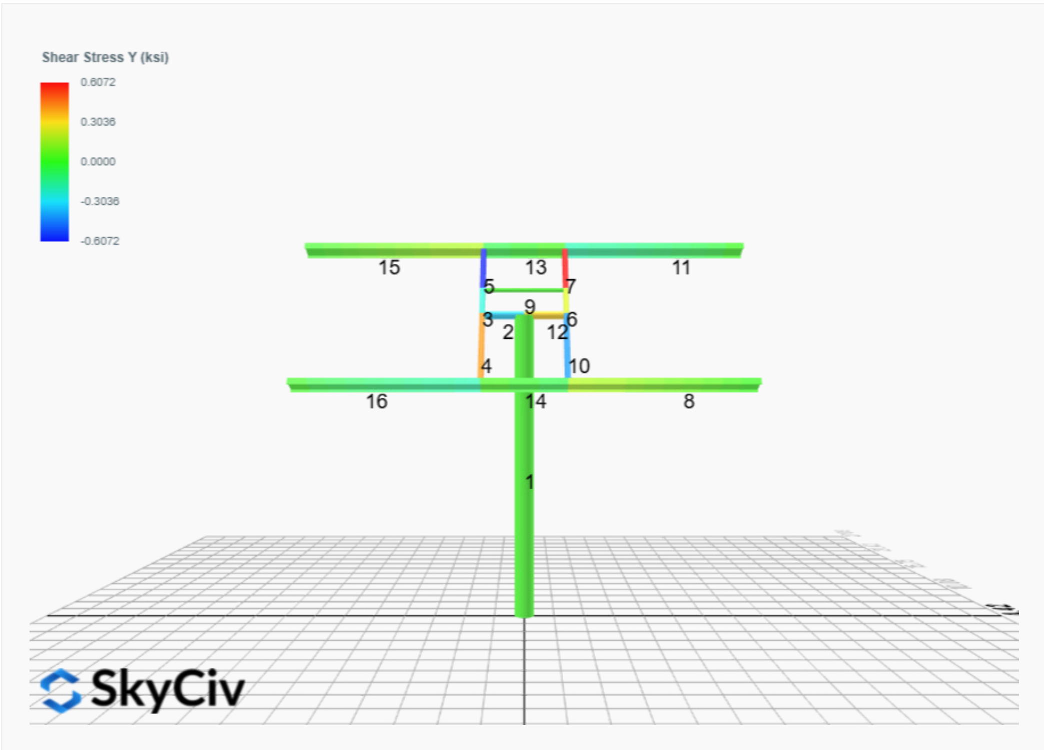
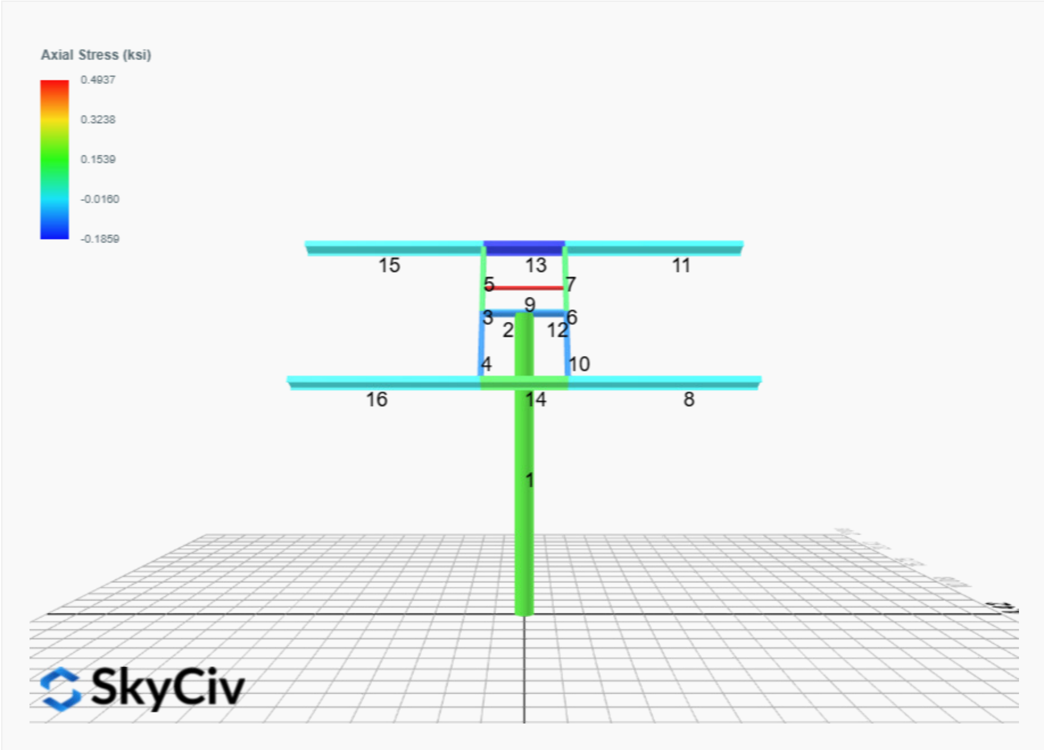
3
2
12
6
4
10
16
14
8
1
SkyCiv


Shear Stress Y (ksi)
0.6072
0.3036
0.0000
-0.3036
-0.6072
15
13
11
5
7
9
3
2
12
6
4
10
16
14
8
1
SkyCiv


Axial Stress (ksi)
0.4937
0.3238
0.1539
-0.0160
-0.1859
15
13
11
5
7
9
3
2
12
6
4
10
16
14
8
1
SkyCiv

Reaction Forces for Foundation 1 (Node ID#1), (kip, kip-ft)

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	0.0000	3.2544	0.0000	0.0000	-0.0000	0.0185
ULS: 2. D + L	0.0000	3.2544	0.0000	0.0000	-0.0000	0.0185
ULS: 3. D + (S or Lr or R)	0.0000	5.0919	0.0000	0.0000	-0.0000	0.0214
ULS: 3. D + (S or Lr or R)	0.0000	3.2544	0.0000	0.0000	-0.0000	0.0185
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	4.6325	0.0000	0.0000	-0.0000	0.0207
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	3.2544	0.0000	0.0000	-0.0000	0.0185
ULS: 5b. D + 0.7E	0.0000	3.2544	0.0000	0.0000	-0.0000	0.0185
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0000	4.6325	0.0000	0.0000	-0.0000	0.0207
ULS: 8. 0.6D + 0.7E	0.0000	1.9526	0.0000	0.0000	-0.0000	0.0111
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.9558	5.3577	0.0000	0.0000	-0.0000	57.0289
ULS: 5a. D + 0.6W_Wind downforce Case B only	0.0000	3.2544	0.0000	0.0000	-0.0000	0.0185
ULS: 5a. D + 0.6W_Wind uplift Case A only	3.9558	1.1511	0.0000	0.0000	-0.0000	-56.1557
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.0000	3.2544	0.0000	0.0000	-0.0000	0.0185
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.9668	6.2100	0.0000	0.0000	-0.0000	42.7784
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0000	4.6325	0.0000	0.0000	-0.0000	0.0207
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.9668	3.0550	0.0000	0.0000	-0.0000	-42.1100
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0000	4.6325	0.0000	0.0000	-0.0000	0.0207
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.9668	4.8319	0.0000	0.0000	-0.0000	42.7763
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0000	3.2544	0.0000	0.0000	-0.0000	0.0185
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.9668	1.6769	0.0000	0.0000	-0.0000	-42.1122
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0000	3.2544	0.0000	0.0000	-0.0000	0.0185
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.9558	4.0560	0.0000	0.0000	-0.0000	57.0215
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	0.0000	1.9526	0.0000	0.0000	-0.0000	0.0111
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	3.9558	-0.1507	0.0000	0.0000	-0.0000	-56.1631
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.0000	1.9526	0.0000	0.0000	-0.0000	0.0111

Worst Case Reactions LRFD

These calculations are taken directly from the FEA via SkyCiv and are used in the Concrete Checks of the Foundatino Module.
Note: Worst case values are assumed as downforce wind load cases.

Result	Value (kip, kip-ft)
Axial	8.5980
Shear X	-6.5930
Shear Z	0.0000
Moment X	0.0000
Moment Y (Twist)	0.0000
Moment Z	96.0924

Worst Case Reactions ASD

These results are taken from the worst case values in the above table and are used in the Soil Checks in the Foundation Module.
Note: Worst case values are assumed as downforce wind load cases.

Result	Value (kip, kip-ft)
Axial	6.2100
Shear X	-3.9558
Shear Z	0.0000
Moment X	0.0000
Moment Y (Twist)	0.0000
Moment Z	57.0289

Project Details

Design Code: AISC 360-16 LRFD
Provision: LRFD
Country: United States

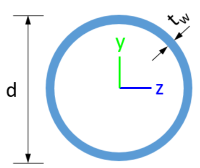
User Name: sales@mtsolar.us
Unit System: imperial

Design Input Information

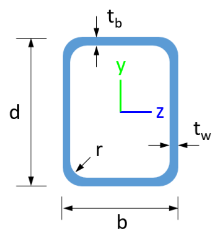
Design Factors			
Φ_t	Φ_c	Φ_b	Φ_v
0.9	0.9	0.9	0.9

Design Materials			
ID	E (ksi)	F_y (ksi)	F_u (ksi)
1	29000	50	65

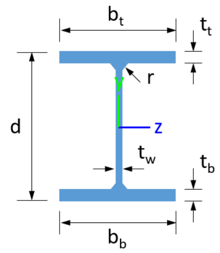
Section Dimensions



ID	Name	d (in)	t_w (in)					
3	2in Pipe Sch 120	2.38	0.25					
6	4in Pipe Sch 120	4.50	0.44					
11	10in Pipe Sch 40	10.75	0.36					



ID	Name	d (in)	b (in)	t_w (in)	t_b (in)	r (in)		
17	HSS5x3x1/4	5.00	3.00	0.23	0.23	0.23		



ID	Name	d (in)	t_w (in)	b_t (in)	b_b (in)	t_t (in)	t_b (in)	r (in)
20	W10x12	9.87	0.19	3.96	3.96	0.21	0.21	0.30

Section Properties								
ID	Name	A (in^2)	J (in^4)	I_{yp} (in^4)	I_{zp} (in^4)	I_w (in^6)	S_{yp} (in^3)	S_{zp} (in^3)

3	2in Pipe Sch 120	1.67	1.91	0.96	0.96	0.00	1.13	1.13
6	4in Pipe Sch 120	5.58	23.29	11.64	11.64	0.00	7.24	7.24
11	10in Pipe Sch 40	11.91	321.47	160.73	160.73	0.00	39.38	39.38
17	HSS5x3x1/4	3.37	11.00	4.81	10.70	0.93	3.77	5.38
20	W10x12	3.54	0.05	2.18	53.80	50.90	1.74	12.60

Member Properties								
Member ID	Section ID	K_zL (ft)	K_yL (ft)	L_b(ft)	C_b	LST	LSC	LD
1	11	30.04	30.04	14.31	-	300	200	1
2	6	1.30	1.30	2.00	-	300	200	1
3	17	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.18,1.18,1.18,1.19,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.17,1.19,1.18,1.19,1.18,1.19	300	200	1
4	17	2.44	2.44	3.75	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68	300	200	1
5	17	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.65,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68	300	200	1
6	17	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.18,1.18,1.18,1.19,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.17,1.19,1.18,1.19,1.18,1.19	300	200	1
7	17	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.65,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68	300	200	1
8	20	14.70	14.70	7.00	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	1
9	3	2.60	2.60	4.00	-	300	200	1
10	17	2.44	2.44	3.75	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68	300	200	1
11	20	14.70	14.70	7.00	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	1
12	6	1.30	1.30	2.00	-	300	200	1
13	20	4.88	4.00	7.50	1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02	300	200	1
14	20	4.88	4.00	7.50	1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02,1.02	300	200	1
15	20	14.70	14.70	7.00	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	1
16	20	14.70	14.70	7.00	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	1

Member Design Capacity

Member ID	Φ_tP_n (kip)	Φ_cP_n (kip)	Φ_bM_{zn} (k-ft)	Φ_bM_{yn} (k-ft)	Φ_vV_{yn} (kip)	Φ_vV_{zn} (kip)
1	535.87	265.05	147.68	147.68	160.76	160.76
2	251.01	248.88	27.16	27.16	75.30	75.30
3	151.65	150.70	20.17	14.14	54.12	28.95
4	151.65	145.15	20.17	14.14	54.12	28.95
5	151.65	149.10	20.17	14.14	54.12	28.95
6	151.65	150.70	20.17	14.14	54.12	28.95
7	151.65	149.10	20.17	14.14	54.12	28.95
8	159.30	15.83	46.90	6.46	56.26	44.91
9	75.10	66.32	4.25	4.25	22.53	22.53
10	151.65	145.15	20.17	14.14	54.12	28.95
11	159.30	15.83	46.90	6.46	56.26	44.91
12	251.01	248.88	27.16	27.16	75.30	75.30
13	159.30	97.43	31.07	6.46	56.26	44.91
14	159.30	97.43	31.06	6.46	56.26	44.91

15	159.30	15.83	46.90	6.46	56.26	44.91
16	159.30	15.83	46.90	6.46	56.26	44.91

Design Ratio

Member ID	**P**	**M_z**	**M_y**	**V_y**	**V_z**	**(P,M_z,M_y)**	**Worst LC**	**KL/r**	**δ**	**Status**
1	0.032	0.651	0.000	0.041	0.000	0.666	#13	0.491	Not Required	Pass
2	0.008	0.213	0.240	0.052	0.044	0.455	#13	0.036	Not Required	Pass
3	0.009	0.437	0.069	0.043	0.017	0.455	#13	0.046	Not Required	Pass
4	0.009	0.435	0.260	0.043	0.053	0.533	#13	0.082	Not Required	Pass
5	0.009	0.271	0.270	0.043	0.072	0.321	#13	0.076	Not Required	Pass
6	0.009	0.437	0.069	0.043	0.017	0.455	#13	0.046	Not Required	Pass
7	0.009	0.271	0.270	0.043	0.072	0.322	#13	0.076	Not Required	Pass
8	0.000	0.112	0.454	0.027	0.019	0.532	#21	Not Required	Not Required	Pass
9	0.039	0.025	0.052	0.001	0.000	0.082	#13	0.206	Not Required	Pass
10	0.009	0.435	0.260	0.043	0.053	0.533	#13	0.082	Not Required	Pass
11	0.000	0.112	0.454	0.027	0.019	0.532	#21	Not Required	Not Required	Pass
12	0.008	0.213	0.240	0.052	0.044	0.455	#13	0.036	Not Required	Pass
13	0.013	0.275	0.709	0.033	0.023	0.894	#21	0.204	Not Required	Pass
14	0.016	0.278	0.709	0.033	0.023	0.894	#21	0.204	Not Required	Pass
15	0.000	0.112	0.454	0.027	0.019	0.532	#21	Not Required	Not Required	Pass
16	0.000	0.112	0.454	0.027	0.019	0.532	#21	Not Required	Not Required	Pass

Definitions

Φ_t	Safety factor for tensile
Φ_c	Safety factor for compression
Φ_b	Safety factor for flexure
Φ_v	Safety factor for shear
E	Modulus of elasticity
F_y	Specified minimum yield stress
F_u	Specified minimum tensile strength
A	Cross-sectional area
J	Torsional constant
I_{yp}	Moment of inertia about the Y axes
I_{zp}	Moment of inertia about the Z axes
I_w	Warping constant
S_{yp}	Plastic section modulus about the Y axis
S_{zp}	Plastic section modulus about the Z axis
KL	Effective length
C_b	Buckling modification factor (from all load combinations)
L_b	Length between braced points
LST	Limited slenderness for tension
LSC	Limited slenderness for compression
LD	Limited deflection
P_n	Nominal axial strength (tension/comression)
M_n	Nominal flexural strength (about Z/Y axis)
V_n	Nominal shear strength (along Z/Y axis)
P	Design ratio in case of axial force
M_z	Design ratio in case of bending about Z axis
M_y	Design ratio in case of bending about Y axis
V_y	Design ratio in case of shear along Y axis
V_z	Design ratio in case of shear along Z axis
(P,M_z,M_y)	Design ratio in case of axial force and bending action
KL/r	Design ratio in case of section slenderness
δ	Design ratio in case of member deflection
OK	Capacity is provided
NG	Capacity is not provided

REFERENCES	CALCULATIONS	RESULTS

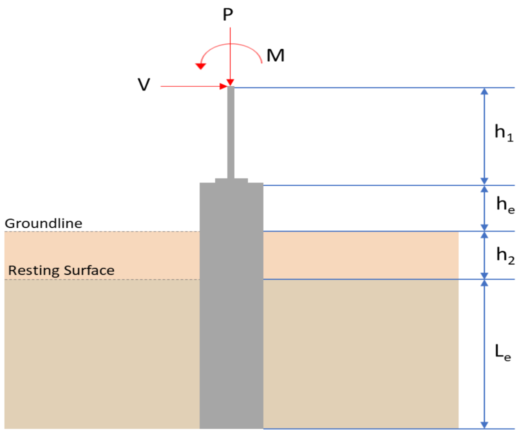
SkyCiv Foundation Design

Pile Foundation

Design Information :

Design code : IBC 2021 (International Building Code)
Unit System : Imperial

Pile Input



Geometry

Pile shape: rectangular

$b = 48\ \text{in}$ - Pile width

$D = 48\ \text{in}$ - Pile depth

$L = 8.25\ \text{ft}$ - Total pile length

$h_1 = 0\ \text{ft}$ - Lateral load height from the top of the pile,

$h_2 = 0\ \text{ft}$ - Depth to resisting surface

$h_e = 0\ \text{ft}$ - Length of pile above the ground

Tabulation of Soil Parameters

Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) (psf/ft)
1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000

Tabulation of Loads

Load Component	ASD	LRFD
P (kip)	6.210	8.598
V_x (kip)	-3.956	-6.593
V_z (kip)	0.000	0.000
M_x (kipft)	0.000	0.000
M_z (kipft)	57.029	96.092

Material Properties

$f'_{ck} = 2.5\ \text{ksi}$ - Concrete strength,

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

$$H = (0\ \text{ft}) + (0\ \text{ft}) + (0\ \text{ft})$$

$$H = 0\ \text{ft}$$

Considering x-direction:

H_o - Lateral force per length of pile,

$$H_o = \frac{V_x}{1.57\ D}$$

$$H_o = \frac{(-3.956\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = -0.62994\ \text{kip/ft}$$

	M_o - Moment per length of pile, $$M_o = \frac{M_z + (V_x\,H)}{1.57\,D}$$ $$M_o = \frac{(57.029\ \mathrm{kipft}) + ((-3.956\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$ $$M_o = 9.0811\ \mathrm{kipft/ft}$$ Required depth of embedment in earth: $$L_x^3 - \left(14.14 \times \frac{H_o \times L_x}{R}\right) - \left(18.85 \times \frac{M_o}{R}\right) = 0$$ Solving the cubic equation: $L_{e,x} = 7.6012\ \mathrm{ft}$ - Required depth in x-direction, **Considering z-direction:** $L_{e,z} = 0\ \mathrm{ft}$ - Required depth in z-direction, **Minimum embedded depth required:** $L_{e,req}$ - Depth of pile required, $$L_{e,req} = MAX[L_{e,x}, L_{e,z}]$$ $$L_{e,req} = MAX[(7.6012\ \mathrm{ft}), (0\ \mathrm{ft})]$$ $$L_{e,req} = 7.601\ \mathrm{ft}$$ L_e - Actual embedded length of pile, $$L_e = L - h_e - h_2$$ $$L_e = (8.25\ \mathrm{ft}) - (0\ \mathrm{ft}) - (0\ \mathrm{ft})$$ $$L_e = 8.25\ \mathrm{ft}$$ $Ratio$ - Embedded depth $$Ratio = \frac{L_{e,req}}{L_e}$$ $$Ratio = \frac{(7.601\ \mathrm{ft})}{(8.25\ \mathrm{ft})}$$ $$Ratio = 0.92133$$	Status: **PASS** Ratio: **0.920**
	End-bearing Capacity (ASD) A - Pile cross-section area $$A = b\,D$$ $$A = (48\ \mathrm{in}) \times (48\ \mathrm{in})$$ $$A = 16\ \mathrm{ft}^2$$ q - End-bearing pressure $$q = \frac{P_v}{A}$$ $$q = \frac{(6.21\ \mathrm{kip})}{(16\ \mathrm{ft}^2)}$$ $$q = 0.38812\ \mathrm{kip/ft}^2$$ **Check bearing capacity ratio:** $Ratio$ - Capacity $$Ratio = \frac{q}{q_a}$$ $$Ratio = \frac{(0.38812\ \mathrm{kip/ft}^2)}{(2000\ \mathrm{psf})}$$ $$Ratio = 0.19406$$	Status: **PASS** Ratio: **0.190**
Czerniak	**Lateral Soil Pressure (ASD):** L/D - Length to least lateral dimension ratio,	

$$L/D = \frac{L}{D}$$

$$L/D = \frac{(8.25\ \mathrm{ft})}{(48\ \mathrm{in})}$$

$$L/D = 2.0625$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.62994\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 9.0811\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

$$a = \frac{(4\, M_o\, L_e) + \left(3\, H_o\, L_e^2\right)}{(6\, M_o) + (4\, H_o\, L_e)}$$

$$a = \frac{(4 \times (9.0811\ \mathrm{kipft/ft}) \times (8.25\ \mathrm{ft})) + \left(3 \times (-0.62994\ \mathrm{kip/ft}) \times (8.25\ \mathrm{ft})^2\right)}{(6 \times (9.0811\ \mathrm{kipft/ft})) + (4 \times (-0.62994\ \mathrm{kip/ft}) \times (8.25\ \mathrm{ft}))}$$

$$a = 5.6899\ \mathrm{ft}$$

p - Earth pressure against the pile at distance a/2 from resting surface,

$$p = \frac{0.75\ [(4\, M_o) + (3\, H_o\, L_e)]^2}{L_e^2\ [(3\, M_o) + (2\, H_o\, L_e)]}$$

$$p = \frac{0.75 \times [(4 \times (9.0811\ \mathrm{kipft/ft})) + (3 \times (-0.62994\ \mathrm{kip/ft}) \times (8.25\ \mathrm{ft}))]^{\ 2}}{(8.25\ \mathrm{ft})^2 \times [(3 \times (9.0811\ \mathrm{kipft/ft})) + (2 \times (-0.62994\ \mathrm{kip/ft}) \times (8.25\ \mathrm{ft}))]}$$

$$p = 0.28113\ \mathrm{kip/ft^2}$$

s - Earth pressure against the pile at distance L_e,

$$s = \frac{6\ [(2\, M_o) + (H_o\, L_e)]}{L_e^2}$$

$$s = \frac{6 \times [(2 \times (9.0811\ \mathrm{kipft/ft})) + ((-0.62994\ \mathrm{kip/ft}) \times (8.25\ \mathrm{ft}))]}{(8.25\ \mathrm{ft})^2}$$

$$s = 1.1429\ \mathrm{kip/ft^2}$$

Check lateral soil pressure capacity:

p_a - Allowable lateral soil pressure at depth a/2,

$$p_a = R\, \frac{a}{2}$$

$$p_a = (150\ \mathrm{psf/ft}) \times \frac{(5.6899\ \mathrm{ft})}{2}$$

$$p_a = 0.42674\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

$$Ratio = \frac{p}{p_a}$$

$$Ratio = \frac{\left(0.28113\ \mathrm{kip/ft^2}\right)}{\left(0.42674\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.65879$$

Status: **PASS**
Ratio: **0.660**

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\, L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (8.25\ \mathrm{ft})$$

$$p_s = 1.2375\ \mathrm{kip/ft^2}$$

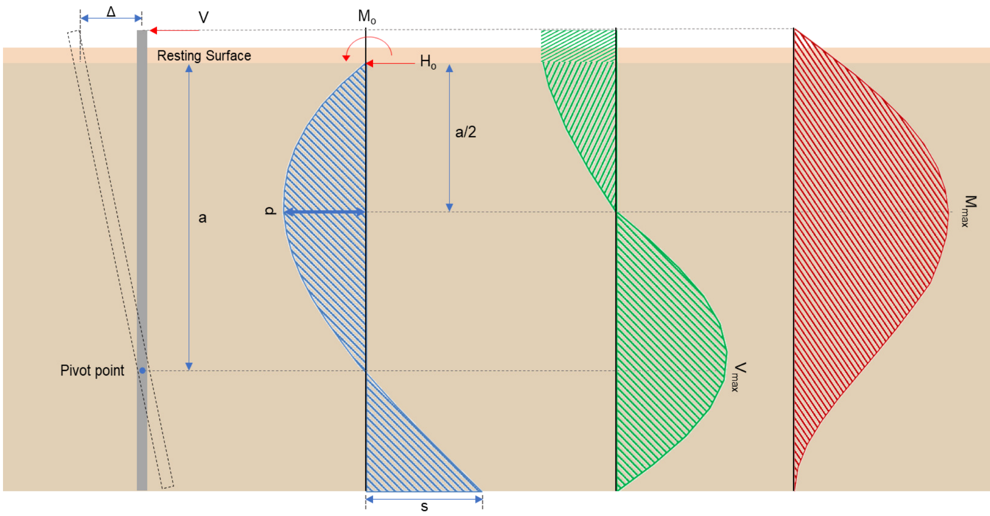
$Ratio$ - Lateral soil capacity

$$Ratio = \frac{s}{p_s}$$

$$Ratio = \frac{\left(1.1429\ \mathrm{kip/ft^2}\right)}{\left(1.2375\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.92358$$

Status: PASS
Ratio: 0.920



Pile Rotation | Pressure Diagram | Shear Diagram | Moment Diagram

Shear force and Bending moment (x-direction, LRFD)

H_o - Lateral force per length of pile,

$$H_o = \frac{V_x}{1.57\,D}$$

$$H_o = \frac{(-6.593\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -1.0498\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

$$M_o = \frac{M_z + (V_x\,H)}{1.57\,D}$$

$$M_o = \frac{(96.092\ \mathrm{kipft}) + ((-6.593\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 15.301\ \mathrm{kipft/ft}$$

E - Distance from lateral load to resisting surface,

$$E = \frac{M_o}{H_o}$$

$$E = \frac{(15.301\ \mathrm{kipft/ft})}{(-1.0498\ \mathrm{kip/ft})}$$

$$E = 14.575\ \mathrm{ft}$$

a - Distance from resting surface to pivot point,

$$a = \frac{(4\,M_o\,L_e) + \left(3\,H_o\,L_e^2\right)}{(6\,M_o) + (4\,H_o\,L_e)}$$

$$a = \frac{(4 \times (15.301\ \mathrm{kipft/ft}) \times (8.25\ \mathrm{ft})) + \left(3 \times (-1.0498\ \mathrm{kip/ft}) \times (8.25\ \mathrm{ft})^2\right)}{(6 \times (15.301\ \mathrm{kipft/ft})) + (4 \times (-1.0498\ \mathrm{kip/ft}) \times (8.25\ \mathrm{ft}))}$$

$$a = 5.6884\ \mathrm{ft}$$

V_{max} - Max shear force located at depth a,

$$V_{max} = (H_o\,D)\left[1 - \left[3\left(\frac{4\,E}{L_e} + 3\right)\left(\frac{a}{L_e}\right)^2\right] + \left[4\left(\frac{3\,E}{L_e} + 2\right)\left(\frac{a}{L_e}\right)^3\right]\right]$$

$$V_{max} = ((-1.0498\ \mathrm{kip/ft}) \times (48\ \mathrm{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (14.575\ \mathrm{ft})}{(8.25\ \mathrm{ft})} + 3\right) \times \left(\frac{(5.6884\ \mathrm{ft})}{(8.25\ \mathrm{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (14.575\ \mathrm{ft})}{(8.25\ \mathrm{ft})} + 2\right) \times \left(\frac{(5.6884\ \mathrm{ft})}{(8.25\ \mathrm{ft})}\right)^3\right]\right]$$

$$V_{max} = 15.898\ \mathrm{kip}$$

$$V_{max} = 15.898\ \text{kip}$$

M_{max} - Max bending moment located at depth a/2,

$$M_{max} = (H_o\, D\, L_e)\left[\left(\frac{E}{L_e} + \frac{a}{2\,L_e}\right) - \left[\left(\frac{4\,E}{L_e} + 3\right)\left(\frac{a}{2\,L_e}\right)^3\right] + \left[\left(\frac{3\,E}{L_e} + 2\right)\left(\frac{a}{2\,L_e}\right)^4\right]\right]$$

$$M_{max} = ((-1.0498\ \text{kip/ft}) \times (48\ \text{in}) \times (8.25\ \text{ft})) \times \left[\left(\frac{(14.575\ \text{ft})}{(8.25\ \text{ft})} + \frac{(5.6884\ \text{ft})}{2 \times (8.25\ \text{ft})}\right) - \left[\left(\frac{4 \times (14.575\ \text{ft})}{(8.25\ \text{ft})} + 3\right) \times \left(\frac{(5.6884\ \text{ft})}{2 \times (8.25\ \text{ft})}\right)^3\right] + \left[\left(\frac{3 \times (14.575\ \text{ft})}{(8.25\ \text{ft})} + 2\right) \times \left(\frac{(5.6884\ \text{ft})}{2 \times (8.25\ \text{ft})}\right)^4\right]\right]$$

$$M_{max} = 62.431\ \text{kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

$f'_{ck} = 2.5\ \text{ksi}$ - Concrete strength,
$f_{yk} = 60\ \text{ksi}$ - Longitudinal reinforcement strength,
$\phi = 0.65$ - Reduction factor for axial strength,
Table 22.4.2.1 $\alpha = 0.8$ - Alpha factor for axial strength,
$A_g = 2304\ \text{in}^2$ - Gross area of concrete,

Longitudinal reinforcement:

Required reinforcement due to axial load, $A_{st,required}$

22.4.2.2, 10.6.1.1 $A_{st,required}$

$$A_{st,required} = Min\left[\frac{\frac{P}{\phi\,\alpha} - (0.85\, f'_{ck}\, A_g)}{f_{yk} - (0.85\, f'_{ck})}, (0.08\, A_g)\right]$$

$$A_{st,required} = Min\left[\frac{\frac{(8.598\ \text{kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5\ \text{ksi}) \times (2304\ \text{in}^2))}{(60\ \text{ksi}) - (0.85 \times (2.5\ \text{ksi}))}, (0.08 \times (2304\ \text{in}^2))\right]$$

$$A_{st,required} = -84.31\ \text{in}^2$$

A_{min} - Governing minimum reinforcement area,

$$A_{min} = Max\,[A_{st,required}, (0.0018\, A_g)]$$

$$A_{min} = Max\left[(-84.31\ \text{in}^2), (0.0018 \times (2304\ \text{in}^2))\right]$$

$$A_{min} = 4.1472\ \text{in}^2$$

n_{rebar} - Required number of reinforcement,

$$n_{rebar} = \frac{A_{min}}{A_{rebar}}$$

$$n_{rebar} = \frac{(4.1472\ \text{in}^2)}{(0.3068\ \text{in}^2)}$$

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

$$A_{st} = n_{rebar}\,\frac{\pi\, d_{bar}^2}{4}$$

$$A_{st} = (14) \times \frac{\pi \times (0.625\ \text{in})^2}{4}$$

$$A_{st} = 4.2951\ \text{in}^2$$

$Ratio$ - Capacity

$$Ratio = \frac{A_{min}}{A_{st}}$$

$$Ratio = \frac{(4.1472\ \text{in}^2)}{(4.2951\ \text{in}^2)}$$

$$Ratio = 0.96556$$

Status: **PASS**
Ratio: **0.970**

25.2.3 s_{rebar} - Minimum spacing of reinforcement,

$$s_{rebar} = Max\,[1.5, (1.5\, d_{bar})]$$

	$$s_{rebar} = Max\left[1.5, (1.5 \times (0.625\text{ in}))\right]$$ $$s_{rebar} = 1.5\text{ in}$$	
	Ties:	
25.7.2.2	Since longitudinal reinforcement is $\leq$ No. 10⌀: Use #3(0.375 in)	
25.7.2.1	s_{ties} - Maximum spacing of ties, $$s_{ties} = Min\left[(16\, d_{bar}), (48\, d_{ties}), Min\,(D, b)\right]$$ $$s_{ties} = Min\left[(16 \times (0.625\text{ in})), (48 \times (0.375\text{ in})), Min\,((48\text{ in}), (48\text{ in}))\right]$$ $$s_{ties} = 10\text{ in}$$	
	Summary: Main reinforcement: **14 - #5 (0.625 in)** Ties: **#3(0.375 in) - 10 in**	
	Axial Compression Strength (ACI 318-19, LRFD)	
22.4.2.2	ϕP_N - Allowable axial compressive strength $$\phi P_N = \phi\, 0.80\, \left[\left(0.85\, f'_{ck}\, [A_g - A_{st}]\right) + (f_{yk}\, A_{st})\right]$$ $$\phi P_N = (0.65) \times 0.80 \times \left[\left(0.85 \times (2.5\text{ ksi}) \times \left[\left(2304\text{ in}^2\right) - \left(4.2951\text{ in}^2\right)\right]\right) + \left((60\text{ ksi}) \times \left(4.2951\text{ in}^2\right)\right)\right]$$ $$\phi P_N = 2675.2\text{ kip}$$ $Ratio$ - Capacity $$Ratio = \frac{P}{\phi P_N}$$ $$Ratio = \frac{(8.598\text{ kip})}{(2675.2\text{ kip})}$$ $$Ratio = 0.003214$$	Status: **PASS** Ratio: **0.000**
	Shear Strength (ACI 318-19, LRFD)	
	Parameters: $b_w = 48\text{ in}$ - Effective width,	
22.5.2.2	d - Effective depth $$d = 0.80\, D$$ $$d = 0.80 \times (48\text{ in})$$ $$d = 38.4\text{ in}$$	
22.5.5.1.3	λ_s - size effect modification factor $$\lambda_s = MIN\left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1\right]$$ $$\lambda_s = MIN\left[\sqrt{\frac{2}{1 + \frac{(38.4\text{ in})}{10}}}, 1\right]$$ $$\lambda_s = 0.64282$$ The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5\text{ ksi} \rightarrow 2500\text{ psi}$,	
22.5.5.1.1	$V_{c,max}$ - Max shear strength of concrete $$V_{c,max} = 5\, \lambda_s\, \sqrt{f'_{ck}}\, b_w\, d$$ $$V_{c,max} = 5 \times (0.64282) \times \sqrt{(2500\text{ psi})} \times (48\text{ in}) \times (38.4\text{ in})$$ $$V_{c,max} = 296.21\text{ kip}$$ The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5\text{ ksi} \rightarrow 2500\text{ psi}$, $P = 8.598\text{ kip} \rightarrow 8598\text{ lbf}$,	
22.5.5.1.1(a)	$V_{c,a}$ - Shear strength of concrete (a) $$V_{c,a} = \left[2\, \lambda_s\, \sqrt{f'_{ck}} + \frac{P}{6\, A_g}\right]\, b_w\, d$$	

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(8598 \text{ lbf})}{6 \times (2304 \text{ in}^2)}\right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 119.63 \text{ kip}$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$,

22.5.5.1.2 $V_{c,b}$ - Shear strength of concrete (b)

$$V_{c,b} = \left[2\, \lambda_s\, \sqrt{f'_{ck}} + \left(0.05\, f'_{ck}\right)\right]\, b_w\, d$$

$$V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + (0.05 \times (2500 \text{ psi}))\right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,b} = 348.89 \text{ kip}$$

V_c - Governing shear strength of concrete

$$V_c = Min\left[V_{c,max}, V_{c,a}, V_{c,b}\right]$$

$$V_c = Min\left[(296.21 \text{ kip}), (119.63 \text{ kip}), (348.89 \text{ kip})\right]$$

$$V_c = 119.63 \text{ kip}$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$,

22.5.1.2 $V_{s,a}$ - Shear strength of steel (a)

$$V_{s,a} = 8\, \sqrt{f'_{ck}}\, b_w\, d$$

$$V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{s,a} = 737.28 \text{ kip}$$

A_v - Ties rebar area,

$$A_v = \frac{\pi\, d_{ties}^2}{4}$$

$$A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$$

$$A_v = 0.11045 \text{ in}^2$$

22.5.8.5.3 $V_{s,b}$ - Shear strength of steel (b)

$$V_{s,b} = \frac{2\, A_v\, f_{ywk}\, d}{s_{ties}}$$

$$V_{s,b} = \frac{2 \times \left(0.11045 \text{ in}^2\right) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$$

$$V_{s,b} = 50.894 \text{ kip}$$

V_s - Governing shear strength of steel

$$V_s = MIN\left[V_{s,a}, V_{s,b}\right]$$

$$V_s = MIN\left[(737.28 \text{ kip}), (50.894 \text{ kip})\right]$$

$$V_s = 50.894 \text{ kip}$$

22.5.1.1 ϕV_n - Allowable shear strength

$$\phi V_n = \phi\ \left(V_c + V_s\right)$$

$$\phi V_n = (0.65) \times ((119.63 \text{ kip}) + (50.894 \text{ kip}))$$

$$\phi V_n = 110.84 \text{ kip}$$

Considering x-direction:

$V_{max} = 15.898 \text{ kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

$$Ratio = \frac{V_{max}}{\phi V_n}$$

$$Ratio = \frac{(15.898 \text{ kip})}{(110.84 \text{ kip})}$$

$$Ratio = 0.14343$$

Status: **PASS**
Ratio: **0.140**

14.5.2.1b	**Flexural Strength (ACI 318-19, LRFD)** S_m - Section modulus $$S_m = \frac{b\,D^2}{6}$$ $$S_m = \frac{(48\text{ in}) \times (48\text{ in})^2}{6}$$ $$S_m = 18432\text{ in}^3$$ $\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$ $$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f_c')} \times S_m$$ $$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5ksi)} \times 18432.001in^3$$ $$\phi M_{n,1} = 249.600kipft$$ $\phi M_{n,2}$ $$\phi M_{n,2} = \phi\;0.85\;f_{ck}'\;S_m$$ $$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5\text{ ksi}) \times \left(18432\text{ in}^3\right)$$ $$\phi M_{n,2} = 2121.6\text{ kipft}$$ Therefore, ϕM_n - Allowable flexural strength, $$\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$$ $$\phi M_n = MIN[(249.6\text{ kipft}), (2121.6\text{ kipft})]$$ $$\phi M_n = 249.6\text{ kipft}$$ **Considering x-direction:** $M_{max} = 62.431\text{ kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(62.431\text{ kipft})}{(249.6\text{ kipft})}$$ $$Ratio = 0.25013$$	Status: **PASS** Ratio: **0.250**