

## Project Details



**Project Name:** Dyer-09042024-v2CU

**Date:** Wed Sep 04 2024

**Location:** 20755 Brewer Rd, Grass Valley, CA 95949, USA

**Number of Modules:** 25

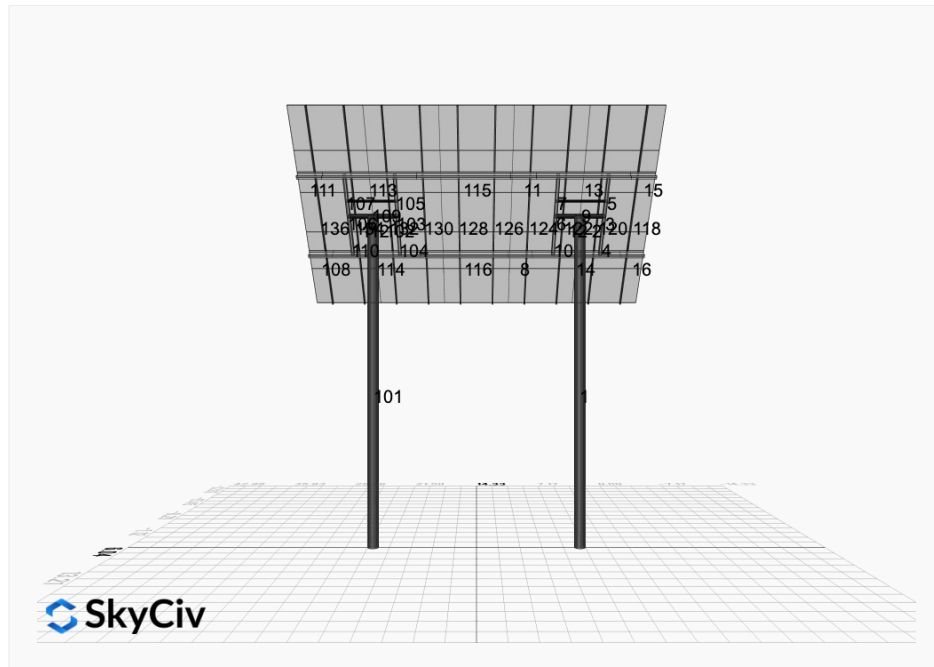
**Unique ID:** 2P-17-10TOP-HD-24-L-5Hx5W-IHLA

**Number of Poles:** 2

**Date Sold:**

**Dealer:** \_\_\_\_\_

\_\_\_\_\_



<b>Array Dimensions N/S</b>	18.81 ft
<b>Array Dimensions E/W</b>	28.66 ft
<b>Winter Tilt Angle</b>	50
<b>Front Edge Clearance</b>	20 ft

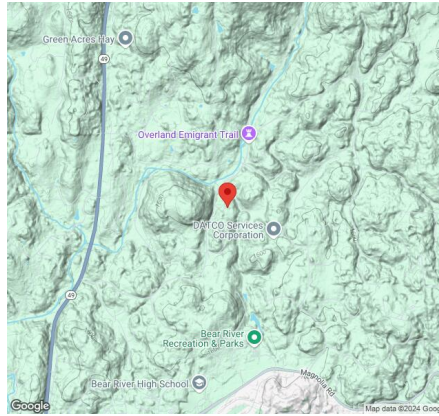
### MT Solar Bill of Materials (2P-17-10TOP-HD-24-L-5Hx5W-IHLA)

Part	Short Description	BOM Qty
MTS-PC-10	10IN Pole Cap Assembly	2
MTS-HF-HD	H-Frame Assembly-HD	2
MTS-HD-Wing-24	24IN HD Wing	4
MTS-HD-Splice-57	57IN HD Splice	4
MTS-CLAMP-ANGLE-4PK	Angle Clamp	5

### Rail Bill of Materials

Part	Qty
Rails (223in)	10
Rail Attachment	40
Module Mid Clamp	40
Module End Clamp	20
Ground Lug	5

## Site Details:



**Site Address:** 20755 Brewer Rd, Grass Valley, CA 95949, USA

### Array Specification

<b>Duty Classification:</b>	HD
<b>Module Width:</b>	44.64 in
<b>Module Length:</b>	67.79in
<b>Number of Rows:</b>	5
<b>Number of Columns:</b>	5
<b>Total Number of Modules:</b>	25
<b>Winter Tilt Angle:</b>	50
<b>Front Edge Clearance:</b>	20
<b>Total Array Height at Tilt:</b>	34.41 ft
<b>Total Frame Length:</b>	28.50 ft
<b>Frame Weight:</b>	3732 lbs
<b>Array Dimensions N/S:</b>	18.81 ft
<b>Array Dimensions E/W:</b>	28.66 ft
<b>Rail Length:</b>	225.70 in
<b>Rail Spacing:</b>	2.87 ft

### Support Specifications

<b>Pole Size:</b>	10in Pipe Sch 40
<b>Pole Length above Grade:</b>	27.20 ft
<b>Number of Poles:</b>	2
<b>Pole Spacing:</b>	17 ft

### Foundation Specifications

<b>Foundation Type:</b>	Square
<b>Foundation Dimensions:</b>	48 x 48 in
<b>Foundation Depth (below grade):</b>	Pile 1: 9.25 ft Pile 2: 9.25 ft
<b>Foundation Volume:</b>	10.963 y <sup>3</sup>

### Site Info

<b>Risk Category:</b>	I
<b>Exposure:</b>	B
<b>Soil Classification:</b>	sand
<b>Site Location:</b>	20755 Brewer Rd, Grass Valley, CA 95949, USA
<b>Wind Speed:</b>	110 mph
<b>Snow Load:</b>	29 psf

### **Design Disclaimer**

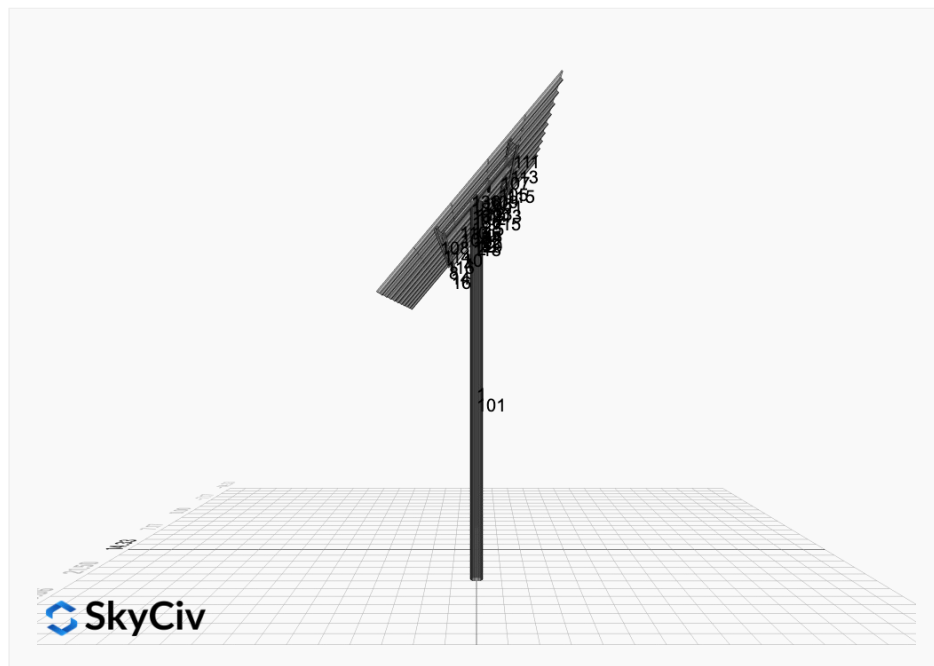
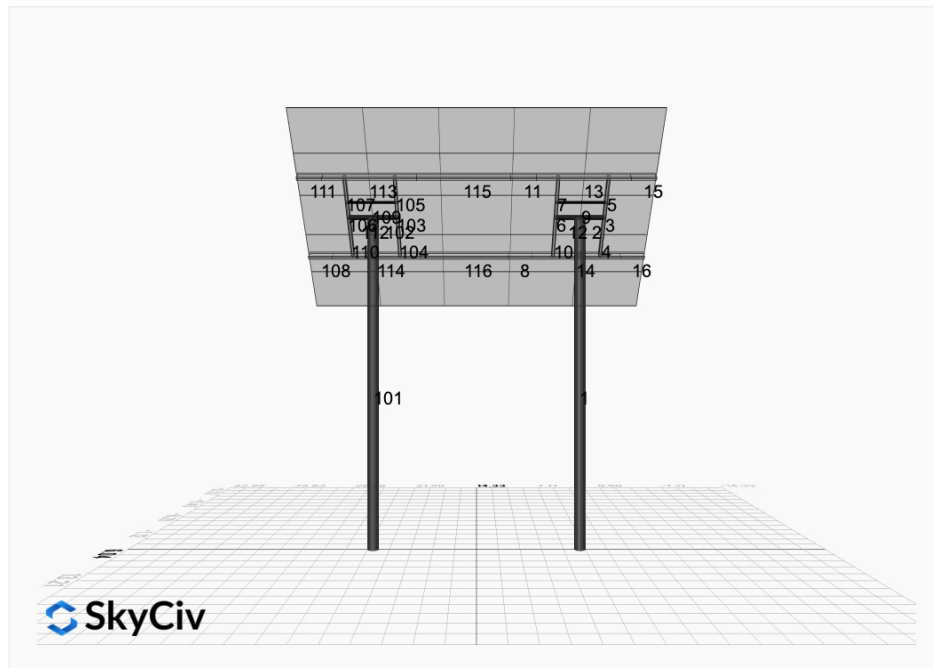
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

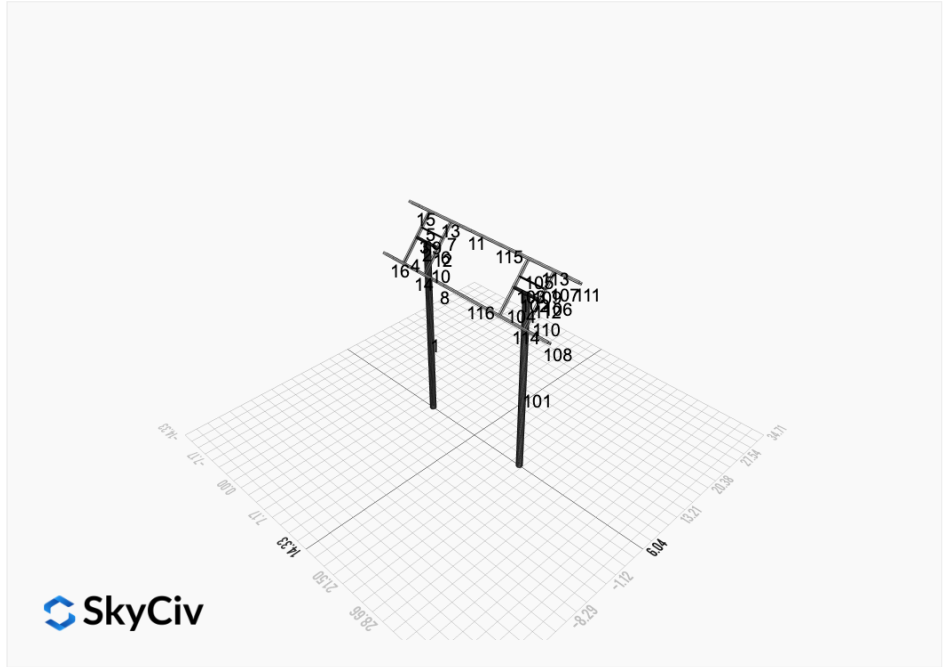
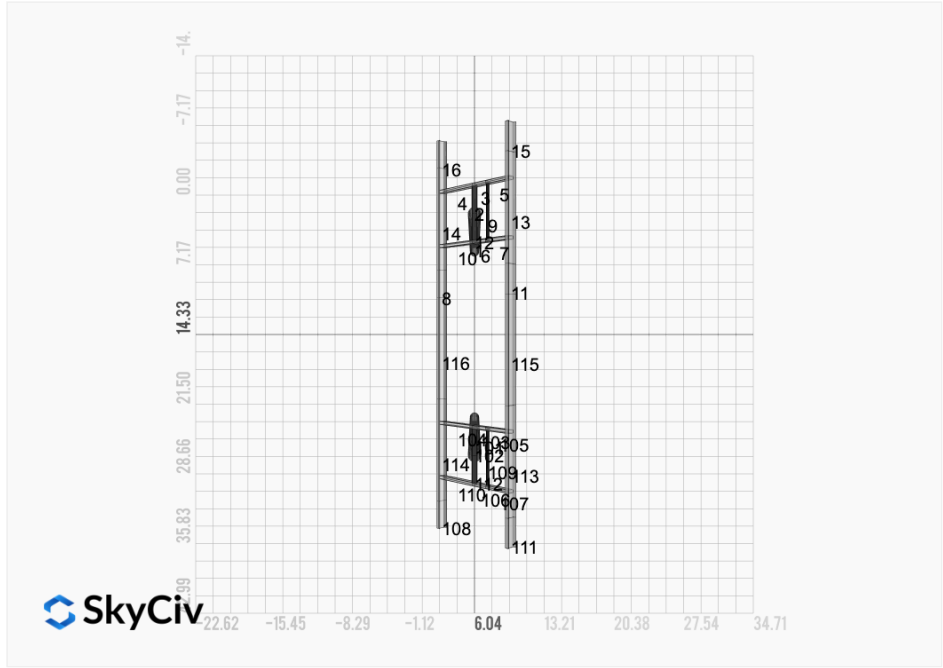
## AutoDesigner Input

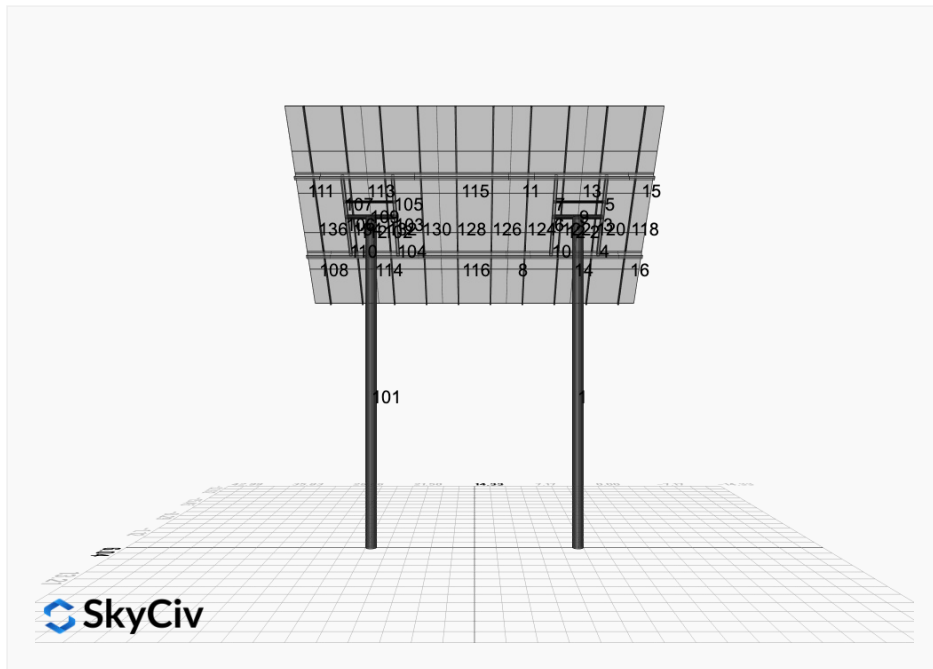
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{ "wind_speed_override": 110, "snow_load_override": 29, "direct_snow_load": false, "add_angle_brace": false, "product_type": "Beam", "designer_name": "", "designer_email": "christina@mtsolar.us", "designer_phone": "", "project_id": "Dyer-09042024-v2CU", "site_address": "20755 Brewer Rd, Grass Valley, CA 95949, USA", "module_width": 44.64, "module_length": 67.79, "number_rows": 5, "number_columns": 5, "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": 50, "ground_clearance": 20, "risk_category": "I", "exposure_category": "B", "frame_duty_override": "HD", "pole_override": "10_40", "soil_type": "sand", "customer_foundation_override": "48_Square", "foundation_type": "Square", "foundation_size": 48, "check_rails": false }
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### Design Notes:

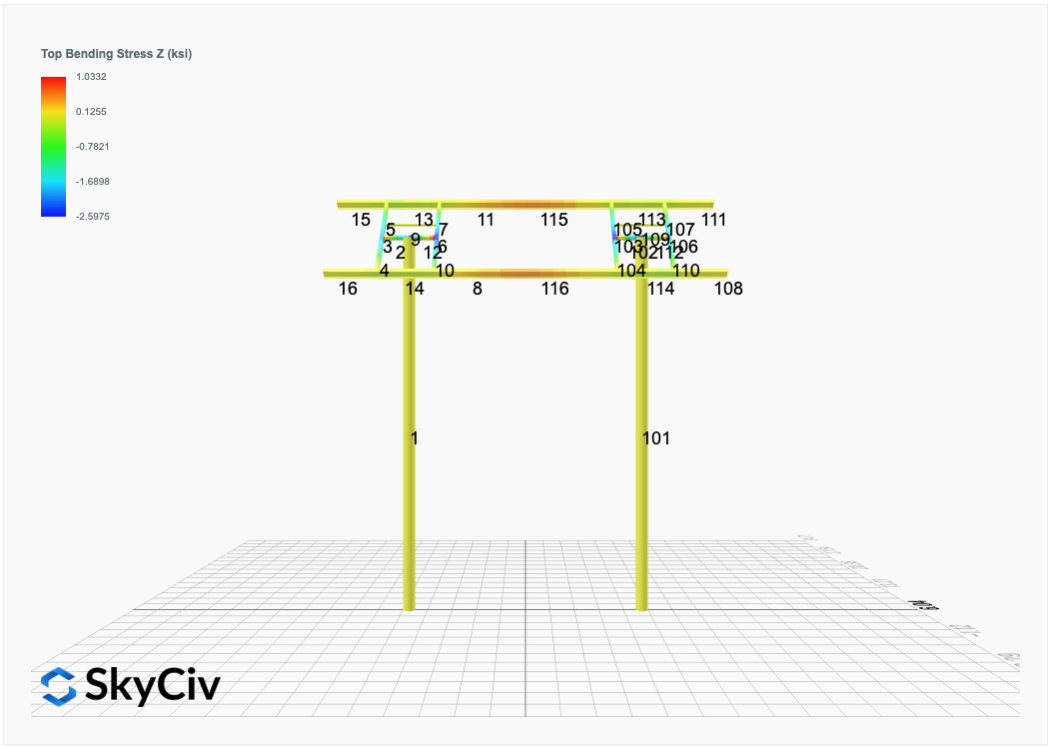
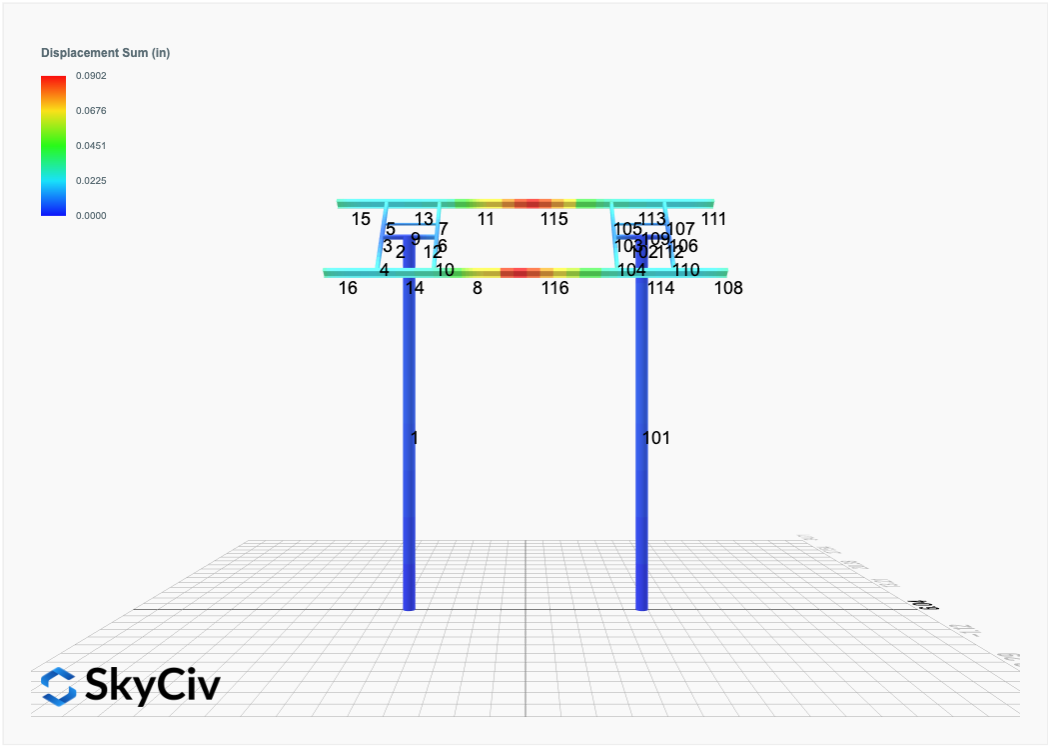
- AISC Deflection checks are set to L/1 due to structure design intent
- Foundation Soil Parameters used in this Autodesign are all estimates, proper geotechnical reports are required to confirm soil profiles
- Wind speeds, snow loads and other site specific results are based on ASCE 7 2016
- Steel frame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

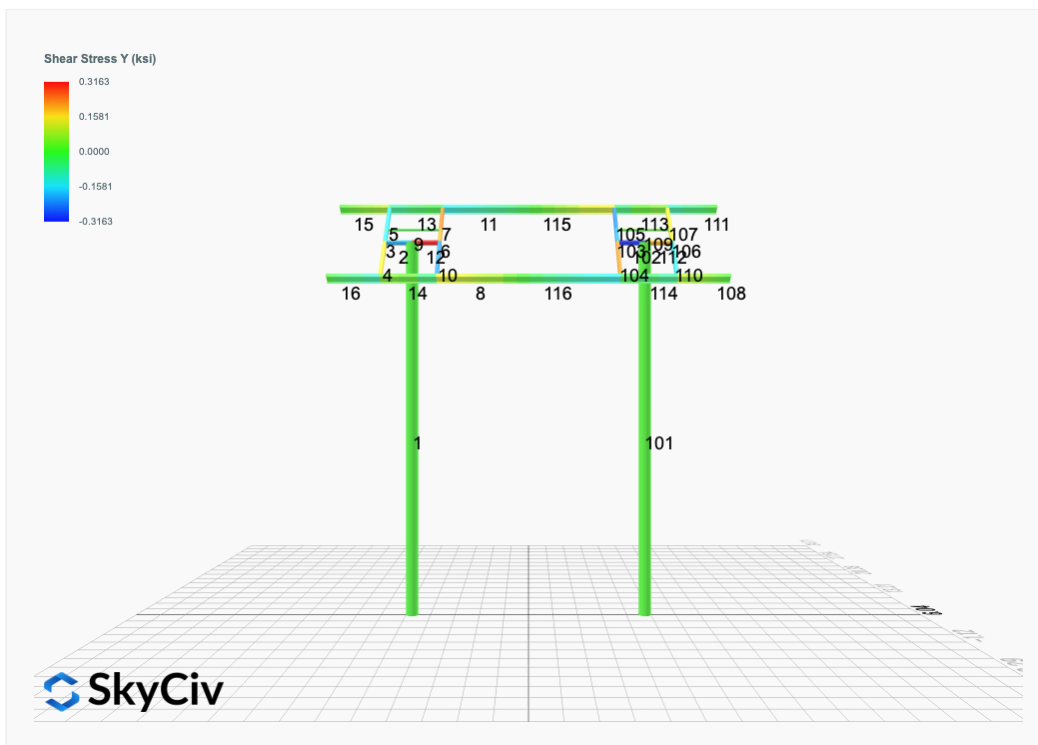
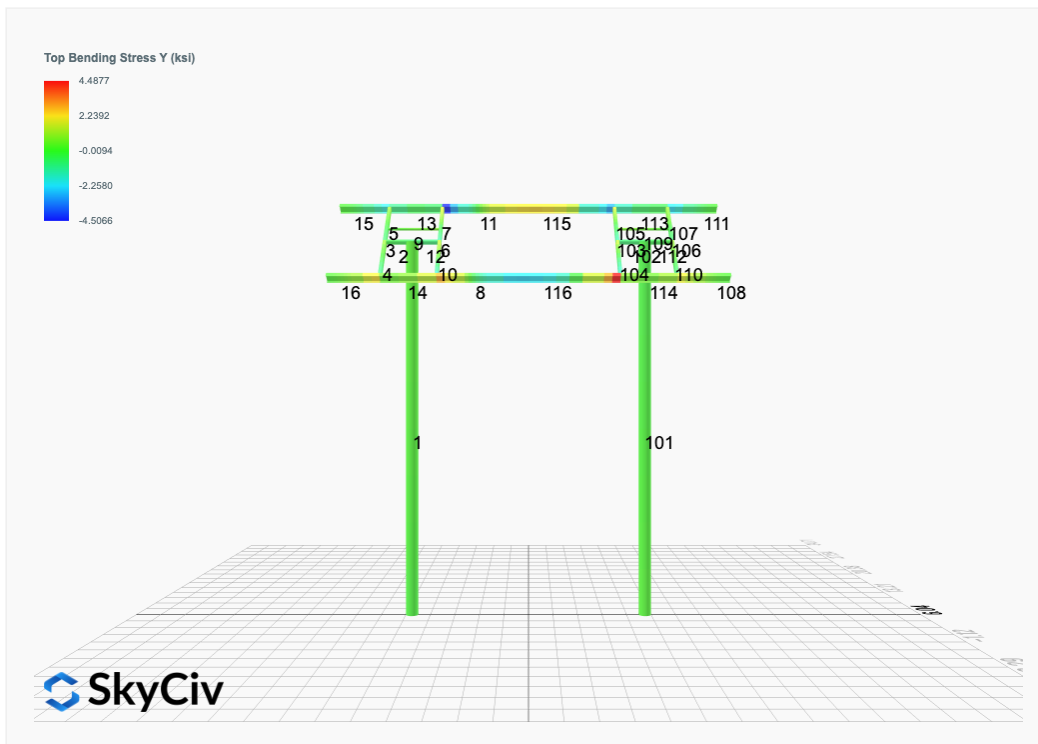




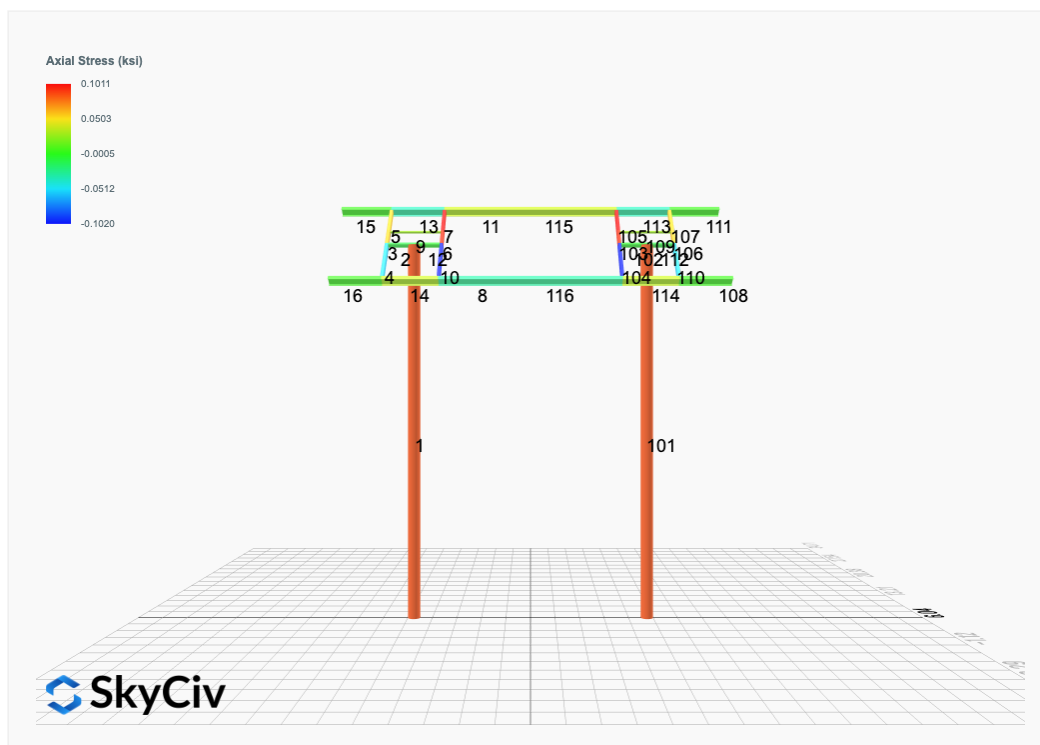


# FEM Results (Envelope Worst Case for each member)









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	2.8294	0.0198	0.1781	-0.0350	0.0208
ULS: 2. D + L	0.0000	2.8294	0.0198	0.1781	-0.0350	0.0208
ULS: 3. D + (S or Lr or R)	0.0000	3.9281	0.0342	0.3077	-0.0607	0.0223
ULS: 3. D + (S or Lr or R)	0.0000	2.8294	0.0198	0.1781	-0.0350	0.0208
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	3.6535	0.0306	0.2753	-0.0543	0.0220
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	2.8294	0.0198	0.1781	-0.0350	0.0208
ULS: 5b. D + 0.7E	0.0000	2.8294	0.0198	0.1781	-0.0350	0.0208
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0000	3.6535	0.0306	0.2753	-0.0543	0.0220
ULS: 8. 0.6D + 0.7E	0.0000	1.6976	0.0119	0.1069	-0.0210	0.0125
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.5589	4.9766	0.0593	0.5274	-0.4251	71.5972
ULS: 5a. D + 0.6W_Wind downforce Case B only	0.0000	2.8294	0.0198	0.1781	-0.0350	0.0208
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.5589	0.6822	-0.0198	-0.1699	0.3565	-67.7543
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.0000	2.8294	0.0198	0.1781	-0.0350	0.0208
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.9192	5.2639	0.0602	0.5373	-0.3468	53.7043
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0000	3.6535	0.0306	0.2753	-0.0543	0.0220
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.9192	2.0430	0.0008	0.0143	0.2393	-50.8094
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0000	3.6535	0.0306	0.2753	-0.0543	0.0220
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.9192	4.4398	0.0494	0.4401	-0.3275	53.7031
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0000	2.8294	0.0198	0.1781	-0.0350	0.0208
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.9192	1.2190	-0.0099	-0.0829	0.2586	-50.8106
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0000	2.8294	0.0198	0.1781	-0.0350	0.0208
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.5589	3.8448	0.0514	0.4562	-0.4111	71.5889
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	0.0000	1.6976	0.0119	0.1069	-0.0210	0.0125
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.5589	-0.4496	-0.0278	-0.2411	0.3705	-67.7626
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.0000	1.6976	0.0119	0.1069	-0.0210	0.0125

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 (kip, kip-ft)
Axial	7.5233
Shear X	-4.2650
Shear Z	0.0964
Moment X	0.8583
Moment Y (Twist)	0.6998
Moment Z	123.2306

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	5.2639
Shear X	-2.5589
Shear Z	0.0602
Moment X	0.5373
Moment Y (Twist)	0.4251
Moment Z	71.5972

Reaction Forces for Foundation 2 (Node ID#101), (kip, kip-ft)

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	-0.0000	2.8294	-0.0198	-0.1781	0.0350	0.0208
ULS: 2. D + L	-0.0000	2.8294	-0.0198	-0.1781	0.0350	0.0208
ULS: 3. D + (S or Lr or R)	-0.0000	3.9281	-0.0342	-0.3077	0.0607	0.0224
ULS: 3. D + (S or Lr or R)	-0.0000	2.8294	-0.0198	-0.1781	0.0350	0.0208
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0000	3.6535	-0.0306	-0.2753	0.0543	0.0220

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0000	2.8294	-0.0198	-0.1781	0.0350	0.0208
ULS: 5b. D + 0.7E	-0.0000	2.8294	-0.0198	-0.1781	0.0350	0.0208
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0000	3.6535	-0.0306	-0.2753	0.0543	0.0220
ULS: 8. 0.6D + 0.7E	-0.0000	1.6976	-0.0119	-0.1069	0.0210	0.0125
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.5589	4.9766	-0.0593	-0.5274	0.4251	71.5972
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.0000	2.8294	-0.0198	-0.1781	0.0350	0.0208
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.5589	0.6822	0.0198	0.1699	-0.3565	-67.7543
ULS: 5a. D + 0.6W_Wind uplift Case B only	-0.0000	2.8294	-0.0198	-0.1781	0.0350	0.0208
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.9192	5.2639	-0.0602	-0.5373	0.3468	53.7043
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0000	3.6535	-0.0306	-0.2753	0.0543	0.0220
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.9192	2.0430	-0.0008	-0.0143	-0.2393	-50.8094
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0000	3.6535	-0.0306	-0.2753	0.0543	0.0220
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.9192	4.4398	-0.0494	-0.4401	0.3275	53.7031
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0000	2.8294	-0.0198	-0.1781	0.0350	0.0208
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.9192	1.2190	0.0099	0.0829	-0.2586	-50.8105
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0000	2.8294	-0.0198	-0.1781	0.0350	0.0208
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.5589	3.8448	-0.0514	-0.4562	0.4111	71.5889
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.0000	1.6976	-0.0119	-0.1069	0.0210	0.0125
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.5589	-0.4496	0.0278	0.2411	-0.3705	-67.7626
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	-0.0000	1.6976	-0.0119	-0.1069	0.0210	0.0125

### 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 (kip, kip-ft)
Axial	7.5233
Shear X	-4.2649
Shear Z	-0.0964
Moment X	-0.8588
Moment Y (Twist)	0.6989
Moment Z	123.2306

### 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	5.2639
Shear X	-2.5589
Shear Z	-0.0602
Moment X	-0.5373
Moment Y (Twist)	0.4251
Moment Z	71.5972

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			
$\Phi_t$	$\Phi_c$	$\Phi_b$	$\Phi_v$
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					
11	10in Pipe Sch 40	10.75	0.36					
ID	Name	d (in)	b (in)	$t_w$ (in)	$t_b$ (in)	r (in)		
16	HSS5x3x3/16	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 <sup>2</sup> )	J (in <sup>4</sup> )	$I_{yp}$ (in <sup>4</sup> )	$I_{zp}$ (in <sup>4</sup> )	$I_w$ (in <sup>6</sup> )	$S_{yp}$ (in <sup>3</sup> )	$S_{zp}$ (in <sup>3</sup> )
-	-	-	-	-	-	-	-	-

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
11	10in Pipe Sch 40	11.91	321.47	160.73	160.73	0.00	39.38	39.38
16	HSS5x3x3/16	2.58	8.64	3.85	8.53	0.73	2.96	4.21
19	W8x10	2.96	0.04	2.09	30.80	30.90	1.66	8.87

Member Properties									
Member ID	Section ID	K <sub>z</sub> L (ft)	K <sub>y</sub> L (ft)	L <sub>b</sub> (ft)	C <sub>b</sub>	LS T	LS C	L D	
1	11	57.13	57.13	27.20	-	300	200	1	
2	5	1.30	1.30	2.00	-	300	200	1	
3	16	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.17,1.19,1.18,1.18,1.15,1.18,1.18,1.19,1.17,1.19,1.18,1.19,1.17,1.19	300	200	1	
4	16	2.44	2.44	3.75	1.69,1.68,1.69,1.68,1.69,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.68,1.62,1.68,1.67,1.69,1.65,1.69,1.67,1.69,1.66,1.69	300	200	1	
5	16	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.64,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68	300	200	1	
6	16	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.15,1.19,1.18,1.19,1.17,1.19,1.18,1.19,1.17,1.19	300	200	1	
7	16	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.64,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68	300	200	1	
8	19	1.33	1.33	2.05	1.28,1.28,1.28,1.28,1.28,1.28,1.27,1.28,1.26,1.28,1.27,1.28,1.27,1.28,1.27,1.28,1.21,1.28,1.27,1.28,1.26,1.28,1.27,1.28,1.27,1.28	300	200	1	
9	2	2.60	2.60	4.00	-	300	200	1	
10	16	2.44	2.44	3.75	1.69,1.68,1.69,1.68,1.68,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.68,1.62,1.68,1.67,1.69,1.65,1.69,1.67,1.69,1.66,1.69	300	200	1	
11	19	1.33	1.33	2.05	1.29,1.29,1.29,1.29,1.29,1.29,1.27,1.29,1.27,1.29,1.27,1.29,1.27,1.29,1.28,1.29,1.21,1.29,1.28,1.29,1.26,1.29,1.27,1.29,1.27,1.29	300	200	1	
12	5	1.30	1.30	2.00	-	300	200	1	
13	19	4.88	4.00	7.50	1.24,1.24,1.24,1.24,1.24,1.24,1.27,1.24,1.29,1.24,1.27,1.24,1.28,1.24,1.26,1.24,1.49,1.24,1.26,1.24,1.30,1.24,1.27,1.24,1.28,1.24	300	200	1	
14	19	4.88	4.00	7.50	1.23,1.23,1.23,1.23,1.23,1.23,1.26,1.23,1.28,1.23,1.26,1.23,1.27,1.23,1.25,1.23,1.48,1.23,1.25,1.23,1.29,1.23,1.26,1.23,1.27,1.23	300	200	1	
15	19	4.20	4.20	2.00	2.33,2.33	300	200	1	
16	19	4.20	4.20	2.00	2.33,2.33	300	200	1	
101	11	57.13	57.13	27.20	-	300	200	1	
102	5	1.30	1.30	2.00	-	300	200	1	
103	16	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.15,1.19,1.18,1.19,1.17,1.19,1.18,1.19,1.17,1.19	300	200	1	
104	16	2.44	2.44	3.75	1.69,1.68,1.69,1.68,1.68,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.68,1.62,1.68,1.67,1.69,1.65,1.69,1.67,1.69,1.66,1.69	300	200	1	
105	16	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.64,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68	300	200	1	
106	16	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.17,1.19,1.18,1.18,1.15,1.18,1.18,1.19,1.17,1.19,1.18,1.19,1.17,1.19	300	200	1	
107	16	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.64,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68	300	200	1	
108	19	4.20	4.20	2.00	2.33,2.33	300	200	1	
109	2	2.60	2.60	4.00	-	300	200	1	
110	16	2.44	2.44	3.75	1.69,1.68,1.69,1.68,1.69,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.68,1.62,1.68,1.67,1.69,1.65,1.69,1.67,1.69,1.66,1.69	300	200	1	
111	19	4.20	4.20	2.00	2.33,2.33	300	200	1	
112	5	1.30	1.30	2.00	-	300	200	1	

113	19	4.88	4.00	7.50	1.24,1.24,1.24,1.24,1.24,1.24,1.26,1.24,1.28,1.24,1.26,1.24,1.28,1.24,1.26,1.24,1.48,1.24,1.26,1.24,1.30,1.24,1.27,1.24,1.28,1.24	300	200	1
114	19	4.88	4.00	7.50	1.23,1.23,1.23,1.23,1.23,1.23,1.26,1.23,1.28,1.23,1.26,1.23,1.27,1.23,1.25,1.23,1.49,1.23,1.25,1.23,1.29,1.23,1.26,1.23,1.27,1.23	300	200	1
115	19	4.84	4.84	7.45	1.09,1.09,1.09,1.09,1.09,1.09,1.08,1.09,1.08,1.09,1.08,1.09,1.08,1.09,1.08,1.09,1.07,1.09,1.08,1.09,1.08,1.09,1.08,1.09,1.08,1.09	300	200	1
116	19	4.84	4.84	7.45	1.09,1.09,1.09,1.09,1.09,1.09,1.08,1.09,1.08,1.09,1.08,1.09,1.08,1.09,1.08,1.09,1.07,1.09,1.08,1.09,1.08,1.09,1.08,1.09,1.08,1.09	300	200	1

## Member Design Capacity

Member ID	$\Phi_t P_n$ (kip)	$\Phi_c P_n$ (kip)	$\Phi_b M_{zn}$ (k-ft)	$\Phi_b M_{yn}$ (k-ft)	$\Phi_v V_{yn}$ (kip)	$\Phi_v V_{zn}$ (kip)
1	535.87	77.26	147.68	147.68	160.76	160.76
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	123.95	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	123.95	32.87	6.12	40.24	43.62
12	198.33	196.72	21.95	21.95	59.50	59.50
13	133.20	85.85	28.34	6.12	40.24	43.62
14	133.20	85.85	28.13	6.12	40.24	43.62
15	133.20	102.39	32.87	6.12	40.24	43.62
16	133.20	102.39	32.87	6.12	40.24	43.62
101	535.87	77.26	147.68	147.68	160.76	160.76
102	198.33	196.72	21.95	21.95	59.50	59.50
103	116.10	115.41	15.79	11.10	42.08	23.28
104	116.10	111.33	15.79	11.10	42.08	23.28
105	116.10	114.23	15.79	11.10	42.08	23.28
106	116.10	115.41	15.79	11.10	42.08	23.28
107	116.10	114.23	15.79	11.10	42.08	23.28
108	133.20	102.39	32.87	6.12	40.24	43.62
109	66.48	58.89	3.82	3.82	19.94	19.94
110	116.10	111.33	15.79	11.10	42.08	23.28
111	133.20	102.39	32.87	6.12	40.24	43.62
112	198.33	196.72	21.95	21.95	59.50	59.50
113	133.20	85.85	28.34	6.12	40.24	43.62
114	133.20	85.85	28.13	6.12	40.24	43.62
115	133.20	86.20	24.66	6.12	40.24	43.62
116	133.20	86.20	24.65	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	$\delta$	Status
1	0.097	0.834	0.012	0.027	0.001	0.889	#13	0.933	Not Required	Pass
2	0.000	0.187	0.168	0.045	0.035	0.355	#13	0.053	Not Required	Pass
3	0.005	0.393	0.033	0.039	0.008	0.419	#13	0.045	Not Required	Pass
4	0.005	0.391	0.047	0.039	0.011	0.428	#13	0.080	Not Required	Pass

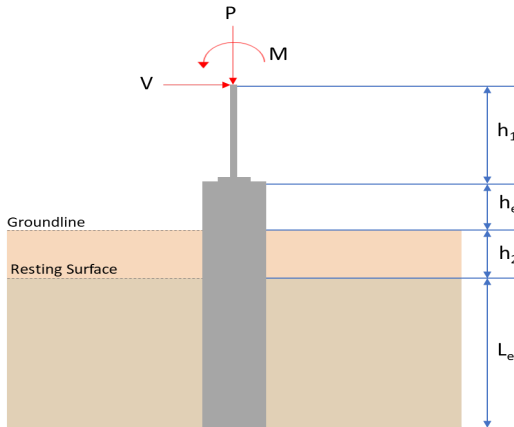
5	0.005	0.244	0.044	0.039	0.011	0.251	#13	0.074	Not Required	Pass
6	0.008	0.469	0.063	0.047	0.018	0.514	#13	0.045	Not Required	Pass
7	0.008	0.291	0.088	0.046	0.021	0.302	#13	0.074	Not Required	Pass
8	0.002	0.096	0.063	0.029	0.010	0.138	#13	0.095	Not Required	Pass
9	0.001	0.031	0.045	0.002	0.001	0.076	#13	0.204	Not Required	Pass
10	0.008	0.467	0.088	0.046	0.020	0.505	#13	0.080	Not Required	Pass
11	0.002	0.095	0.063	0.029	0.010	0.136	#13	0.095	Not Required	Pass
12	0.000	0.268	0.200	0.059	0.040	0.468	#13	0.053	Not Required	Pass
13	0.003	0.079	0.213	0.040	0.014	0.245	#21	0.286	Not Required	Pass
14	0.003	0.081	0.211	0.040	0.014	0.242	#21	0.190	Not Required	Pass
15	0.000	0.015	0.031	0.012	0.004	0.042	#21	Not Required	Not Required	Pass
16	0.000	0.015	0.031	0.012	0.004	0.042	#21	Not Required	Not Required	Pass
101	0.097	0.834	0.012	0.027	0.001	0.889	#13	0.933	Not Required	Pass
102	0.000	0.268	0.200	0.059	0.040	0.467	#13	0.053	Not Required	Pass
103	0.008	0.469	0.063	0.047	0.018	0.514	#13	0.045	Not Required	Pass
104	0.008	0.467	0.088	0.046	0.020	0.505	#13	0.080	Not Required	Pass
105	0.008	0.291	0.088	0.046	0.021	0.302	#13	0.074	Not Required	Pass
106	0.005	0.393	0.033	0.039	0.008	0.419	#13	0.045	Not Required	Pass
107	0.005	0.244	0.044	0.039	0.011	0.251	#13	0.074	Not Required	Pass
108	0.000	0.015	0.031	0.012	0.004	0.042	#21	Not Required	Not Required	Pass
109	0.001	0.031	0.045	0.002	0.001	0.076	#13	0.204	Not Required	Pass
110	0.005	0.391	0.047	0.039	0.011	0.428	#13	0.080	Not Required	Pass
111	0.000	0.015	0.031	0.012	0.004	0.042	#21	Not Required	Not Required	Pass
112	0.000	0.187	0.168	0.045	0.035	0.356	#13	0.053	Not Required	Pass
113	0.003	0.079	0.213	0.040	0.014	0.245	#21	0.190	Not Required	Pass
114	0.003	0.081	0.211	0.040	0.014	0.242	#21	0.286	Not Required	Pass
115	0.003	0.161	0.121	0.029	0.010	0.241	#13	0.346	Not Required	Pass
116	0.002	0.162	0.120	0.029	0.010	0.242	#13	0.346	Not Required	Pass

## Definitions

$\Phi_t$	Safety factor for tensile
$\Phi_c$	Safety factor for compression
$\Phi_b$	Safety factor for flexure
$\Phi_v$	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/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 <sub>z</sub> ,M <sub>y</sub> )	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																											
	<div>SkyCiv Foundation Design</div> <div>Pile Foundation</div> <div>Design Information :</div> <div>Design code : IBC 2021 (International Building Code)</div> <div>Unit System : Imperial</div>																												
	<div>Pile Input</div> <div></div> <div>Geometry</div> <div>Pile shape: rectangular</div> <div>b = 48 in - Pile width</div> <div>D = 48 in - Pile depth</div> <div>L = 9.25 ft - Total pile length</div> <div>h1 = 0 ft - Lateral load height from the top of the pile,</div> <div>h2 = 0 ft - Depth to resisting surface</div> <div>he = 0 ft - Length of pile above the ground</div> <div>Tabulation of Soil Parameters</div> <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 &amp; clayey gravel</td><td>2000.000</td><td>150.000</td></tr></table> <div>Tabulation of Loads</div> <table><tr><th>Load Component</th><th>ASD</th><th>LRFD</th></tr><tr><td>P (kip)</td><td>5.264</td><td>7.523</td></tr><tr><td>Vx (kip)</td><td>-2.559</td><td>-4.265</td></tr><tr><td>Vz (kip)</td><td>0.060</td><td>0.096</td></tr><tr><td>Mx (kipft)</td><td>0.537</td><td>0.858</td></tr><tr><td>Mz (kipft)</td><td>71.597</td><td>123.231</td></tr></table> <div>Material Properties</div> <div>f'ck = 2.5 ksi - Concrete strength,</div>	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)	5.264	7.523	Vx (kip)	-2.559	-4.265	Vz (kip)	0.060	0.096	Mx (kipft)	0.537	0.858	Mz (kipft)	71.597	123.231	<div>Required depth to resist lateral loads (ASD)</div> <div>H - Point of application of the lateral load</div> <div><math display="block">H = h_1 + h_2 + h_e</math></div> <div><math display="block">H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})</math></div> <div><math display="block">H = 0 \text{ ft}</math></div> <div>Considering x-direction:</div> <div>Ho - Lateral force per length of pile,</div> <div><math display="block">H_o = \frac{V_x}{1.57 \text{ } D}</math></div> <div><math display="block">H_o = \frac{(-2.559 \text{ kip})}{1.57 \times (48 \text{ in})}</math></div> <div><math display="block">H_o = -0.40748 \text{ kip/ft}</math></div>	
Layer	Label	Allowable Bearing Pressure (qa) (psf)	Allowable Lateral Pressure (R) (psf/ft)																										
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Mz (kipft)	71.597	123.231																											

	<p><math>M_o</math> - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$ $M_o = \frac{(71.597 \text{ kipft}) + ((-2.559 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 11.401 \text{ kipft/ft}$ <p>Required depth of embedment in earth:</p> $L_x^3 - \left( 14.14 \times \frac{H_o \times L_x}{R} \right) - \left( 18.85 \times \frac{M_o}{R} \right) = 0$ <p>Solving the cubic equation:  <math>L_{e,x} = 8.8598 \text{ ft}</math> - Required depth in x-direction,</p> <p><b>Considering z-direction:</b></p> <p><math>H_o</math> - Lateral force per length of pile,</p> $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(0.06 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = 0.0095541 \text{ kip/ft}$ <p><math>M_o</math> - Moment per length of pile,</p> $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(0.537 \text{ kipft}) + ((0.06 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.08551 \text{ kipft/ft}$ <p>Required depth of embedment in earth:</p> $L_z^3 - \left( 14.14 \times \frac{H_o \times L_z}{R} \right) - \left( 18.85 \times \frac{M_o}{R} \right) = 0$ <p>Solving the cubic equation:  <math>L_{e,z} = 1.9988 \text{ ft}</math> - Required depth in z-direction,</p> <p><b>Minimum embedded depth required:</b></p> <p><math>L_{e,req}</math> - Depth of pile required,</p> $L_{e,req} = MAX[L_{e,x}, L_{e,z}]$ $L_{e,req} = MAX[(8.8598 \text{ ft}), (1.9988 \text{ ft})]$ $L_{e,req} = 8.86 \text{ ft}$ <p><math>L_e</math> - Actual embedded length of pile,</p> $L_e = L - h_e - h_2$ $L_e = (9.25 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 9.25 \text{ ft}$ <p><b>Ratio</b> - Embedded depth</p> $Ratio = \frac{L_{e,req}}{L_e}$ $Ratio = \frac{(8.86 \text{ ft})}{(9.25 \text{ ft})}$ $Ratio = 0.95784$	<p>Status: <b>PASS</b>  Ratio: <b>0.960</b></p>
	<p><b>End-bearing Capacity (ASD)</b></p> <p><math>A</math> - Pile cross-section area</p> $A = b D$ $A = (48 \text{ in}) \times (48 \text{ in})$ $A = 16 \text{ ft}^2$ <p><math>q</math> - End-bearing pressure</p>	

$$q = \frac{P_v}{A}$$

$$q = \frac{(5.264 \text{ kip})}{(16 \text{ ft}^2)}$$

$$q = 0.329 \text{ kip/ft}^2$$

**Check bearing capacity ratio:**

Ratio - Capacity

$$\text{Ratio} = \frac{q}{q_a}$$

$$\text{Ratio} = \frac{(0.329 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$\text{Ratio} = 0.1645$$

Status: **PASS**  
Ratio: **0.160**

Czerniak

**Lateral Soil Pressure (ASD):**

$L/D$  - Length to least lateral dimension ratio,

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

$$L/D = \frac{(9.25 \text{ ft})}{(48 \text{ in})}$$

$$L/D = 2.3125$$

Since  $L/D \leq 10$ ,

Pile is short.

**Considering x-direction:**

$H_o = -0.40748 \text{ kip/ft}$  - Lateral force per length of pile,

$M_o = 11.401 \text{ kipft/ft}$  - Overturning moment per length of pile,

$a$  - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (11.401 \text{ kipft/ft}) \times (9.25 \text{ ft})) + (3 \times (-0.40748 \text{ kip/ft}) \times (9.25 \text{ ft})^2)}{(6 \times (11.401 \text{ kipft/ft})) + (4 \times (-0.40748 \text{ kip/ft}) \times (9.25 \text{ ft}))}$$

$$a = 6.3059 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (11.401 \text{ kipft/ft})) + (3 \times (-0.40748 \text{ kip/ft}) \times (9.25 \text{ ft}))]^2}{(9.25 \text{ ft})^2 \times [(3 \times (11.401 \text{ kipft/ft})) + (2 \times (-0.40748 \text{ kip/ft}) \times (9.25 \text{ ft}))]}$$

$$p = 0.38666 \text{ kip/ft}^2$$

$s$  - Earth pressure against the pile at distance  $L_e$ ,

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

$$s = \frac{6 \times [(2 \times (11.401 \text{ kipft/ft})) + ((-0.40748 \text{ kip/ft}) \times (9.25 \text{ ft}))]}{(9.25 \text{ ft})^2}$$

$$s = 1.3346 \text{ kip/ft}^2$$

**Check lateral soil pressure capacity:**

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(6.3059 \text{ ft})}{2}$$

$$p_a = 0.47294 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

	$Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.38666 \text{ kip/ft}^2)}{(0.47294 \text{ kip/ft}^2)}$ $Ratio = 0.81756$ <p><math>p_s</math> - Allowable lateral soil pressure at depth <math>L_e</math>,</p> $p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (9.25 \text{ ft})$ $p_s = 1.3875 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $Ratio = \frac{s}{p_s}$ $Ratio = \frac{(1.3346 \text{ kip/ft}^2)}{(1.3875 \text{ kip/ft}^2)}$ $Ratio = 0.96189$	<p>Status: <b>PASS</b> Ratio: <b>0.820</b></p> <p>Status: <b>PASS</b> Ratio: <b>0.960</b></p>
	<p><b>Considering z-direction:</b></p> <p><math>H_o = 0.0095541 \text{ kip/ft}</math> - Lateral force per length of pile,  <math>M_o = 0.08551 \text{ kipft/ft}</math> - Overturning moment per length of pile,  <math>a</math> - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.08551 \text{ kipft/ft}) \times (9.25 \text{ ft})) + (3 \times (0.0095541 \text{ kip/ft}) \times (9.25 \text{ ft})^2)}{(6 \times (0.08551 \text{ kipft/ft})) + (4 \times (0.0095541 \text{ kip/ft}) \times (9.25 \text{ ft}))}$ $a = 6.4811 \text{ ft}$ <p><math>p</math> - Earth pressure against the pile at distance <math>a/2</math> from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.08551 \text{ kipft/ft})) + (3 \times (0.0095541 \text{ kip/ft}) \times (9.25 \text{ ft}))]^2}{(9.25 \text{ ft})^2 \times [(3 \times (0.08551 \text{ kipft/ft})) + (2 \times (0.0095541 \text{ kip/ft}) \times (9.25 \text{ ft}))]}$ $p = 0.007458 \text{ kip/ft}^2$ <p><math>s</math> - Earth pressure against the pile at distance <math>L_e</math>,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.08551 \text{ kipft/ft})) + ((0.0095541 \text{ kip/ft}) \times (9.25 \text{ ft}))]}{(9.25 \text{ ft})^2}$ $s = 0.01819 \text{ kip/ft}^2$ <p><b>Check lateral soil pressure capacity:</b></p> <p><math>p_a</math> - Allowable lateral soil pressure at depth <math>a/2</math>,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(6.4811 \text{ ft})}{2}$ $p_a = 0.48608 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.007458 \text{ kip/ft}^2)}{(0.48608 \text{ kip/ft}^2)}$	

$$Ratio = 0.015343$$

Status: **PASS**  
Ratio: **0.020**

$p_s$  - Allowable lateral soil pressure at depth  $L_e$ ,

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (9.25 \text{ ft})$$

$$p_s = 1.3875 \text{ kip/ft}^2$$

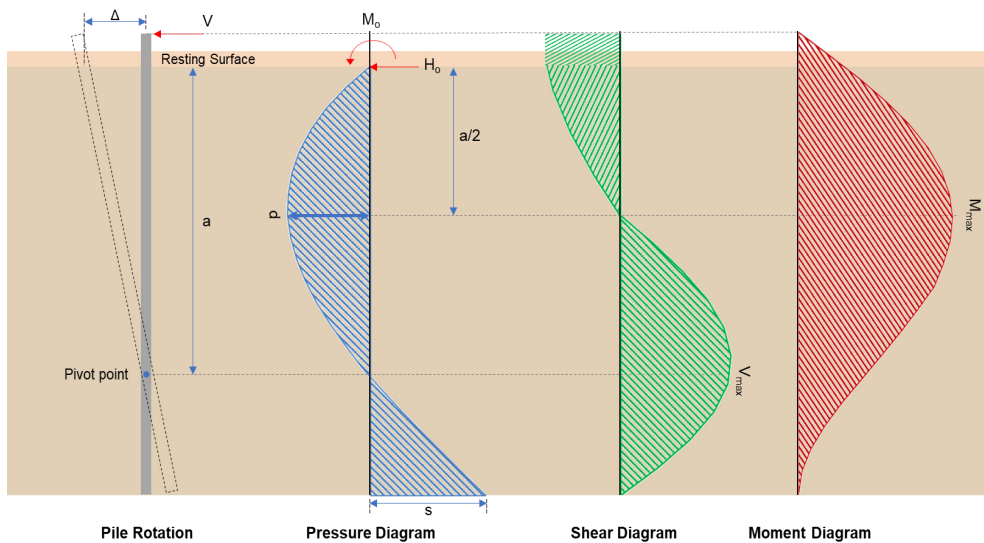
$Ratio$  - Lateral soil capacity

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

$$Ratio = \frac{(0.01819 \text{ kip/ft}^2)}{(1.3875 \text{ kip/ft}^2)}$$

$$Ratio = 0.01311$$

Status: **PASS**  
Ratio: **0.010**



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

$H_o$  - Lateral force per length of pile,

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

$$H_o = \frac{(-4.265 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.67914 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

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

$$M_o = \frac{(123.23 \text{ kipft}) + ((-4.265 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 19.623 \text{ kipft/ft}$$

$E$  - Distance from lateral load to resisting surface,

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

$$E = \frac{(19.623 \text{ kipft/ft})}{(-0.67914 \text{ kip/ft})}$$

$$E = 28.894 \text{ ft}$$

$a$  - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (19.623 \text{ kipft/ft}) \times (9.25 \text{ ft})) + (3 \times (-0.67914 \text{ kip/ft}) \times (9.25 \text{ ft})^2)}{(6 \times 19.623 \text{ kipft/ft}) + (4 \times (-0.67914 \text{ kip/ft}) \times 9.25 \text{ ft})}$$

$$a = \frac{(-0.67914 \text{ kip/ft}) \times (48 \text{ in})}{(6 \times (19.623 \text{ kip/ft}) + (4 \times (-0.67914 \text{ kip/ft}) \times (9.25 \text{ ft})))}$$

$$a = 6.3022 \text{ ft}$$

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

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

$$V_{max} = ((-0.67914 \text{ kip/ft}) \times (48 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (28.894 \text{ ft})}{(9.25 \text{ ft})} + 3 \right) \times \left( \frac{(6.3022 \text{ ft})}{(9.25 \text{ ft})} \right)^2 \right] + \left[ 4 \times \left( \frac{3 \times (28.894 \text{ ft})}{(9.25 \text{ ft})} + 2 \right) \times \left( \frac{(6.3022 \text{ ft})}{(9.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 16.823 \text{ kip}$$

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

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

$$M_{max} = ((-0.67914 \text{ kip/ft}) \times (48 \text{ in}) \times (9.25 \text{ ft})) \times \left[ \left( \frac{(28.894 \text{ ft})}{(9.25 \text{ ft})} + \frac{(6.3022 \text{ ft})}{2 \times (9.25 \text{ ft})} \right) - \left[ \left( \frac{4 \times (28.894 \text{ ft})}{(9.25 \text{ ft})} + 3 \right) \times \left( \frac{(6.3022 \text{ ft})}{2 \times (9.25 \text{ ft})} \right)^3 \right] + \left[ \left( \frac{3 \times (28.894 \text{ ft})}{(9.25 \text{ ft})} + 2 \right) \times \left( \frac{(6.3022 \text{ ft})}{2 \times (9.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 75.507 \text{ kipft}$$

#### Shear force and Bending moment (z-direction, LRFD)

$H_o$  - Lateral force per length of pile,

$$H_o = \frac{V_z}{1.57 b}$$

$$H_o = \frac{(0.096 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.015287 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

$$M_o = \frac{M_x + (V_z H)}{1.57 b}$$

$$M_o = \frac{(0.858 \text{ kipft}) + ((0.096 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.13662 \text{ kipft/ft}$$

$E$  - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.13662 \text{ kipft/ft})}{(0.015287 \text{ kip/ft})}$$

$$E = 8.9375 \text{ ft}$$

$a$  - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.13662 \text{ kipft/ft}) \times (9.25 \text{ ft})) + (3 \times (0.015287 \text{ kip/ft}) \times (9.25 \text{ ft})^2)}{(6 \times (0.13662 \text{ kipft/ft})) + (4 \times (0.015287 \text{ kip/ft}) \times (9.25 \text{ ft}))}$$

$$a = 6.4814 \text{ ft}$$

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

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

$$V_{max} = ((0.015287 \text{ kip/ft}) \times (48 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (8.9375 \text{ ft})}{(9.25 \text{ ft})} + 3 \right) \times \left( \frac{(6.4814 \text{ ft})}{(9.25 \text{ ft})} \right)^2 \right] \right. \\ \left. + \left[ 4 \times \left( \frac{3 \times (8.9375 \text{ ft})}{(9.25 \text{ ft})} + 2 \right) \times \left( \frac{(6.4814 \text{ ft})}{(9.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.14494 \text{ kip}$$

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

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

$$M_{max} = ((0.015287 \text{ kip/ft}) \times (48 \text{ in}) \times (9.25 \text{ ft})) \times \left[ \left( \frac{(8.9375 \text{ ft})}{(9.25 \text{ ft})} + \frac{(6.4814 \text{ ft})}{2 \times (9.25 \text{ ft})} \right) \right. \\ \left. - \left[ \left( \frac{4 \times (8.9375 \text{ ft})}{(9.25 \text{ ft})} + 3 \right) \times \left( \frac{(6.4814 \text{ ft})}{2 \times (9.25 \text{ ft})} \right)^3 \right] + \left[ \left( \frac{3 \times (8.9375 \text{ ft})}{(9.25 \text{ ft})} + 2 \right) \times \left( \frac{(6.4814 \text{ ft})}{2 \times (9.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.61943 \text{ kipft}$$

#### 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,  
 $\alpha = 0.8$  - Alpha factor for axial strength,  
 $A_g = 2304 \text{ in}^2$  - Gross area of concrete,

##### Longitudinal reinforcement:

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

$A_{st,required}$

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

$$A_{st,required} = Min \left[ \frac{\frac{(7.523 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$$

$$A_{st,required} = -84.346 \text{ in}^2$$

$A_{min}$  - Governing minimum reinforcement area,

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

$$A_{min} = Max[(-84.346 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$$

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

$n_{rebar}$  - 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

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

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

Table 22.4.2.1

22.4.2.2, 10.6.1.1

<p>25.2.3</p>	<div> <div> <math display="block">Ratio = 0.96556</math> </div> </div> <p><math>s_{rebar}</math> - Minimum spacing of reinforcement,</p> <div> <math display="block">s_{rebar} = Max[1.5, (1.5 d_{bar})]</math> <math display="block">s_{rebar} = Max[1.5, (1.5 \times (0.625 \text{ in}))]</math> <math display="block">s_{rebar} = 1.5 \text{ in}</math> </div> <p><b>Ties:</b></p> <p>25.7.2.2 Since longitudinal reinforcement is <math>\leq</math> No. 10ø: Use #3(0.375 in)</p> <p>25.7.2.1 <math>s_{ties}</math> - Maximum spacing of ties,</p> <div> <math display="block">s_{ties} = Min[(16 d_{bar}), (48 d_{ties}), Min(D, b)]</math> <math display="block">s_{ties} = Min[(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), Min((48 \text{ in}), (48 \text{ in}))]</math> <math display="block">s_{ties} = 10 \text{ in}</math> </div> <p><b>Summary:</b></p> <p>Main reinforcement: <b>14 - #5 (0.625 in)</b> Ties: <b>#3(0.375 in) - 10 in</b></p>	<p>Status: <b>PASS</b> Ratio: <b>0.970</b></p>
<p>22.4.2.2</p>	<p><b>Axial Compression Strength (ACI 318-19, LRFD)</b></p> <p><math>\phi P_N</math> - Allowable axial compressive strength</p> <div> <math display="block">\phi P_N = \phi 0.80 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st})]</math> <math display="block">\phi P_N = (0.65) \times 0.80 \times [(0.85 \times (2.5 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2))]</math> <math display="block">\phi P_N = 2675.2 \text{ kip}</math> </div> <p><i>Ratio</i> - Capacity</p> <div> <math display="block">Ratio = \frac{P}{\phi P_N}</math> <math display="block">Ratio = \frac{(7.523 \text{ kip})}{(2675.2 \text{ kip})}</math> <math display="block">Ratio = 0.0028121</math> </div>	<p>Status: <b>PASS</b> Ratio: <b>0.000</b></p>
<p>22.5.2.2</p> <p>22.5.1.3</p> <p>22.5.1.1</p>	<p><b>Shear Strength (ACI 318-19, LRFD)</b></p> <p><b>Parameters:</b></p> <p><math>b_w = 48 \text{ in}</math> - Effective width, <math>d</math> - Effective depth</p> <div> <math display="block">d = 0.80 D</math> <math display="block">d = 0.80 \times (48 \text{ in})</math> <math display="block">d = 38.4 \text{ in}</math> </div> <p><math>\lambda_s</math> - size effect modification factor</p> <div> <math display="block">\lambda_s = MIN \left[ \sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]</math> <math display="block">\lambda_s = MIN \left[ \sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]</math> <math display="block">\lambda_s = 0.64282</math> </div> <p>The following variables were converted to be consistent with empirical formula <math>f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}</math>,</p> <p><math>V_{c,max}</math> - Max shear strength of concrete</p> <div> <math display="block">V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d</math> <math display="block">V_{c,max} = 5 \times (0.64282) \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})</math> </div>	



$$V_{c,max} = 296.21 \text{ kip}$$

22.5.5.1.1(a) The following variables were converted to be consistent with empirical formula  $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$ ,  $P = 7.523 \text{ kip} \rightarrow 7523 \text{ lbf}$ ,  
 $V_{c,a}$  - Shear strength of concrete (a)

$$V_{c,a} = \left[ 2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$$

$$V_{c,a} = \left[ 2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(7523 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 119.49 \text{ kip}$$

22.5.5.1.2 The following variables were converted to be consistent with empirical formula  $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$ ,  
 $V_{c,b}$  - Shear strength of concrete (b)

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

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

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

$V_c$  - Governing shear strength of concrete

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

$$V_c = \text{Min}[(296.21 \text{ kip}), (119.49 \text{ kip}), (348.89 \text{ kip})]$$

$$V_c = 119.49 \text{ kip}$$

22.5.5.1.2 The following variables were converted to be consistent with empirical formula  $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$ ,  
 $V_{s,a}$  - Shear strength of steel (a)

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

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

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

$A_v$  - 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)

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

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

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

$V_s$  - Governing shear strength of steel

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

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

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

22.5.1.1  $\phi V_n$  - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((119.49 \text{ kip}) + (50.894 \text{ kip}))$$

$$\phi V_n = 110.75 \text{ kip}$$

**Considering x-direction:**

$V_{max} = 16.823 \text{ kip}$  - Maximum shear force in the x-direction,  
 $Ratio$  - Capacity

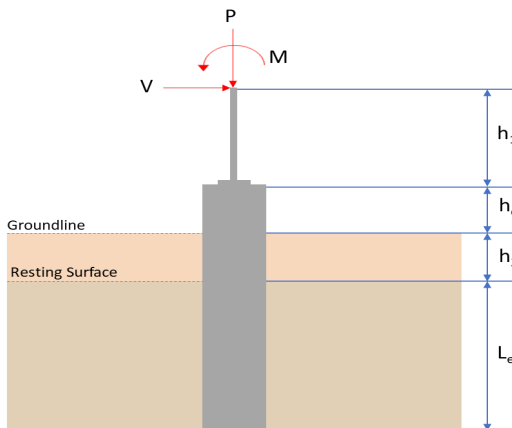
$$Ratio = \frac{V_{max}}{\phi V_n}$$

	$Ratio = \frac{(16.823 \text{ kip})}{(110.75 \text{ kip})}$ $Ratio = 0.1519$ <p><b>Considering z-direction:</b></p> <p><math>V_{max} = 0.14494 \text{ kip}</math> - Maximum shear force in the z-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.14494 \text{ kip})}{(110.75 \text{ kip})}$ $Ratio = 0.0013088$	<p>Status: <b>PASS</b> Ratio: <b>0.150</b></p> <p>Status: <b>PASS</b> Ratio: <b>0.000</b></p>
14.5.2.1b	<p><b>Flexural Strength (ACI 318-19, LRFD)</b></p> <p><math>S_m</math> - Section modulus</p> $S_m = \frac{b D^2}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$ <p><math>\lambda = 1</math> - Concrete modification factor (Normal concrete),  Allowable flexural strength:  <math>M_n</math> shall be the lesser of:  <math>\phi M_{n,1}</math></p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 \text{ ksi})} \times 18432.001 \text{ in}^3$ $\phi M_{n,1} = 249.600 \text{ kipft}$ <p><math>\phi M_{n,2}</math></p> $\phi M_{n,2} = \phi \times 0.85 \times f'_{ck} \times S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (18432 \text{ in}^3)$ $\phi M_{n,2} = 2121.6 \text{ kipft}$ <p>Therefore,  <math>\phi M_n</math> - Allowable flexural strength,</p> $\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = MIN[(249.6 \text{ kipft}), (2121.6 \text{ kipft})]$ $\phi M_n = 249.6 \text{ kipft}$ <p><b>Considering x-direction:</b></p> <p><math>M_{max} = 75.507 \text{ kipft}</math> - Maximum moment in the x-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(75.507 \text{ kipft})}{(249.6 \text{ kipft})}$ $Ratio = 0.30251$	<p>Status: <b>PASS</b> Ratio: <b>0.300</b></p>
	<p><b>Considering z-direction:</b></p> <p><math>M_{max} = 0.61943 \text{ kipft}</math> - Maximum moment in the z-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$	

$$Ratio = \frac{(0.61943 \text{ kipft})}{(249.6 \text{ kipft})}$$

$$Ratio = 0.0024817$$

Status: **PASS**  
Ratio: **0.000**

REFERENCES	CALCULATIONS	RESULTS																										
	<div><div>SkyCiv Foundation Design</div><div>Pile Foundation</div><div>Design Information :</div><div>Design code : IBC 2021 (International Building Code)</div><div>Unit System : Imperial</div></div>																											
	<div><div>Pile Input</div><div></div><div><div>Geometry</div><div>Pile shape: rectangular</div><div>b = 48 in - Pile width</div><div>D = 48 in - Pile depth</div><div>L = 9.25 ft - Total pile length</div><div>h1 = 0 ft - Lateral load height from the top of the pile,</div><div>h2 = 0 ft - Depth to resisting surface</div><div>he = 0 ft - Length of pile above the ground</div></div><div><div>Tabulation of Soil Parameters</div><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 &amp; clayey gravel</td><td>2000.000</td><td>150.000</td></tr></table></div><div><div>Tabulation of Loads</div><table><tr><th>Load Component</th><th>ASD</th><th>LRFD</th></tr><tr><td>P (kip)</td><td>5.264</td><td>7.523</td></tr><tr><td>Vx (kip)</td><td>-2.559</td><td>-4.265</td></tr><tr><td>Vz (kip)</td><td>-0.060</td><td>-0.096</td></tr><tr><td>Mx (kipft)</td><td>-0.537</td><td>-0.859</td></tr><tr><td>Mz (kipft)</td><td>71.597</td><td>123.231</td></tr></table></div><div><div>Material Properties</div><div>f'ck = 2.5 ksi - Concrete strength,</div></div></div>	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)	5.264	7.523	Vx (kip)	-2.559	-4.265	Vz (kip)	-0.060	-0.096	Mx (kipft)	-0.537	-0.859	Mz (kipft)	71.597	123.231	
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	<div><div>Required depth to resist lateral loads (ASD)</div><div>H - Point of application of the lateral load</div><div><div><div><div><math>H = h_1 + h_2 + h_e</math></div><div><math>H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})</math></div><div><math>H = 0 \text{ ft}</math></div></div></div><div><div>Considering x-direction:</div><div>Ho - Lateral force per length of pile,</div><div><div><div><math>H_o = \frac{V_x}{1.57 D}</math></div><div><math>H_o = \frac{(-2.559 \text{ kip})}{1.57 \times (48 \text{ in})}</math></div><div><math>H_o = -0.40748 \text{ kip/ft}</math></div></div></div></div></div></div>																											

$M_o$  - Moment per length of pile,

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

$$M_o = \frac{(71.597 \text{ kipft}) + ((-2.559 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 11.401 \text{ kipft/ft}$$

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:

$L_{e,x} = 8.8598 \text{ ft}$  - Required depth in x-direction,

**Considering z-direction:**

$H_o$  - Lateral force per length of pile,

$$H_o = \frac{V_z}{1.57 b}$$

$$H_o = \frac{(-0.06 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.0095541 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

$$M_o = \frac{M_x + (V_z H)}{1.57 b}$$

$$M_o = \frac{(0.537 \text{ kipft}) + ((-0.06 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.08551 \text{ kipft/ft}$$

Required depth of embedment in earth:

$$L_z^3 - \left( 14.14 \times \frac{H_o \times L_z}{R} \right) - \left( 18.85 \times \frac{M_o}{R} \right) = 0$$

Solving the cubic equation:

$L_{e,z} = 1.7978 \text{ ft}$  - Required depth in z-direction,

**Minimum embedded depth required:**

$L_{e,req}$  - Depth of pile required,

$$L_{e,req} = MAX[L_{e,x}, L_{e,z}]$$

$$L_{e,req} = MAX[(8.8598 \text{ ft}), (1.7978 \text{ ft})]$$

$$L_{e,req} = 8.86 \text{ ft}$$

$L_e$  - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (9.25 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$$

$$L_e = 9.25 \text{ ft}$$

**Ratio** - Embedded depth

$$Ratio = \frac{L_{e,req}}{L_e}$$

$$Ratio = \frac{(8.86 \text{ ft})}{(9.25 \text{ ft})}$$

$$Ratio = 0.95784$$

Status: **PASS**  
Ratio: **0.960**

### 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

$$q = \frac{P_v}{A}$$

$$q = \frac{(5.264 \text{ kip})}{(16 \text{ ft}^2)}$$

$$q = 0.329 \text{ kip/ft}^2$$

**Check bearing capacity ratio:**

Ratio - Capacity

$$\text{Ratio} = \frac{q}{q_a}$$

$$\text{Ratio} = \frac{(0.329 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$\text{Ratio} = 0.1645$$

Status: **PASS**  
Ratio: **0.160**

Czerniak

**Lateral Soil Pressure (ASD):**

$L/D$  - Length to least lateral dimension ratio,

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

$$L/D = \frac{(9.25 \text{ ft})}{(48 \text{ in})}$$

$$L/D = 2.3125$$

Since  $L/D \leq 10$ ,

Pile is short.

**Considering x-direction:**

$H_o = -0.40748 \text{ kip/ft}$  - Lateral force per length of pile,

$M_o = 11.401 \text{ kipft/ft}$  - Overturning moment per length of pile,

$a$  - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (11.401 \text{ kipft/ft}) \times (9.25 \text{ ft})) + (3 \times (-0.40748 \text{ kip/ft}) \times (9.25 \text{ ft})^2)}{(6 \times (11.401 \text{ kipft/ft})) + (4 \times (-0.40748 \text{ kip/ft}) \times (9.25 \text{ ft}))}$$

$$a = 6.3059 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (11.401 \text{ kipft/ft})) + (3 \times (-0.40748 \text{ kip/ft}) \times (9.25 \text{ ft}))]^2}{(9.25 \text{ ft})^2 \times [(3 \times (11.401 \text{ kipft/ft})) + (2 \times (-0.40748 \text{ kip/ft}) \times (9.25 \text{ ft}))]}$$

$$p = 0.38666 \text{ kip/ft}^2$$

$s$  - Earth pressure against the pile at distance  $L_e$ ,

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

$$s = \frac{6 \times [(2 \times (11.401 \text{ kipft/ft})) + ((-0.40748 \text{ kip/ft}) \times (9.25 \text{ ft}))]}{(9.25 \text{ ft})^2}$$

$$s = 1.3346 \text{ kip/ft}^2$$

**Check lateral soil pressure capacity:**

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(6.3059 \text{ ft})}{2}$$

$$p_a = 0.47294 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

	$Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.38666 \text{ kip/ft}^2)}{(0.47294 \text{ kip/ft}^2)}$ $Ratio = 0.81756$ <p><math>p_s</math> - Allowable lateral soil pressure at depth <math>L_e</math>,</p> $p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (9.25 \text{ ft})$ $p_s = 1.3875 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $Ratio = \frac{s}{p_s}$ $Ratio = \frac{(1.3346 \text{ kip/ft}^2)}{(1.3875 \text{ kip/ft}^2)}$ $Ratio = 0.96189$	<p>Status: <b>PASS</b> Ratio: <b>0.820</b></p> <p>Status: <b>PASS</b> Ratio: <b>0.960</b></p>
	<p><b>Considering z-direction:</b></p> <p><math>H_o = -0.0095541 \text{ kip/ft}</math> - Lateral force per length of pile,  <math>M_o = 0.08551 \text{ kipft/ft}</math> - Overturning moment per length of pile,  <math>a</math> - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.08551 \text{ kipft/ft}) \times (9.25 \text{ ft})) + (3 \times (-0.0095541 \text{ kip/ft}) \times (9.25 \text{ ft})^2)}{(6 \times (0.08551 \text{ kipft/ft})) + (4 \times (-0.0095541 \text{ kip/ft}) \times (9.25 \text{ ft}))}$ $a = 6.4811 \text{ ft}$ <p><math>p</math> - Earth pressure against the pile at distance <math>a/2</math> from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.08551 \text{ kipft/ft})) + (3 \times (-0.0095541 \text{ kip/ft}) \times (9.25 \text{ ft}))]^2}{(9.25 \text{ ft})^2 \times [(3 \times (0.08551 \text{ kipft/ft})) + (2 \times (-0.0095541 \text{ kip/ft}) \times (9.25 \text{ ft}))]}$ $p = 0.00064994 \text{ kip/ft}^2$ <p><math>s</math> - Earth pressure against the pile at distance <math>L_e</math>,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.08551 \text{ kipft/ft})) + ((-0.0095541 \text{ kip/ft}) \times (9.25 \text{ ft}))]}{(9.25 \text{ ft})^2}$ $s = 0.0057953 \text{ kip/ft}^2$ <p><b>Check lateral soil pressure capacity:</b></p> <p><math>p_a</math> - Allowable lateral soil pressure at depth <math>a/2</math>,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(6.4811 \text{ ft})}{2}$ $p_a = 0.48608 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.00064994 \text{ kip/ft}^2)}{(0.48608 \text{ kip/ft}^2)}$	

$$Ratio = 0.0013371$$

Status: **PASS**  
Ratio: **0.000**

$p_s$  - Allowable lateral soil pressure at depth  $L_e$ ,

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (9.25 \text{ ft})$$

$$p_s = 1.3875 \text{ kip/ft}^2$$

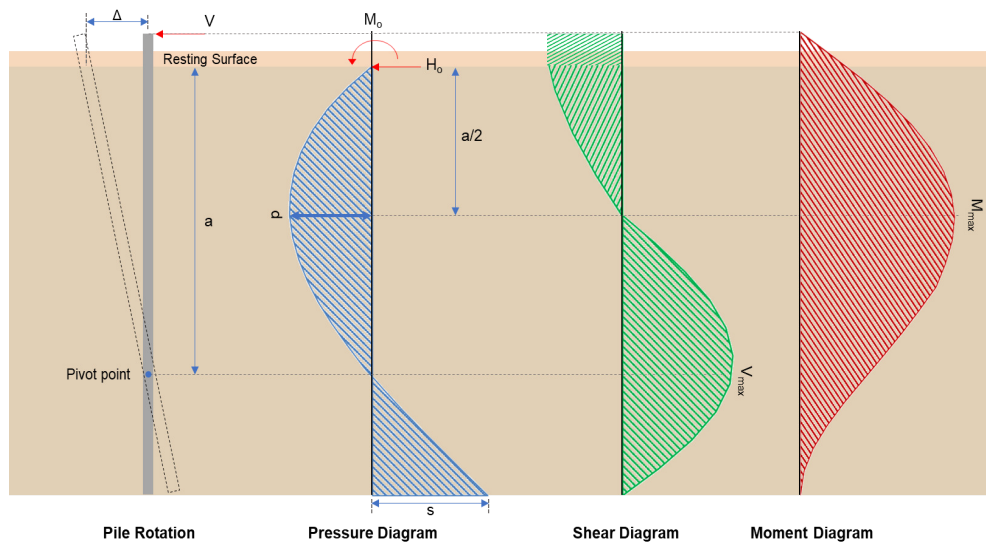
$Ratio$  - Lateral soil capacity

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

$$Ratio = \frac{(0.0057953 \text{ kip/ft}^2)}{(1.3875 \text{ kip/ft}^2)}$$

$$Ratio = 0.0041768$$

Status: **PASS**  
Ratio: **0.000**



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

$H_o$  - Lateral force per length of pile,

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

$$H_o = \frac{(-4.265 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.67914 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

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

$$M_o = \frac{(123.23 \text{ kipft}) + ((-4.265 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 19.623 \text{ kipft/ft}$$

$E$  - Distance from lateral load to resisting surface,

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

$$E = \frac{(19.623 \text{ kipft/ft})}{(-0.67914 \text{ kip/ft})}$$

$$E = 28.894 \text{ ft}$$

$a$  - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (19.623 \text{ kipft/ft}) \times (9.25 \text{ ft})) + (3 \times (-0.67914 \text{ kip/ft}) \times (9.25 \text{ ft})^2)}{(6 \times (19.623 \text{ kipft/ft})) + (4 \times (-0.67914 \text{ kip/ft}) \times (9.25 \text{ ft}))}$$



$$a = \frac{(-0.67914 \text{ kip/ft}) \times (48 \text{ in})}{(6 \times (19.623 \text{ kip/ft}) + (4 \times (-0.67914 \text{ kip/ft}) \times (9.25 \text{ ft})))}$$

$$a = 6.3022 \text{ ft}$$

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

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

$$V_{max} = ((-0.67914 \text{ kip/ft}) \times (48 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (28.894 \text{ ft})}{(9.25 \text{ ft})} + 3 \right) \times \left( \frac{(6.3022 \text{ ft})}{(9.25 \text{ ft})} \right)^2 \right] + \left[ 4 \times \left( \frac{3 \times (28.894 \text{ ft})}{(9.25 \text{ ft})} + 2 \right) \times \left( \frac{(6.3022 \text{ ft})}{(9.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 16.823 \text{ kip}$$

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

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

$$M_{max} = ((-0.67914 \text{ kip/ft}) \times (48 \text{ in}) \times (9.25 \text{ ft})) \times \left[ \left( \frac{(28.894 \text{ ft})}{(9.25 \text{ ft})} + \frac{(6.3022 \text{ ft})}{2 \times (9.25 \text{ ft})} \right) - \left[ \left( \frac{4 \times (28.894 \text{ ft})}{(9.25 \text{ ft})} + 3 \right) \times \left( \frac{(6.3022 \text{ ft})}{2 \times (9.25 \text{ ft})} \right)^3 \right] + \left[ \left( \frac{3 \times (28.894 \text{ ft})}{(9.25 \text{ ft})} + 2 \right) \times \left( \frac{(6.3022 \text{ ft})}{2 \times (9.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 75.507 \text{ kipft}$$

#### Shear force and Bending moment (z-direction, LRFD)

$H_o$  - Lateral force per length of pile,

$$H_o = \frac{V_z}{1.57 b}$$

$$H_o = \frac{(-0.096 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.015287 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

$$M_o = \frac{M_x + (V_z H)}{1.57 b}$$

$$M_o = \frac{(0.859 \text{ kipft}) + ((-0.096 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.13678 \text{ kipft/ft}$$

$E$  - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.13678 \text{ kipft/ft})}{(-0.015287 \text{ kip/ft})}$$

$$E = 8.9479 \text{ ft}$$

$a$  - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.13678 \text{ kipft/ft}) \times (9.25 \text{ ft})) + (3 \times (-0.015287 \text{ kip/ft}) \times (9.25 \text{ ft})^2)}{(6 \times (0.13678 \text{ kipft/ft})) + (4 \times (-0.015287 \text{ kip/ft}) \times (9.25 \text{ ft}))}$$

$$a = 6.4812 \text{ ft}$$

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

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

$$V_{max} = ((-0.015287 \text{ kip/ft}) \times (48 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (8.9479 \text{ ft})}{(9.25 \text{ ft})} + 3 \right) \times \left( \frac{(6.4812 \text{ ft})}{(9.25 \text{ ft})} \right)^2 \right] + \left[ 4 \times \left( \frac{3 \times (8.9479 \text{ ft})}{(9.25 \text{ ft})} + 2 \right) \times \left( \frac{(6.4812 \text{ ft})}{(9.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.14506 \text{ kip}$$

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

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

$$M_{max} = ((-0.015287 \text{ kip/ft}) \times (48 \text{ in}) \times (9.25 \text{ ft})) \times \left[ \left( \frac{(8.9479 \text{ ft})}{(9.25 \text{ ft})} + \frac{(6.4812 \text{ ft})}{2 \times (9.25 \text{ ft})} \right) - \left[ \left( \frac{4 \times (8.9479 \text{ ft})}{(9.25 \text{ ft})} + 3 \right) \times \left( \frac{(6.4812 \text{ ft})}{2 \times (9.25 \text{ ft})} \right)^3 \right] + \left[ \left( \frac{3 \times (8.9479 \text{ ft})}{(9.25 \text{ ft})} + 2 \right) \times \left( \frac{(6.4812 \text{ ft})}{2 \times (9.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.62 \text{ kipft}$$

#### 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,

$\alpha = 0.8$  - Alpha factor for axial strength,

$A_g = 2304 \text{ in}^2$  - Gross area of concrete,

##### Longitudinal reinforcement:

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

$A_{st,required}$

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

$$A_{st,required} = \text{Min} \left[ \frac{\frac{(7.523 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$$

$$A_{st,required} = -84.346 \text{ in}^2$$

$A_{min}$  - Governing minimum reinforcement area,

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

$$A_{min} = \text{Max} [(-84.346 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$$

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

$n_{rebar}$  - 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

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

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

Table 22.4.2.1

22.4.2.2, 10.6.1.1

<p>25.2.3</p>	<div style="text-align: right;"><math>Ratio = 0.96556</math></div> <p><math>s_{rebar}</math> - Minimum spacing of reinforcement,</p> $s_{rebar} = Max[1.5, (1.5 d_{bar})]$ $s_{rebar} = Max[1.5, (1.5 \times (0.625 \text{ in}))]$ $s_{rebar} = 1.5 \text{ in}$ <p><b>Ties:</b></p> <p>25.7.2.2 Since longitudinal reinforcement is <math>\leq</math> No. 10ø: Use #3(0.375 in)</p> <p>25.7.2.1 <math>s_{ties}</math> - Maximum spacing of ties,</p> $s_{ties} = Min[(16 d_{bar}), (48 d_{ties}), Min(D, b)]$ $s_{ties} = Min[(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), Min((48 \text{ in}), (48 \text{ in}))]$ $s_{ties} = 10 \text{ in}$ <p><b>Summary:</b></p> <p style="text-align: center;">Main reinforcement: <b>14 - #5 (0.625 in)</b> Ties: <b>#3(0.375 in) - 10 in</b></p>	<p>Status: <b>PASS</b> Ratio: <b>0.970</b></p>
<p>22.4.2.2</p>	<p><b>Axial Compression Strength (ACI 318-19, LRFD)</b></p> <p><math>\phi P_N</math> - Allowable axial compressive strength</p> $\phi P_N = \phi 0.80 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st})]$ $\phi P_N = (0.65) \times 0.80 \times [(0.85 \times (2.5 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2))]$ $\phi P_N = 2675.2 \text{ kip}$ <p><i>Ratio</i> - Capacity</p> $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(7.523 \text{ kip})}{(2675.2 \text{ kip})}$ $Ratio = 0.0028121$	<p>Status: <b>PASS</b> Ratio: <b>0.000</b></p>
<p>22.5.2.2</p> <p>22.5.1.3</p> <p>22.5.1.1</p>	<p><b>Shear Strength (ACI 318-19, LRFD)</b></p> <p><b>Parameters:</b></p> <p><math>b_w = 48 \text{ in}</math> - Effective width, <math>d</math> - Effective depth</p> $d = 0.80 D$ $d = 0.80 \times (48 \text{ in})$ $d = 38.4 \text{ in}$ <p><math>\lambda_s</math> - size effect modification factor</p> $\lambda_s = MIN \left[ \sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = MIN \left[ \sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.64282$ <p>The following variables were converted to be consistent with empirical formula <math>f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}</math>,</p> <p><math>V_{c,max}</math> - Max shear strength of concrete</p> $V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$ $V_{c,max} = 5 \times (0.64282) \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$	

$$V_{c,max} = 296.21 \text{ kip}$$

22.5.5.1.1(a) The following variables were converted to be consistent with empirical formula  $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$ ,  $P = 7.523 \text{ kip} \rightarrow 7523 \text{ lbf}$ ,  
 $V_{c,a}$  - Shear strength of concrete (a)

$$V_{c,a} = \left[ 2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$$

$$V_{c,a} = \left[ 2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(7523 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 119.49 \text{ kip}$$

22.5.5.1.2 The following variables were converted to be consistent with empirical formula  $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$ ,  
 $V_{c,b}$  - Shear strength of concrete (b)

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

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

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

$V_c$  - Governing shear strength of concrete

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

$$V_c = \text{Min}[(296.21 \text{ kip}), (119.49 \text{ kip}), (348.89 \text{ kip})]$$

$$V_c = 119.49 \text{ kip}$$

22.5.5.1.2 The following variables were converted to be consistent with empirical formula  $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$ ,  
 $V_{s,a}$  - Shear strength of steel (a)

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

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

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

$A_v$  - 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)

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

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

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

$V_s$  - Governing shear strength of steel

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

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

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

22.5.1.1  $\phi V_n$  - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((119.49 \text{ kip}) + (50.894 \text{ kip}))$$

$$\phi V_n = 110.75 \text{ kip}$$

**Considering x-direction:**

$V_{max} = 16.823 \text{ kip}$  - Maximum shear force in the x-direction,  
 $Ratio$  - Capacity

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

	$Ratio = \frac{(16.823 \text{ kip})}{(110.75 \text{ kip})}$ $Ratio = 0.1519$ <p><b>Considering z-direction:</b></p> <p><math>V_{max} = 0.14506 \text{ kip}</math> - Maximum shear force in the z-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.14506 \text{ kip})}{(110.75 \text{ kip})}$ $Ratio = 0.0013099$	<p>Status: <b>PASS</b> Ratio: <b>0.150</b></p> <p>Status: <b>PASS</b> Ratio: <b>0.000</b></p>
14.5.2.1b	<p><b>Flexural Strength (ACI 318-19, LRFD)</b></p> <p><math>S_m</math> - Section modulus</p> $S_m = \frac{b D^2}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$ <p><math>\lambda = 1</math> - Concrete modification factor (Normal concrete),  Allowable flexural strength:  <math>M_n</math> shall be the lesser of:  <math>\phi M_{n,1}</math></p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 \text{ ksi})} \times 18432.001 \text{ in}^3$ $\phi M_{n,1} = 249.600 \text{ kipft}$ <p><math>\phi M_{n,2}</math></p> $\phi M_{n,2} = \phi \times 0.85 \times f'_{ck} \times S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (18432 \text{ in}^3)$ $\phi M_{n,2} = 2121.6 \text{ kipft}$ <p>Therefore,  <math>\phi M_n</math> - Allowable flexural strength,</p> $\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = MIN[(249.6 \text{ kipft}), (2121.6 \text{ kipft})]$ $\phi M_n = 249.6 \text{ kipft}$ <p><b>Considering x-direction:</b></p> <p><math>M_{max} = 75.507 \text{ kipft}</math> - Maximum moment in the x-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(75.507 \text{ kipft})}{(249.6 \text{ kipft})}$ $Ratio = 0.30251$	<p>Status: <b>PASS</b> Ratio: <b>0.300</b></p>
	<p><b>Considering z-direction:</b></p> <p><math>M_{max} = 0.62 \text{ kipft}</math> - Maximum moment in the z-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$	

	$Ratio = \frac{(0.62 \text{ kipft})}{(249.6 \text{ kipft})}$	
	$Ratio = 0.0024839$	
		Status: <b>PASS</b> Ratio: <b>0.000</b>