

Your Project Calculations



Project Name: AlbergAuto|LSCtop9|RevB

S3D Model Link:

https://platform.skyciv.com/structural?preload_name=AlbergAuto|LSCtop9|RevB&preload_path=Shared%20Enterprise%20Folder/MT_Solar_Projects/4_2023

Public Model Link:

https://platform.skyciv.com/structural-viewer?project_id=Jw2Db7gPF62bLKRH64LlfZLFgCm66d3gWCHImtRuMZGLGOLgE5eUqjH8vs1P66NB

Array Specification

Product:	Beam
Unique ID:	1P-0-6TOP-HD-57-L-3Hx3W-GG4L
Duty Classification:	HD
Module Width:	41.26 in
Module Length:	75.91in
Number of Rows:	3
Number of Columns:	3
Total Number of Modules:	9
Desired Tilt Angle:	30
Front Edge Clearance:	5
Total Array Height at Tilt:	10.19 ft
Total Frame Length:	17.00 ft
Frame Weight:	699 lbs
Array Dimensions N/S:	10.44 ft
Array Dimensions E/W:	19.23 ft
Rail Length:	125.28 in
Rail Spacing:	3.16 ft
Rail Check:	Not Checked

Support Specifications

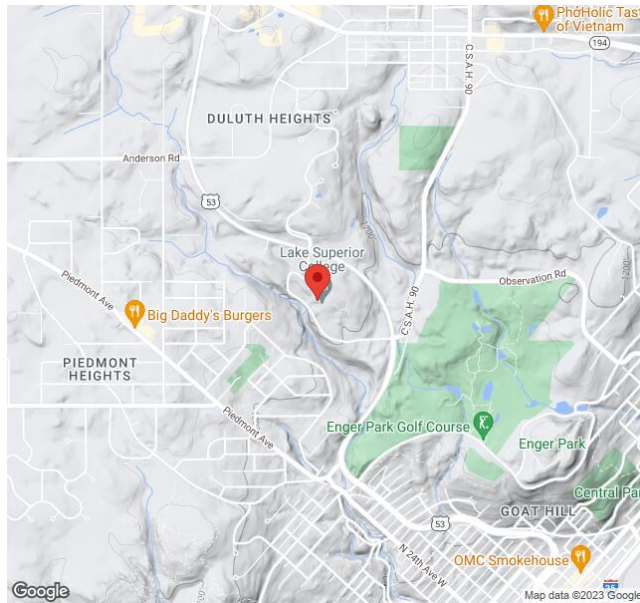
Pole Size:	6in Pipe Sch 40
Pole Length above Grade:	7.61 ft
Number of Poles:	1
Pole Spacing:	0

Foundation Specifications

Foundation Type:	Square
Foundation Dimensions:	48 x 48 in
Foundation Depth (below grade):	Pile 1: 4.75 ft
Foundation Volume:	2.815 y ³
Foundation Result:	PASSED

Site Info

Risk Category:	I
Exposure:	B
Soil Classification:	sand
Site Location:	2101 Trinity Rd, Duluth, MN 55811, USA
Wind Speed:	100 mph
Snow Load:	60 psf
Design Uplift Pressure:	Multiple pressures
Design Downforce Pressure:	Multiple pressures
Design Snow Pressure:	0.022856 ksf



Design Disclaimer

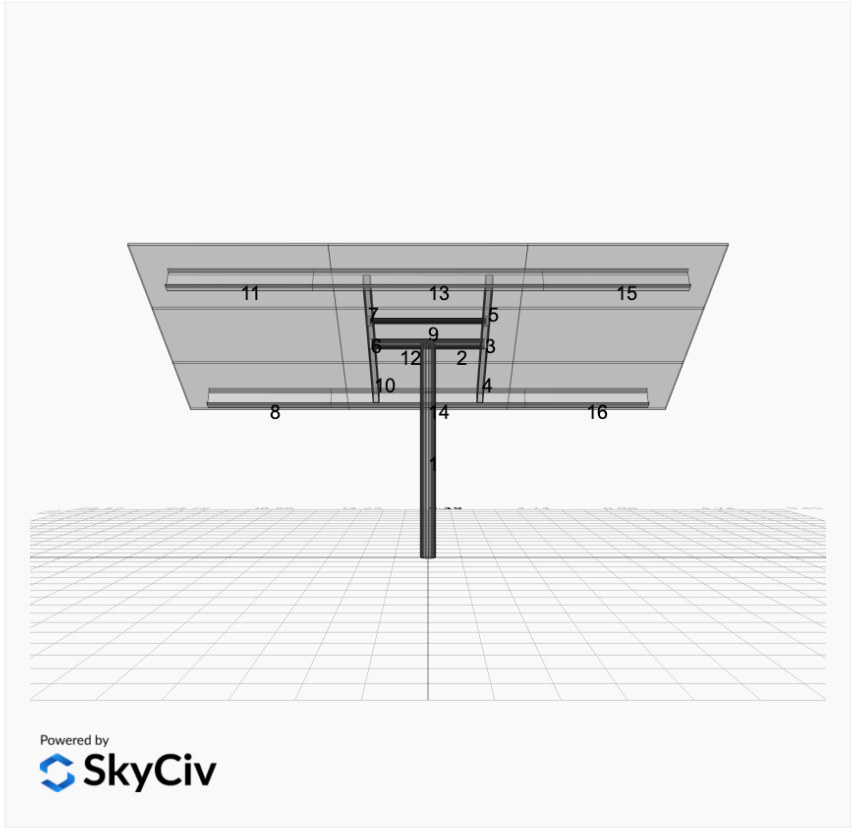
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

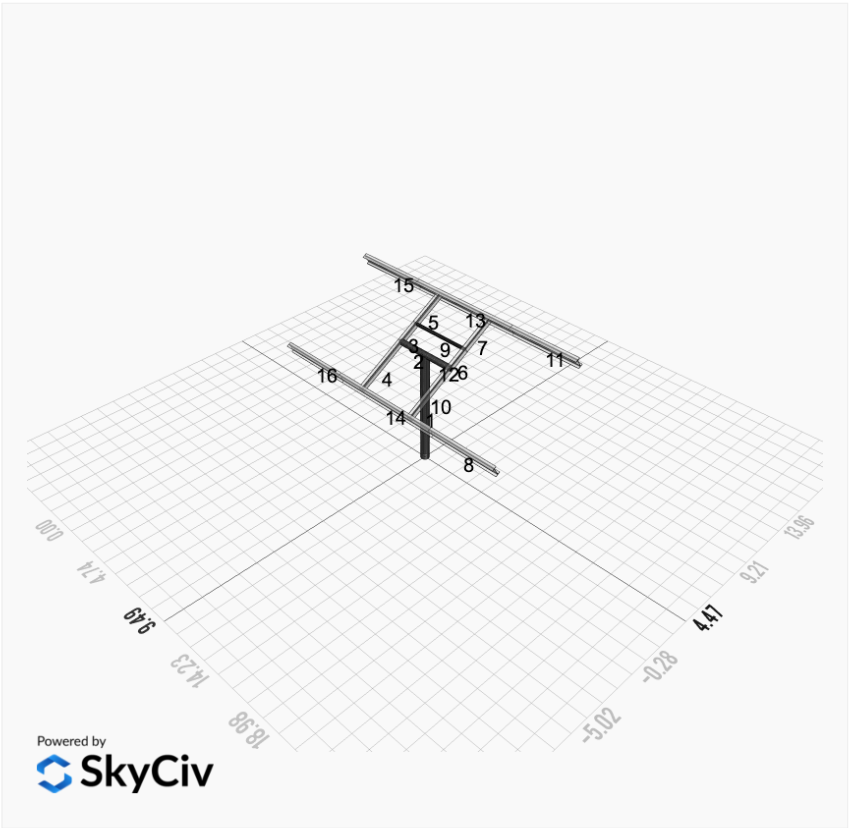
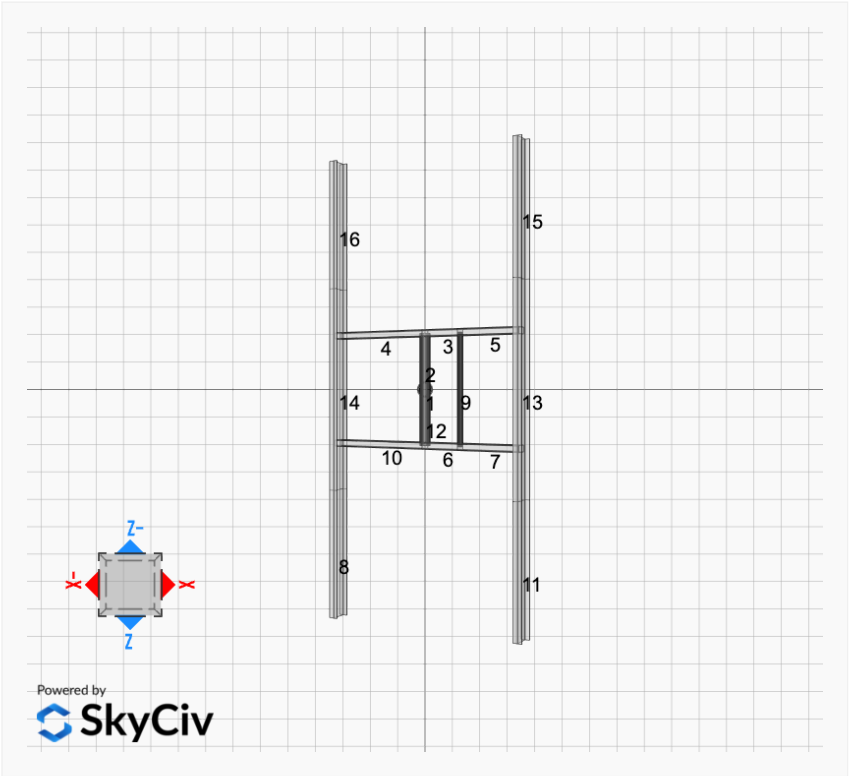
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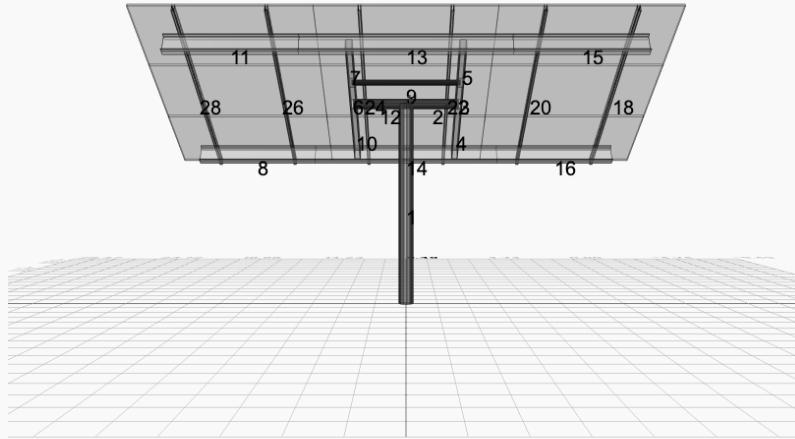
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Design Notes:

- AISC Deflection checks are set to L/1 due to structure design intent
- Foundation Design and Sizing is approximate only

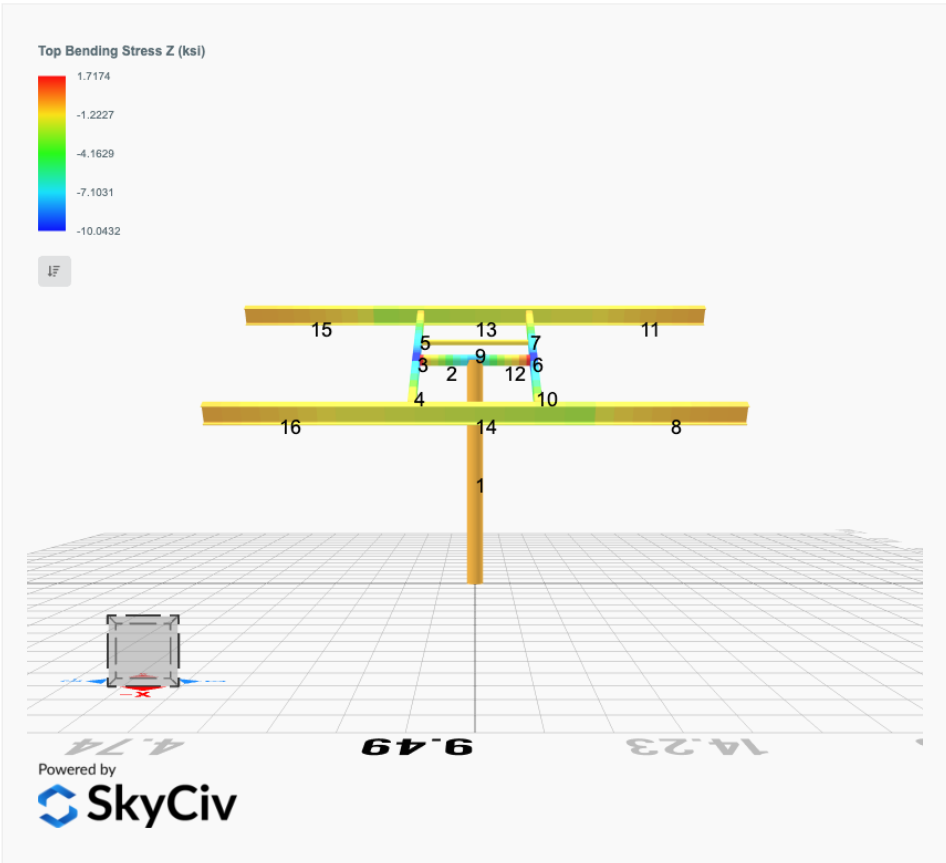
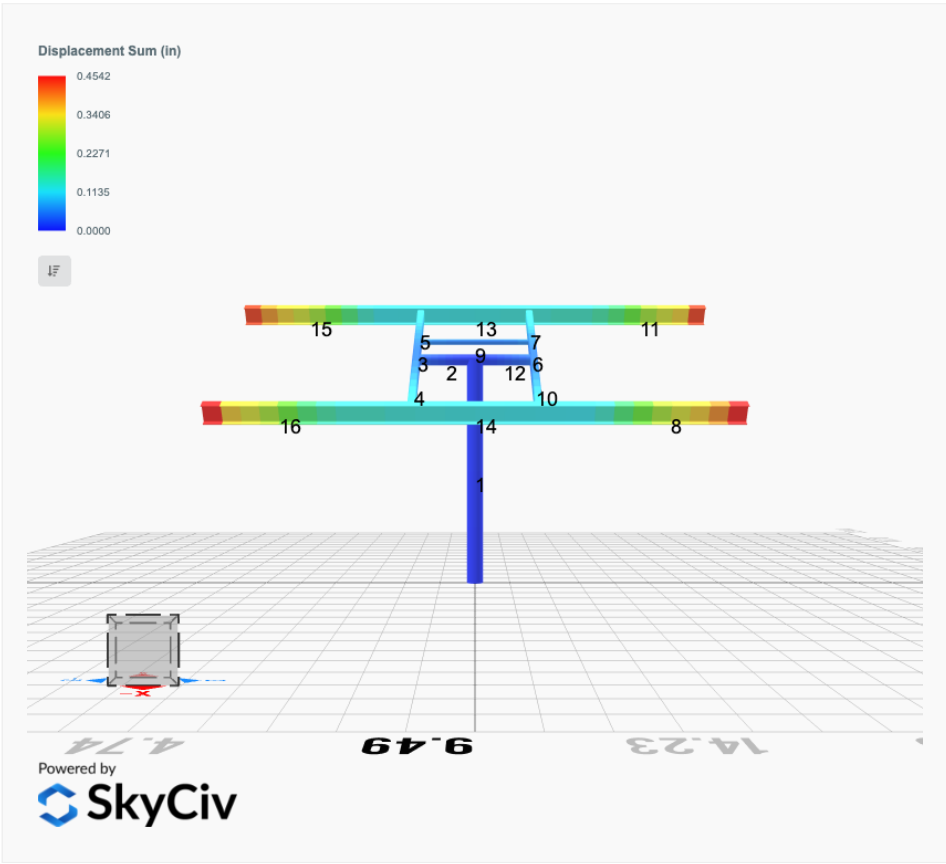


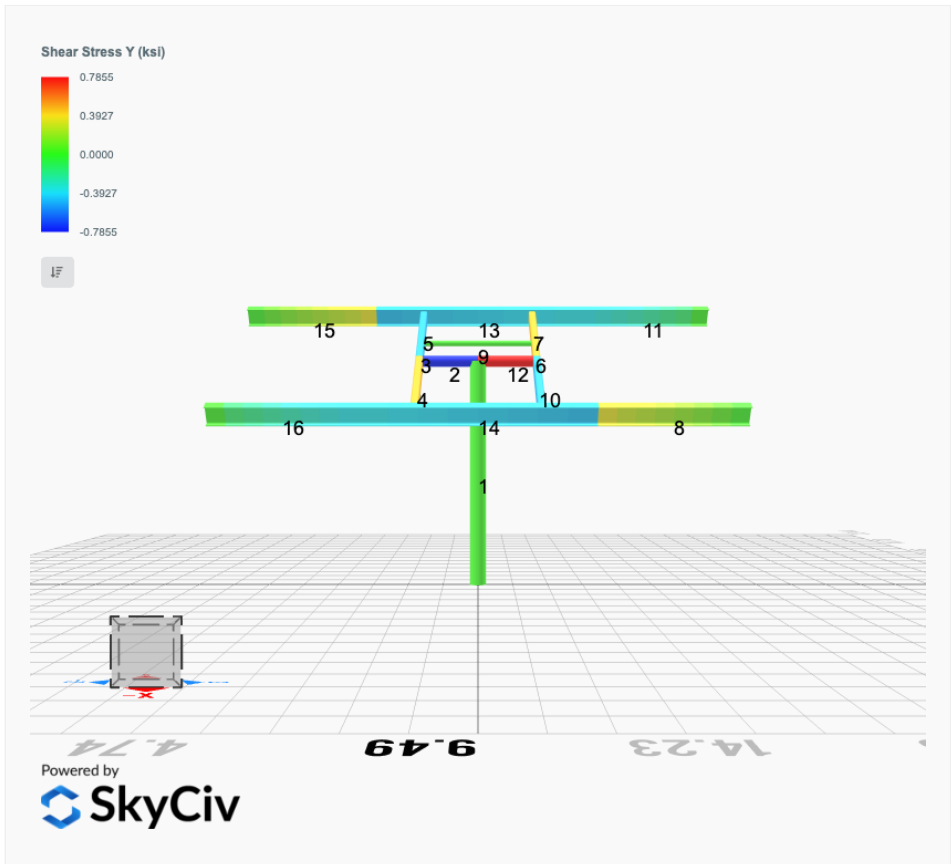
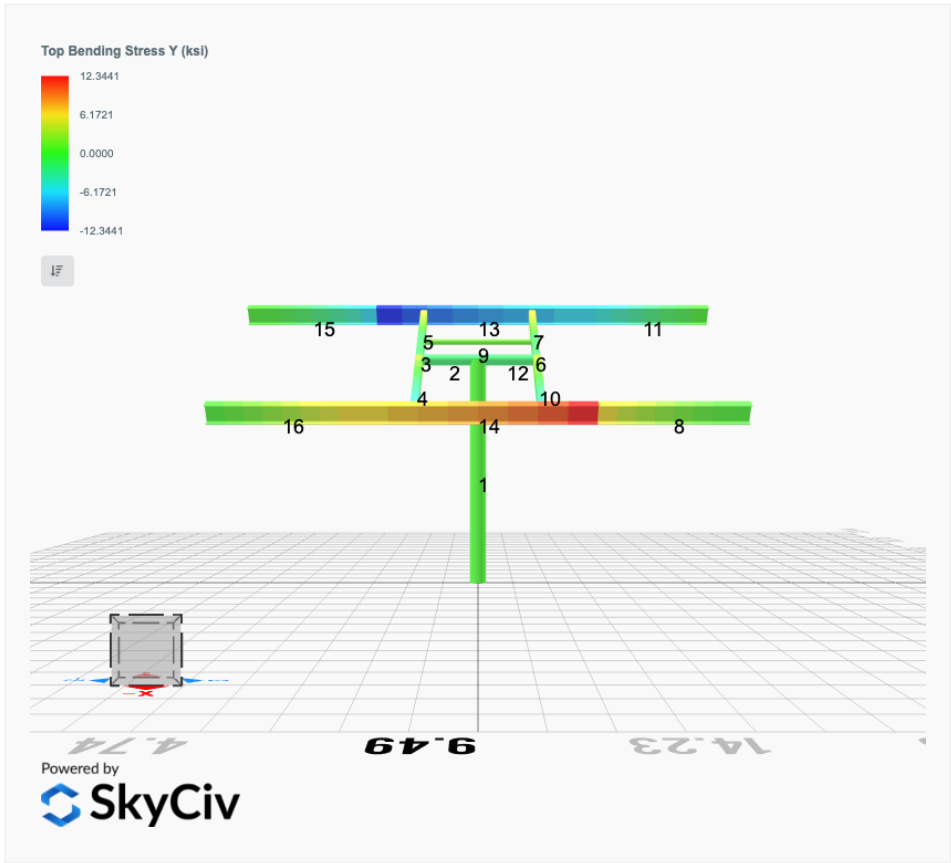


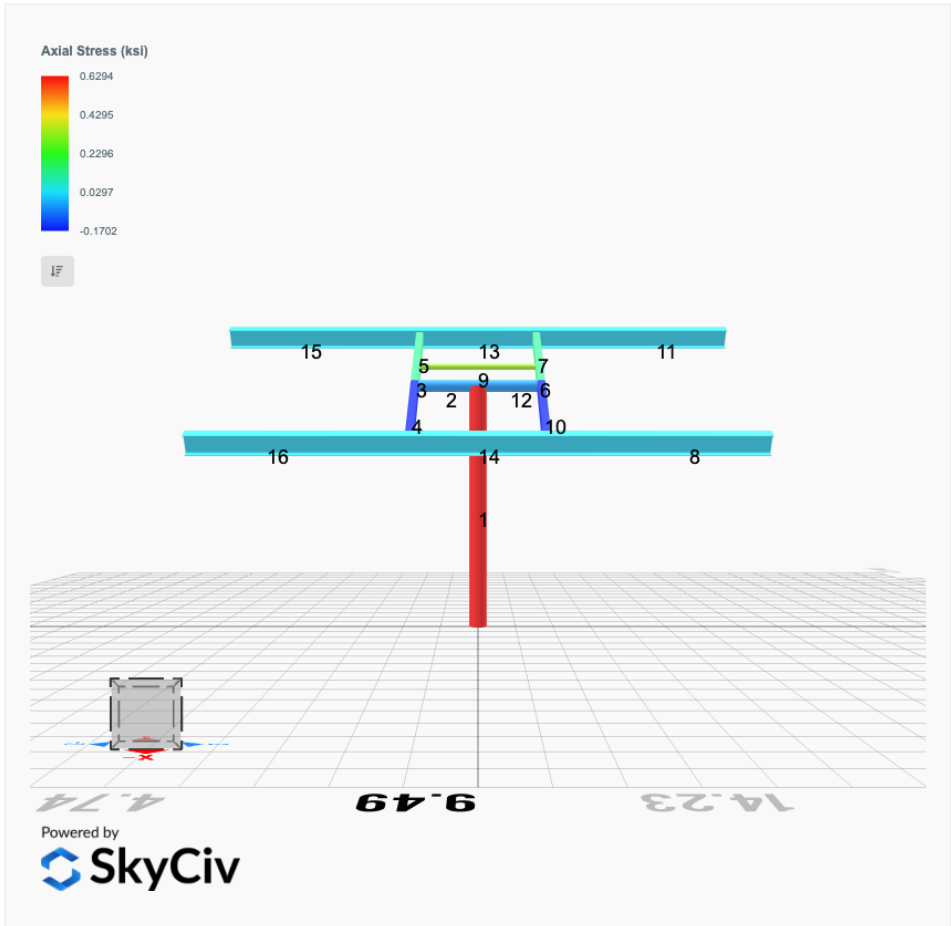


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FEM Results (Envelope Worst Case for each member)







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	1.6817	0.0000	0.0000	-0.0000	0.0260
ULS: 2. D + L	-0.0000	1.6817	0.0000	0.0000	-0.0000	0.0260
ULS: 3. D + (S or Lr or R)	0.0000	5.1947	0.0000	0.0000	-0.0000	0.0399
ULS: 3. D + (S or Lr or R)	-0.0000	1.6817	0.0000	0.0000	-0.0000	0.0260
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	4.3164	0.0000	0.0000	-0.0000	0.0365
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0000	1.6817	0.0000	0.0000	-0.0000	0.0260
ULS: 5b. D + 0.7E	-0.0000	1.6817	0.0000	0.0000	-0.0000	0.0260
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0000	4.3164	0.0000	0.0000	-0.0000	0.0365
ULS: 8. 0.6D + 0.7E	-0.0000	1.0090	0.0000	0.0000	-0.0000	0.0156
ULS: 5a. D + 0.6W_Wind downforce Case A only	-1.2857	3.9085	-0.0000	0.0000	-0.0000	9.9354
ULS: 5a. D + 0.6W_Wind downforce Case B only	-1.2857	3.9085	-0.0000	0.0000	-0.0000	9.9354
ULS: 5a. D + 0.6W_Wind uplift Case A only	1.1020	-0.2270	0.0000	0.0000	-0.0000	-8.2704
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.9183	0.0911	0.0000	0.0000	-0.0000	-11.4301
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.9642	5.9865	0.0000	0.0000	-0.0000	7.4685
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.9642	5.9865	0.0000	0.0000	-0.0000	7.4685
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.8265	2.8849	0.0000	0.0000	-0.0000	-6.1859
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.6887	3.1235	0.0000	0.0000	-0.0000	-8.5556
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.9642	3.3518	0.0000	0.0000	-0.0000	7.4581
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.9642	3.3518	0.0000	0.0000	-0.0000	7.4581
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.8265	0.2502	0.0000	0.0000	-0.0000	-6.1963
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.6887	0.4888	0.0000	0.0000	-0.0000	-8.5661
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-1.2857	3.2358	-0.0000	0.0000	-0.0000	9.9250
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-1.2857	3.2358	-0.0000	0.0000	-0.0000	9.9250
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	1.1020	-0.8997	0.0000	0.0000	-0.0000	-8.2808
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.9183	-0.5816	0.0000	0.0000	-0.0000	-11.4405

Worst Case Reactions LRFD

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

Result	Value
Axial	9.4944
Shear X	-2.1428
Shear Z	-0.0000
Moment X	-0.0000
Moment Z	19.3603

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
Axial	5.9865
Shear X	-1.2857
Shear Z	0.0000
Moment X	0.0000
Moment Z	11.4405

Project Details

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

User Name: sales@mtsolar.us
 Project Name: AlbergAuto|LSCtop9|RevB
 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)					
2	2in Pipe Sch 80	2.38	0.22					
5	4in Pipe Sch 80	4.50	0.34					
7	6in Pipe Sch 40	6.63	0.28					
ID	Name	d (in)	b (in)	t_w (in)	t_b (in)	r (in)		
16	HSS5x3x16	5.00	3.00	0.17	0.17	0.17		
ID	Name	d (in)	t_w (in)	b_t (in)	b_b (in)	t_t (in)	t_b (in)	r (in)
19	W8x10	7.89	0.17	3.94	3.94	0.20	0.20	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)
2	2in Pipe Sch 80	1.48	1.74	0.87	0.87	0.00	1.02	1.02
5	4in Pipe Sch 80	4.41	19.22	9.61	9.61	0.00	5.85	5.85

2	198.33	196.72	21.95	21.95	59.50	59.50
3	116.10	115.41	15.79	11.10	42.08	23.28
4	116.10	111.33	15.79	11.10	42.08	23.28
5	116.10	114.23	15.79	11.10	42.08	23.28
6	116.10	115.41	15.79	11.10	42.08	23.28
7	116.10	114.23	15.79	11.10	42.08	23.28
8	133.20	32.95	32.87	6.12	40.24	43.62
9	66.48	58.89	3.82	3.82	19.94	19.94
10	116.10	111.33	15.79	11.10	42.08	23.28
11	133.20	32.95	32.87	6.12	40.24	43.62
12	198.33	196.72	21.95	21.95	59.50	59.50
13	133.20	126.79	32.87	6.12	40.24	43.62
14	133.20	126.79	32.87	6.12	40.24	43.62
15	133.20	32.95	32.87	6.12	40.24	43.62
16	133.20	32.95	32.87	6.12	40.24	43.62
17	133.20	118.19	32.76	6.12	40.24	43.62
18	133.20	126.79	32.87	6.12	40.24	43.62
19	133.20	118.19	30.91	6.12	40.24	43.62
20	133.20	126.79	32.87	6.12	40.24	43.62

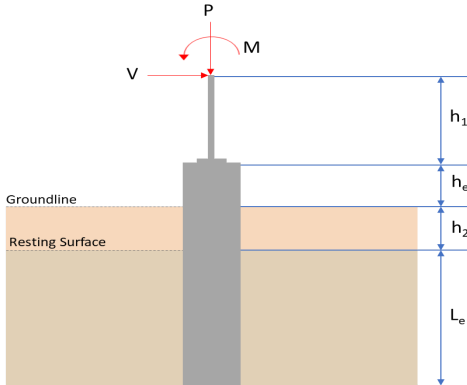
Design Ratio

Member ID	P	M _z	M _y	V _y	V _z	(P,M _z ,M _y)	Worst LC	KL/r	δ	Status
1	0.064	0.458	0.000	0.028	0.000	0.462	#16	0.427	Not Required	Pass
2	0.004	0.356	0.110	0.078	0.018	0.447	#21	0.035	Not Required	Pass
3	0.008	0.506	0.040	0.051	0.001	0.550	#21	0.045	Not Required	Pass
4	0.008	0.502	0.153	0.051	0.032	0.602	#21	0.080	Not Required	Pass
5	0.008	0.313	0.159	0.050	0.041	0.357	#21	0.074	Not Required	Pass
6	0.008	0.506	0.040	0.051	0.001	0.550	#21	0.045	Not Required	Pass
7	0.008	0.313	0.159	0.050	0.041	0.357	#21	0.074	Not Required	Pass
8	0.000	0.085	0.195	0.029	0.012	0.280	#21	Not Required	Not Required	Pass
9	0.016	0.048	0.038	0.001	0.000	0.093	#21	0.204	Not Required	Pass
10	0.008	0.502	0.153	0.051	0.032	0.602	#21	0.080	Not Required	Pass
11	0.000	0.085	0.195	0.029	0.012	0.280	#21	Not Required	Not Required	Pass
12	0.004	0.356	0.110	0.078	0.018	0.447	#21	0.035	Not Required	Pass
13	0.000	0.159	0.366	0.040	0.016	0.525	#21	Not Required	Not Required	Pass
14	0.000	0.159	0.366	0.040	0.016	0.525	#21	Not Required	Not Required	Pass
15	0.000	0.085	0.195	0.029	0.012	0.280	#21	Not Required	Not Required	Pass
16	0.000	0.085	0.195	0.029	0.012	0.280	#21	Not Required	Not Required	Pass
17	0.007	0.167	0.078	0.012	0.005	0.248	#21	0.124	Not Required	Pass
18	0.000	0.159	0.366	0.040	0.016	0.525	#21	Not Required	Not Required	Pass
19	0.006	0.170	0.088	0.012	0.005	0.261	#21	0.186	Not Required	Pass
20	0.000	0.159	0.366	0.040	0.016	0.525	#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

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/compression)
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 in - Pile width D = 48 in - Pile depth L = 4.75 ft - Total pile length h1 = 0 ft - Lateral load height from the top of the pile, h2 = 0 ft - Depth to resisting surface he = 0 ft - Length of pile above the ground Tabulation of Soil Parameters <table><tr><th>Layer</th><th>Label</th><th>Allowable Bearing Pressure (qa) (psf)</th><th>Allowable Lateral Pressure (R) (psf/ft)</th></tr><tr><td>1</td><td>Sand, silty sand, clayey sand, silty gravel & clayey gravel</td><td>2000.000</td><td>150.000</td></tr></table> Tabulation of Loads <table><tr><th>Load Component</th><th>ASD</th><th>LRFD</th></tr><tr><td>P (kip)</td><td>5.987</td><td>9.494</td></tr><tr><td>Vx (kip)</td><td>-1.286</td><td>-2.143</td></tr><tr><td>Vz (kip)</td><td>0.000</td><td>0.000</td></tr><tr><td>Mx (kipft)</td><td>0.000</td><td>0.000</td></tr><tr><td>Mz (kipft)</td><td>11.441</td><td>19.360</td></tr></table> Material Properties f'ck = 3 ksi - Concrete strength,	Layer	Label	Allowable Bearing Pressure (qa) (psf)	Allowable Lateral Pressure (R) (psf/ft)	1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000	Load Component	ASD	LRFD	P (kip)	5.987	9.494	Vx (kip)	-1.286	-2.143	Vz (kip)	0.000	0.000	Mx (kipft)	0.000	0.000	Mz (kipft)	11.441	19.360	
Layer	Label	Allowable Bearing Pressure (qa) (psf)	Allowable Lateral Pressure (R) (psf/ft)																									
1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000																									
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Vz (kip)	0.000	0.000																										
Mx (kipft)	0.000	0.000																										
Mz (kipft)	11.441	19.360																										
	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, $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-1.286 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.20478 \text{ kip/ft}$ M_o - Moment per length of pile, $M_o = \frac{M_z + (V_x H)}{1.57 D}$																											

	$M_o = \frac{(11.441 \text{ kipft}) + ((-1.286 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 1.8218 \text{ kipft/ft}$ 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: $L_{e,x} = 4.4908 \text{ ft}$ - Required depth in x-direction, Considering z-direction: $L_{e,z} = 0 \text{ ft}$ - Required depth in z-direction, Minimum embedded depth required: $L_{e,req}$ - Depth of pile required, $L_{e,req} = \text{MAX}[L_{e,x}, L_{e,z}]$ $L_{e,req} = \text{MAX}[(4.4908 \text{ ft}), (0 \text{ ft})]$ $L_{e,req} = 4.491 \text{ ft}$ L_e - Actual embedded length of pile, $L_e = L - h_e - h_2$ $L_e = (4.75 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 4.75 \text{ ft}$ <i>Ratio</i> - Embedded depth $\text{Ratio} = \frac{L_{e,req}}{L_e}$ $\text{Ratio} = \frac{(4.491 \text{ ft})}{(4.75 \text{ ft})}$ $\text{Ratio} = 0.94547$	Status: PASS Ratio: 0.950
	End-bearing Capacity (ASD) A - Pile cross-section area $A = b \ D$ $A = (48 \text{ in}) \times (48 \text{ in})$ $A = 16 \text{ ft}^2$ q - End-bearing pressure $q = \frac{P_v}{A}$ $q = \frac{(5.987 \text{ kip})}{(16 \text{ ft}^2)}$ $q = 0.37419 \text{ kip/ft}^2$ Check bearing capacity ratio: <i>Ratio</i> - Capacity $\text{Ratio} = \frac{q}{q_a}$ $\text{Ratio} = \frac{(0.37419 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $\text{Ratio} = 0.18709$	Status: PASS Ratio: 0.190
Czerniak	Lateral Soil Pressure (ASD): L/D - Length to least lateral dimension ratio, $L/D = \frac{L}{D}$ $L/D = \frac{(4.75 \text{ ft})}{(48 \text{ in})}$	

$$L/D = 1.1875$$

Since $L/D \leq 10$,

Pile is short.

Considering x-direction:

$H_o = -0.20478$ kip/ft - Lateral force per length of pile,

$M_o = 1.8218$ kipft/ft - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (1.8218 \text{ kipft/ft}) \times (4.75 \text{ ft})) + (3 \times (-0.20478 \text{ kip/ft}) \times (4.75 \text{ ft})^2)}{(6 \times (1.8218 \text{ kipft/ft})) + (4 \times (-0.20478 \text{ kip/ft}) \times (4.75 \text{ ft}))}$$

$$a = 3.2706 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (1.8218 \text{ kipft/ft})) + (3 \times (-0.20478 \text{ kip/ft}) \times (4.75 \text{ ft}))]^2}{(4.75 \text{ ft})^3 \times [(3 \times (1.8218 \text{ kipft/ft})) + (2 \times (-0.20478 \text{ kip/ft}) \times (4.75 \text{ ft}))]}$$

$$p = 0.18027 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

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

$$s = \frac{6 \times [(2 \times (1.8218 \text{ kipft/ft})) + ((-0.20478 \text{ kip/ft}) \times (4.75 \text{ ft}))]}{(4.75 \text{ ft})^2}$$

$$s = 0.71028 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(3.2706 \text{ ft})}{2}$$

$$p_a = 0.24529 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.18027 \text{ kip/ft}^2)}{(0.24529 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.73492$$

p_s - Allowable lateral soil pressure at depth L_e ,

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (4.75 \text{ ft})$$

$$p_s = 0.7125 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

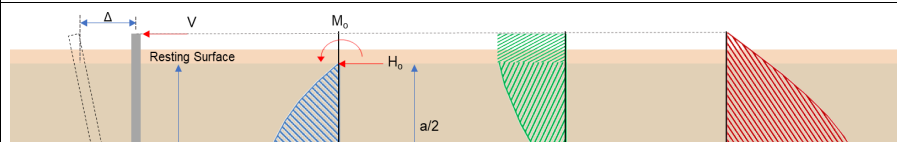
$$\text{Ratio} = \frac{s}{p_s}$$

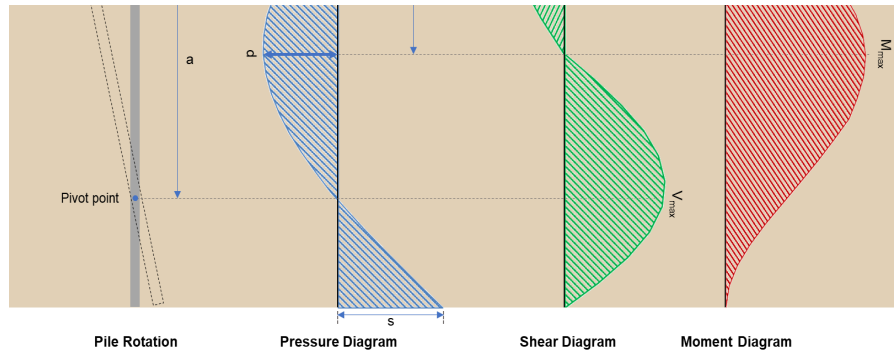
$$\text{Ratio} = \frac{(0.71028 \text{ kip/ft}^2)}{(0.7125 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.99688$$

Status: **PASS**
Ratio: **0.730**

Status: **PASS**
Ratio: **1.000**





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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-2.143 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.34124 \text{ kip/ft}$$

M_o - Moment per length of pile,

$$M_o = \frac{M_e + (V_e H)}{1.57 D}$$

$$M_o = \frac{(19.36 \text{ kipft}) + ((-2.143 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 3.0828 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(3.0828 \text{ kipft/ft})}{(-0.34124 \text{ kip/ft})}$$

$$E = 9.0341 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (3.0828 \text{ kipft/ft}) \times (4.75 \text{ ft})) + (3 \times (-0.34124 \text{ kip/ft}) \times (4.75 \text{ ft})^2)}{(6 \times (3.0828 \text{ kipft/ft})) + (4 \times (-0.34124 \text{ kip/ft}) \times (4.75 \text{ ft}))}$$

$$a = 3.2694 \text{ ft}$$

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

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

$$V_{max} = ((-0.34124 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (9.0341 \text{ ft})}{(4.75 \text{ ft})} + 3 \right) \times \left(\frac{(3.2694 \text{ ft})}{(4.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (9.0341 \text{ ft})}{(4.75 \text{ ft})} + 2 \right) \times \left(\frac{(3.2694 \text{ ft})}{(4.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 5.4945 \text{ kip}$$

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

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

$$M_{max} = ((-0.34124 \text{ kip/ft}) \times (48 \text{ in}) \times (4.75 \text{ ft})) \times \left[\left(\frac{(9.0341 \text{ ft})}{(4.75 \text{ ft})} + \frac{(3.2694 \text{ ft})}{2 \times (4.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (9.0341 \text{ ft})}{(4.75 \text{ ft})} + 3 \right) \times \left(\frac{(3.2694 \text{ ft})}{2 \times (4.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (9.0341 \text{ ft})}{(4.75 \text{ ft})} + 2 \right) \times \left(\frac{(3.2694 \text{ ft})}{2 \times (4.75 \text{ ft})} \right)^4 \right] \right]$$

		$M_{max} = 12.46 \text{ kipft}$	
		Minimum Reinforcement Check (LRFD) Parameters: $f'_{ck} = 3 \text{ ksi}$ - Concrete strength, $f_{yk} = 60 \text{ ksi}$ - Longitudinal reinforcement strength, $\phi = 0.65$ - Reduction factor for axial strength, $\alpha = 0.8$ - Alpha factor for axial strength, $A_g = 2304 \text{ in}^2$ - Gross area of concrete, Longitudinal reinforcement: Required reinforcement due to axial load, $A_{st,required}$ $A_{st,required}$ $A_{st,required} = \text{Min} \left[\frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = \text{Min} \left[\frac{\frac{(9.494 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (3 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -101.95 \text{ in}^2$ A_{min} - Governing minimum reinforcement area, $A_{min} = \text{Max} [A_{st,required}, (0.0018 A_g)]$ $A_{min} = \text{Max} [(-101.95 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ 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 $\text{Ratio} = \frac{A_{min}}{A_{st}}$ $\text{Ratio} = \frac{(4.1472 \text{ in}^2)}{(4.2951 \text{ in}^2)}$ $\text{Ratio} = 0.96556$ 25.2.3 s_{rebar} - Minimum spacing of reinforcement, $s_{rebar} = \text{Max} [1.5, (1.5 d_{bar})]$ $s_{rebar} = \text{Max} [1.5, (1.5 \times (0.625 \text{ in}))]$ $s_{rebar} = 1.5 \text{ in}$ Ties: 25.7.2.2 Since longitudinal reinforcement is $\leq \text{No. } 10\emptyset$: Use #3(0.375 in) 25.7.2.1 s_{ties} - Maximum spacing of ties, $s_{ties} = \text{Min} [(16 d_{bar}), (48 d_{ties}), \text{Min}(D, b)]$ $s_{ties} = \text{Min} [(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), \text{Min}((48 \text{ in}), (48 \text{ in}))]$ $s_{ties} = 10 \text{ in}$ Summary: Main reinforcement: 14 - #5 (0.625 in)	Status: PASS Ratio: 0.970

	Ties: #3(0.375 in) - 10 in	
22.4.2.2	Axial Compression Strength (ACI 318-19, LRFD) ϕP_N - Allowable axial compressive strength $\phi P_N = \phi 0.80 \left[(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st}) \right]$ $\phi P_N = (0.65) \times 0.80 \times \left[(0.85 \times (3 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2)) \right]$ $\phi P_N = 3183.4 \text{ kip}$ Ratio - Capacity $\text{Ratio} = \frac{P}{\phi P_N}$ $\text{Ratio} = \frac{(9.494 \text{ kip})}{(3183.4 \text{ kip})}$ $\text{Ratio} = 0.0029823$	Status: PASS Ratio: 0.000
22.5.2.2	Shear Strength (ACI 318-19, LRFD) Parameters: $b_w = 48 \text{ in}$ - Effective width, 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 $\lambda_s = \text{MIN} \left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = \text{MIN} \left[\sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.64282$	
22.5.5.1.1	The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$, $V_{c,max}$ - Max shear strength of concrete $V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$ $V_{c,max} = 5 \times (0.64282) \times \sqrt{(3000 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,max} = 324.49 \text{ kip}$	
22.5.5.1.1(a)	The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$, $P = 9.494 \text{ kip} \rightarrow 9494 \text{ lbf}$, $V_{c,a}$ - Shear strength of concrete (a) $V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + \frac{(9494 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 131.06 \text{ kip}$	
22.5.5.1.2	The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$, $V_{c,b}$ - Shear strength of concrete (b) $V_{c,b} = \left[2 \lambda_s \sqrt{f'_{ck}} + (0.05 f'_{ck}) \right] b_w d$ $V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + (0.05 \times (3000 \text{ psi})) \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,b} = 406.27 \text{ kip}$ V_c - Governing shear strength of concrete $V_c = \text{Min} [V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = \text{Min} [(324.49 \text{ kip}), (131.06 \text{ kip}), (406.27 \text{ kip})]$ $V_c = 131.06 \text{ kip}$	

22.5.1.2	The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$, $V_{s,a}$ - Shear strength of steel (a) $V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$ $V_{s,a} = 8 \times \sqrt{(3000 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{s,a} = 807.65 \text{ kip}$ 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) $V_{s,b} = \frac{2 A_v f_{ywk} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$ V_s - Governing shear strength of steel $V_s = MIN[V_{s,a}, V_{s,b}]$ $V_s = MIN[(807.65 \text{ kip}), (50.894 \text{ kip})]$ $V_s = 50.894 \text{ kip}$ 22.5.1.1 ϕV_n - Allowable shear strength $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((131.06 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 118.27 \text{ kip}$ Considering x-direction: $V_{max} = 5.4945 \text{ kip}$ - Maximum shear force in the x-direction, $Ratio$ - Capacity $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(5.4945 \text{ kip})}{(118.27 \text{ kip})}$ $Ratio = 0.046457$	Status: PASS Ratio: 0.050
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: $\phi M_{n,1}$ $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(3 \text{ ksi})} \times 18432.001 \text{ in}^3$ $\phi M_{n,1} = 273.423 \text{ kip ft}$ $\phi M_{n,2}$ $\phi M_{n,2} = \phi 0.85 f'_c S_m$	

	$\phi M_{n,2} = (0.65) \times 0.85 \times (3 \text{ ksi}) \times (18432 \text{ in}^3)$ $\phi M_{n,2} = 2545.9 \text{ kipft}$ Therefore, ϕM_n - Allowable flexural strength, $\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = MIN[(273.42 \text{ kipft}), (2545.9 \text{ kipft})]$ $\phi M_n = 273.42 \text{ kipft}$ Considering x-direction: $M_{max} = 12.46 \text{ kipft}$ - Maximum moment in the x-direction, <i>Ratio</i> - Capacity $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(12.46 \text{ kipft})}{(273.42 \text{ kipft})}$ $Ratio = 0.045571$	Status: PASS Ratio: 0.050
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