

Your Project Calculations



Project Name: MTSOLAR_KCBJ8K6920B6

S3D Model Link:

https://platform.skyciv.com/structural?preload_name=MTSOLAR_KCBJ8K6920B6&preload_path=Shared%20Enterprise%20Folder/MT_Solar_Projects/5_2023

Public Model Link:

https://platform.skyciv.com/structural-viewer?project_id=wd6zzlT4emQokgRVK7sYvKdmT6vj5P28LCBZy2jXiW0DnelGmHbgg5t6k3A2FDRr

Array Specification

Product:	Beam
Unique ID:	2P-22.5-8TOP-HD-45-L-4Hx7W-I4D6
Duty Classification:	HD
Module Width:	39.40 in
Module Length:	66.30in
Number of Rows:	4
Number of Columns:	7
Total Number of Modules:	28
Desired Tilt Angle:	56
Front Edge Clearance:	6
Total Array Height at Tilt:	16.96 ft
Total Frame Length:	37.50 ft
Frame Weight:	1837 lbs
Array Dimensions N/S:	13.30 ft
Array Dimensions E/W:	39.26 ft
Rail Length:	159.60 in
Rail Spacing:	2.76 ft
Rail Check:	Not Checked

Support Specifications

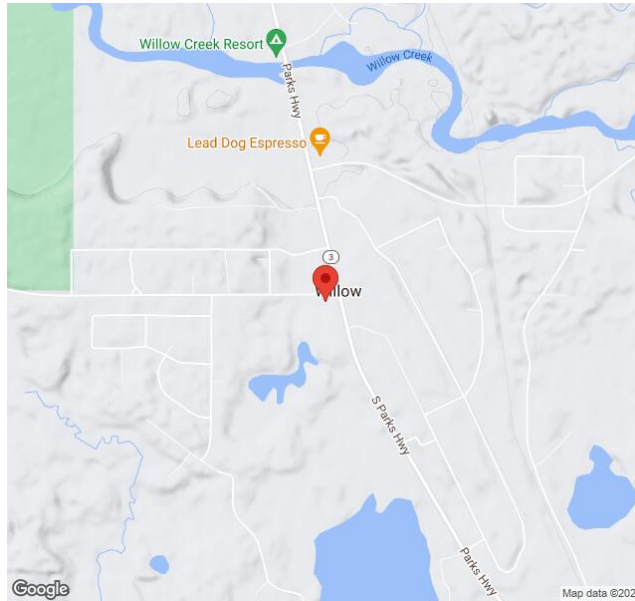
Pole Size:	8in Pipe Sch 40
Pole Length above Grade:	11.51 ft
Number of Poles:	2
Pole Spacing:	22.5 ft

Foundation Specifications

Foundation Type:	Square
Foundation Dimensions:	48 x 48 in
Foundation Depth (below grade):	Pile 1: 7.25 ft Pile 2: 7.25 ft
Foundation Volume:	8.593 y ³
Foundation Result:	PASSED
Mount Twist:	1.804980 kip

Site Info

Risk Category:	I
Exposure:	C
Soil Classification:	sand
Site Location:	33170 Parks Hwy, Willow, AK 99688, USA
Wind Speed:	110 mph
Snow Load:	100.42 psf
Design Uplift Pressure:	0.027435 ksf
Design Downforce Pressure:	-0.027435 ksf
Design Snow Pressure:	0.015460 ksf



Design Disclaimer

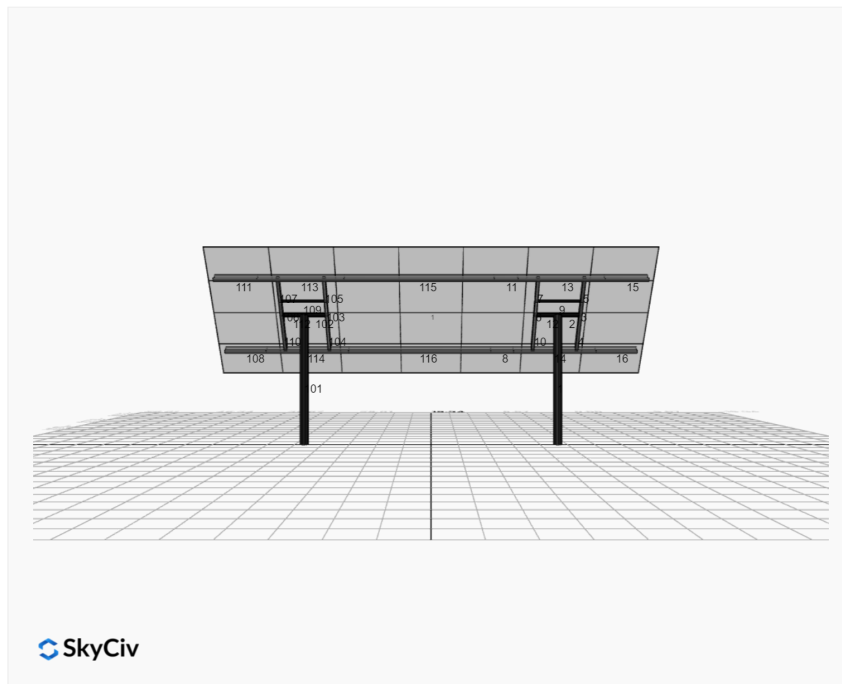
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

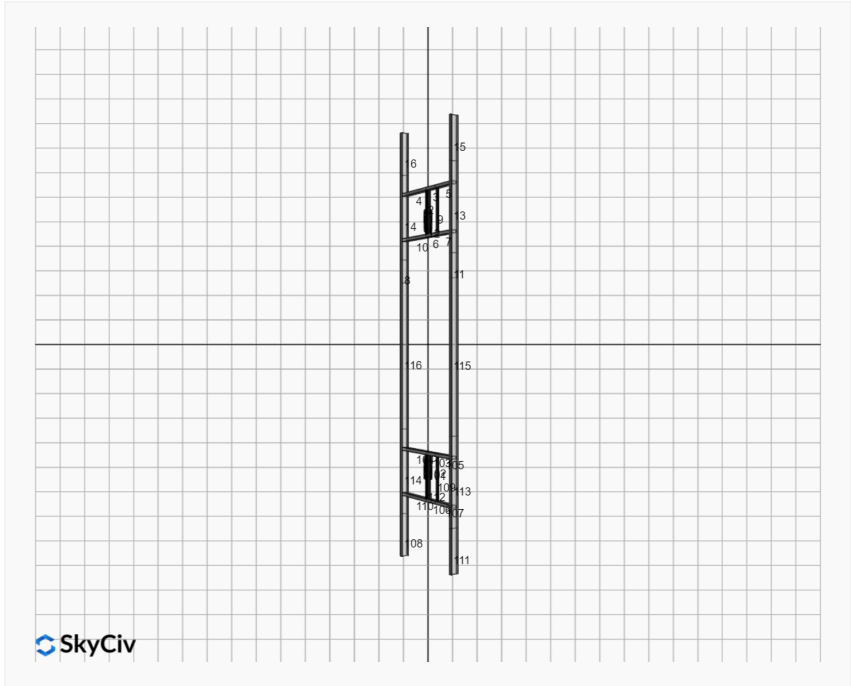
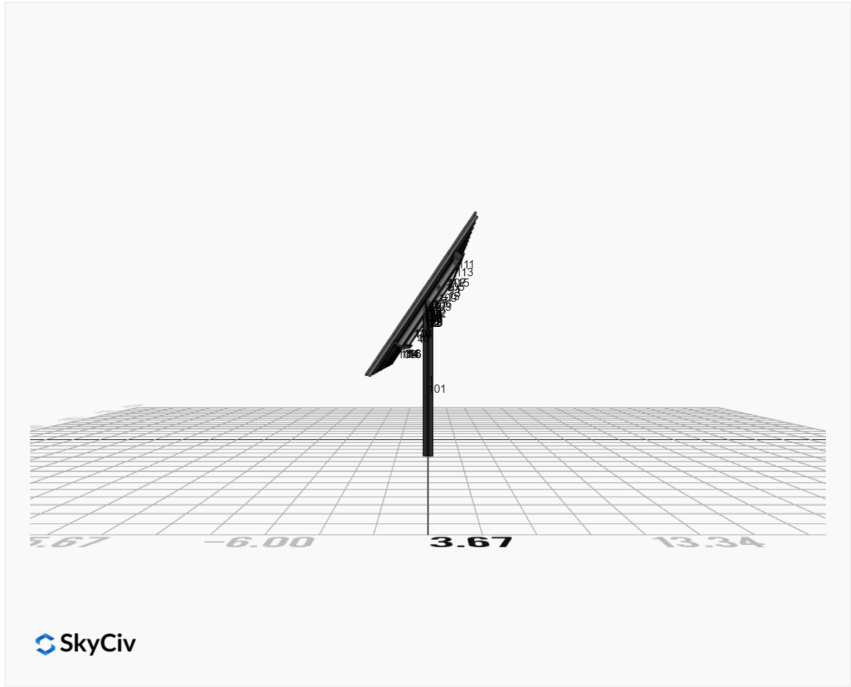
AutoDesigner Input

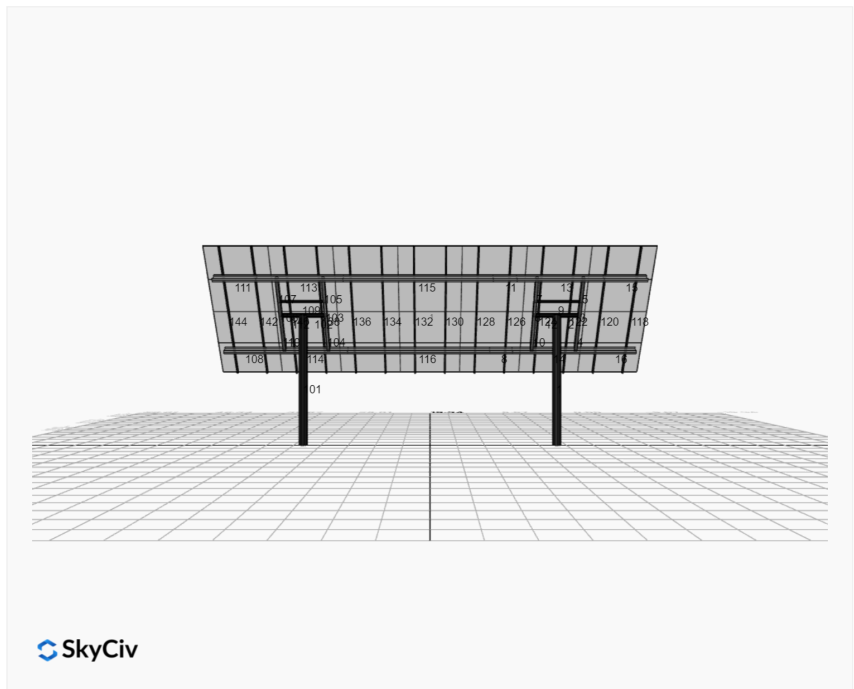
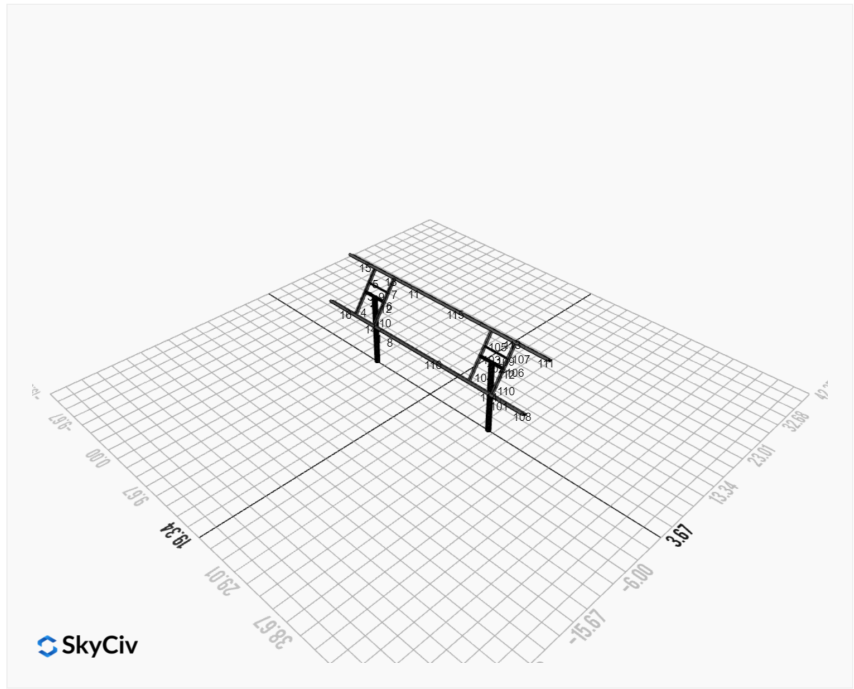
```
{
  "wind_speed_override": null,
  "snow_load_override": null,
  "direct_snow_load": false,
  "product_type": "Beam",
  "project_id": "MTSOLAR_KCBJ8K6920B6",
  "site_address": "33170 Parks Hwy, Willow, AK 99688, USA",
  "module_width": 39.4,
  "module_length": 66.3,
  "number_rows": 4,
  "number_columns": 7,
  "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": 56,
  "ground_clearance": 6,
  "risk_category": "I",
  "exposure_category": "C",
  "frame_duty_override": "auto",
  "pole_override": "auto",
  "soil_type": "sand",
  "foundation_type": "Square",
  "foundation_size": 48,
  "check_rails": false
}
```

Design Notes:

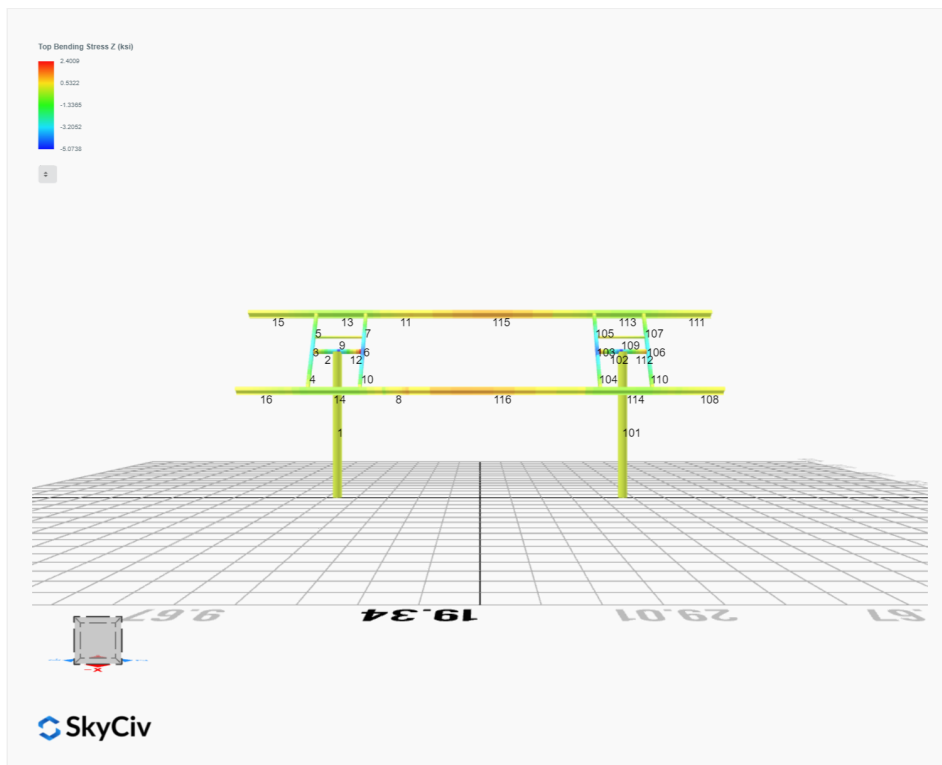
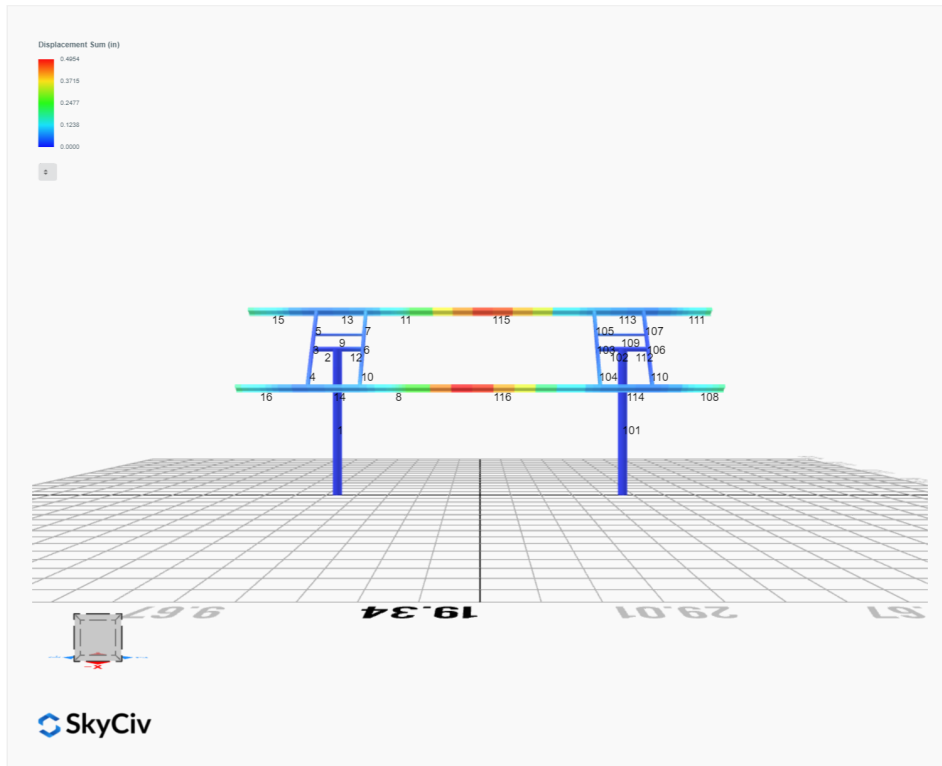
- AISC Deflection checks are set to L/1 due to structure design intent
- Foundation Design and Sizing is approximate only

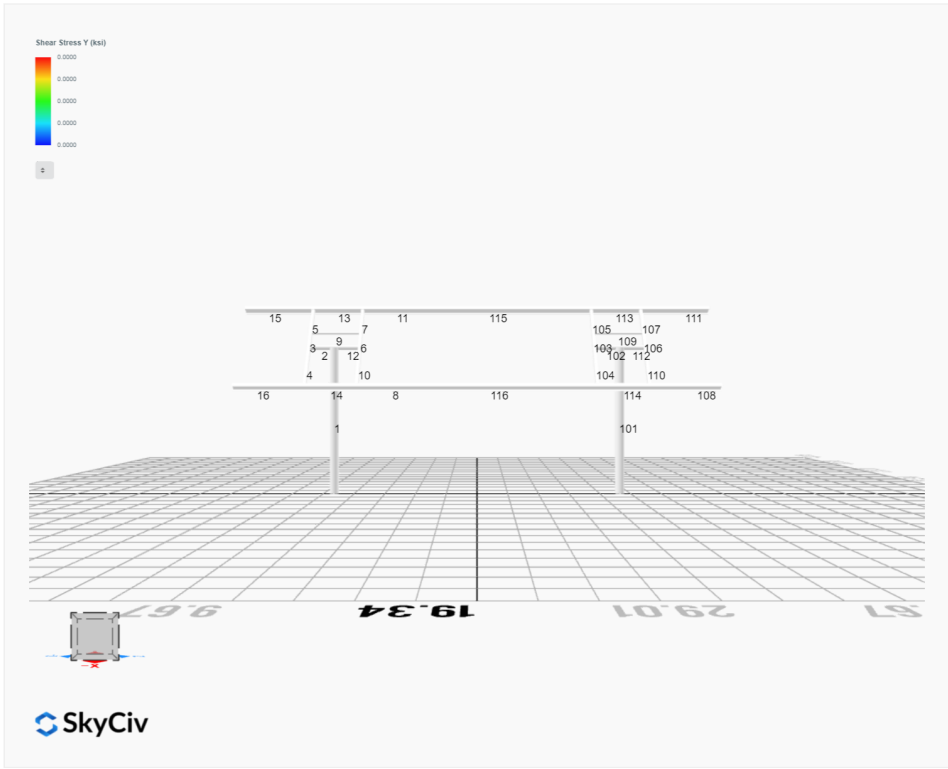
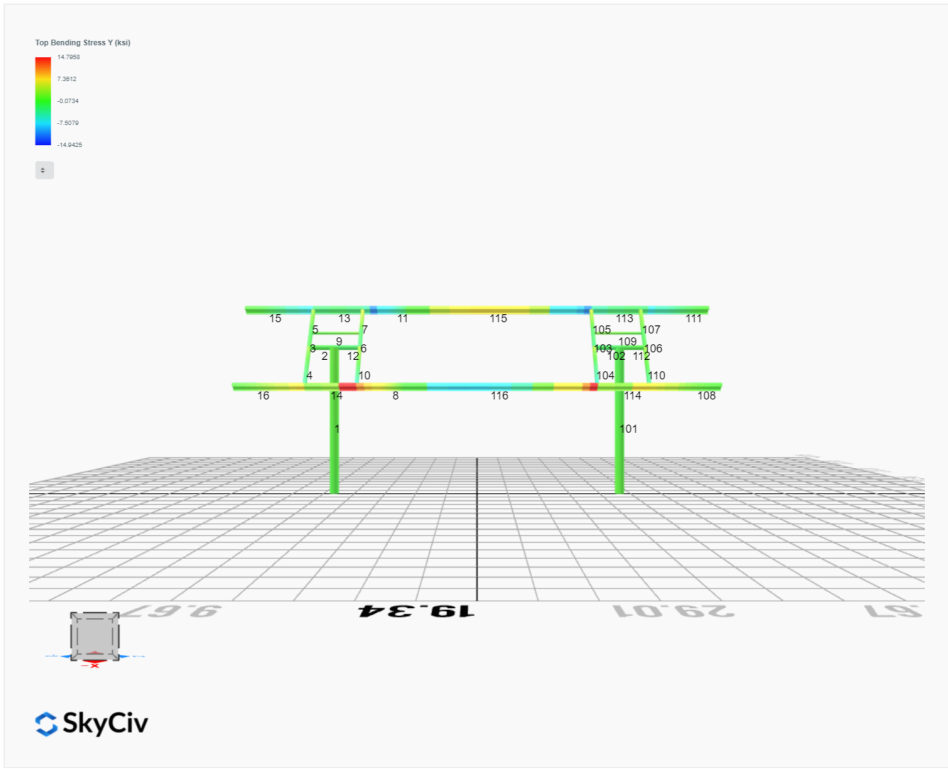


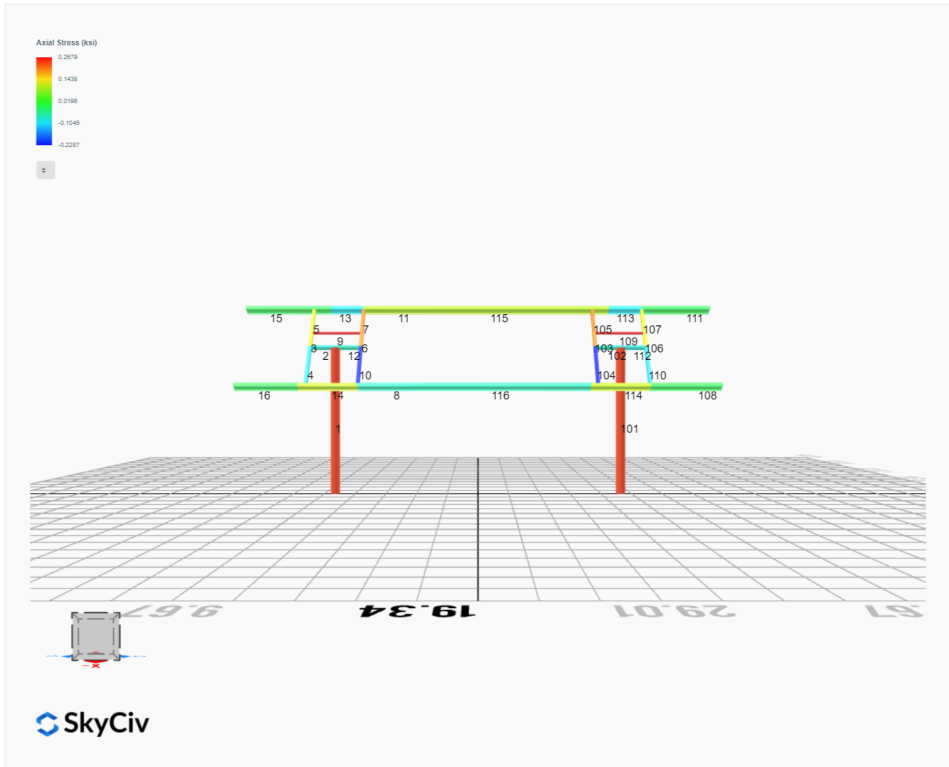




FEM Results (Envelope Worst Case for each member)







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	2.1728	0.0610	0.2100	-0.0978	0.0155
ULS: 2. D + L	-0.0000	2.1728	0.0610	0.2100	-0.0978	0.0155
ULS: 3. D + (S or Lr or R)	-0.0001	4.3287	0.1417	0.4834	-0.2319	0.0145
ULS: 3. D + (S or Lr or R)	-0.0000	2.1728	0.0610	0.2100	-0.0978	0.0155
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0001	3.7898	0.1215	0.4151	-0.1984	0.0147
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0000	2.1728	0.0610	0.2100	-0.0978	0.0155
ULS: 5b. D + 0.7E	-0.0000	2.1728	0.0610	0.2100	-0.0978	0.0155
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0001	3.7898	0.1215	0.4151	-0.1984	0.0147
ULS: 8. 0.6D + 0.7E	-0.0000	1.3037	0.0366	0.1260	-0.0587	0.0093
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.5628	4.5760	0.2144	0.6752	-1.0386	41.5304
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.0000	2.1728	0.0610	0.2100	-0.0978	0.0155
ULS: 5a. D + 0.6W_Wind uplift Case A only	3.5627	-0.2302	-0.0970	-0.3392	0.8236	-40.5044
ULS: 5a. D + 0.6W_Wind uplift Case B only	-0.0000	2.1728	0.0610	0.2100	-0.0978	0.0155
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.6722	5.5921	0.2365	0.7640	-0.9040	31.1509
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0001	3.7898	0.1215	0.4151	-0.1984	0.0147
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.6720	1.9874	0.0029	0.0031	0.4927	-30.3752
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0001	3.7898	0.1215	0.4151	-0.1984	0.0147
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.6721	3.9752	0.1760	0.5589	-0.8034	31.1517
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0000	2.1728	0.0610	0.2100	-0.0978	0.0155
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.6720	0.3705	-0.0575	-0.2019	0.5933	-30.3744
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0000	2.1728	0.0610	0.2100	-0.0978	0.0155
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.5628	3.7068	0.1900	0.5912	-0.9995	41.5242
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.0000	1.3037	0.0366	0.1260	-0.0587	0.0093
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	3.5627	-1.0994	-0.1215	-0.4232	0.8627	-40.5106
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	-0.0000	1.3037	0.0366	0.1260	-0.0587	0.0093

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	8.0609
Shear X	-5.9398
Shear Z	0.3783
Moment X	1.1650
Moment Y (Twist)	1.8463
Moment Z	69.9547

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	5.5921
Shear X	-3.5628
Shear Z	0.2365
Moment X	0.7640
Moment Y (Twist)	1.0386
Moment Z	41.5304

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	2.1728	-0.0610	-0.2105	0.0973	0.0160
ULS: 2. D + L	0.0000	2.1728	-0.0610	-0.2105	0.0973	0.0160
ULS: 3. D + (S or Lr or R)	0.0001	4.3285	-0.1417	-0.4855	0.2291	0.0154
ULS: 3. D + (S or Lr or R)	0.0000	2.1728	-0.0610	-0.2105	0.0973	0.0160
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0001	3.7896	-0.1215	-0.4168	0.1961	0.0155
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	2.1728	-0.0610	-0.2105	0.0973	0.0160
ULS: 5b. D + 0.7E	0.0000	2.1728	-0.0610	-0.2105	0.0973	0.0160

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0001	3.7896	-0.1215	-0.4168	0.1961	0.0155
ULS: 8. 0.6D + 0.7E	0.0000	1.3037	-0.0366	-0.1263	0.0584	0.0096
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.5627	4.5759	-0.2144	-0.6761	1.0385	41.5303
ULS: 5a. D + 0.6W_Wind downforce Case B only	0.0000	2.1728	-0.0610	-0.2105	0.0973	0.0160
ULS: 5a. D + 0.6W_Wind uplift Case A only	3.5628	-0.2303	0.0970	0.3383	-0.8241	-40.5031
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.0000	2.1728	-0.0610	-0.2105	0.0973	0.0160
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.6720	5.5919	-0.2365	-0.7660	0.9021	31.1512
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0001	3.7896	-0.1215	-0.4168	0.1961	0.0155
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.6722	1.9873	-0.0029	-0.0052	-0.4949	-30.3738
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0001	3.7896	-0.1215	-0.4168	0.1961	0.0155
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.6721	3.9751	-0.1760	-0.5597	0.8032	31.1517
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0000	2.1728	-0.0610	-0.2105	0.0973	0.0160
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.6721	0.3705	0.0575	0.2011	-0.5937	-30.3734
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0000	2.1728	-0.0610	-0.2105	0.0973	0.0160
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.5628	3.7068	-0.1900	-0.5919	0.9996	41.5239
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	0.0000	1.3037	-0.0366	-0.1263	0.0584	0.0096
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	3.5628	-1.0995	0.1215	0.4225	-0.8630	-40.5095
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.0000	1.3037	-0.0366	-0.1263	0.0584	0.0096

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	8.0576
Shear X	-5.9380
Shear Z	-0.3783
Moment X	-1.1725
Moment Y (Twist)	1.8050
Moment Z	69.9430

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	5.5919
Shear X	-3.5628
Shear Z	-0.2365
Moment X	-0.7660
Moment Y (Twist)	1.0385
Moment Z	41.5303

Project Details

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



User Name: sales@mtsolar.us
 Project Name: MTSOLAR_KCBJ8K6920B6
 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				
9	8in Pipe Sch 40	8.63	0.32				

--	--	--	--	--	--	--	--

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 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

9	8in Pipe Sch 40	8.40	144.98	72.49	72.49	0.00	22.21	22.21
16	HSS5x3x3/16	2.58	8.64	3.85	8.53	92.39	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 _z L (ft)	K _y L (ft)	L _b (ft)	C _b	L S T	L S C	L D
1	9	24.18	24.18	11.51	-	300	200	1
2	5	1.30	1.30	2.00	-	300	200	1
3	16	0.92	0.92	1.42	1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.17,1.18,1.17,1.18,1.17,1.18,1.17,1.18,1.15,1.18,1.18,1.18,1.17,1.18,1.17,1.18,1.17,1.18	300	200	1
4	16	2.44	2.44	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.67,1.62,1.67,1.67,1.69,1.66,1.69,1.67,1.69,1.66,1.69	300	200	1
5	16	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.68,1.67,1.68,1.67,1.68,1.67,1.68,1.68,1.68,1.65,1.68,1.67,1.68,1.66,1.68,1.67,1.68	300	200	1
6	16	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.16,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19	300	200	1
7	16	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.68,1.67,1.68,1.67,1.68,1.67,1.68,1.68,1.68,1.65,1.68,1.67,1.68,1.66,1.68,1.67,1.68	300	200	1
8	19	1.33	1.33	2.05	2.14,2.17,2.13,2.21,2.15,2.08,1.72,2.17,1.01,2.17,1.37,2.13,1.02,2.13,2.18,2.21,2.22,2.21,1.49,2.13,1.22,2.13,1.29,2.08,1.11,2.08	300	200	1
9	2	2.60	2.60	4.00	-	300	200	1
10	16	2.44	2.44	3.75	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.66,1.67,1.63,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68	300	200	1
11	19	1.33	1.33	2.05	1.77,2.00,1.68,2.18,1.80,1.59,1.29,2.00,1.83,2.00,1.28,1.68,1.56,1.68,1.91,2.18,2.22,2.18,1.19,1.68,1.78,1.68,1.13,1.59,1.34,1.59	300	200	1
12	5	1.30	1.30	2.00	-	300	200	1
13	19	4.88	4.00	7.50	1.09,1.09,1.09,1.08,1.09,1.09,1.12,1.09,1.08,1.09,1.12,1.09,1.08,1.09,1.10,1.08,4.12,1.08,1.11,1.10,1.10,1.09,1.12,1.09,1.08,1.09	300	200	1
14	19	4.88	4.00	7.50	1.20,1.31,1.15,1.68,1.21,1.09,1.12,1.31,1.07,1.31,1.12,1.15,1.07,1.15,1.10,1.68,4.08,1.68,1.11,1.15,1.10,1.15,1.13,1.09,1.07,1.09	300	200	1
15	19	7.88	7.88	3.75	2.17,2.15,2.18,2.22,2.17,2.21,2.37,2.15,2.48,2.15,1.82,2.18,2.01,2.18,2.52,2.22,2.24,2.22,1.82,2.18,2.49,2.18,1.62,2.21,1.62,2.21	300	200	1
16	19	7.88	7.88	3.75	2.45,2.44,2.46,2.40,2.45,2.47,1.61,2.44,2.46,2.44,1.86,2.46,1.66,2.46,1.99,2.40,2.23,2.40,1.91,2.46,2.09,2.46,1.99,2.47,1.79,2.47	300	200	1
101	9	24.18	24.18	11.51	-	300	200	1
102	5	1.30	1.30	2.00	-	300	200	1
103	16	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.16,1.18,1.18,1.19,1.18,1.19,1.18,1.19	300	200	1
104	16	2.44	2.44	3.75	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.63,1.67,1.67,1.68,1.66,1.68,1.67,1.68	300	200	1
105	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.67,1.67,1.67,1.68,1.67,1.68,1.67,1.67,1.64,1.67,1.67,1.68,1.66,1.68,1.67,1.68	300	200	1
106	16	0.92	0.92	1.42	1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.17,1.18,1.17,1.18,1.17,1.18,1.17,1.18,1.15,1.18,1.18,1.18,1.17,1.18,1.17,1.18,1.17,1.18	300	200	1
107	16	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.68,1.67,1.68,1.67,1.68,1.67,1.68,1.68,1.68,1.65,1.68,1.67,1.68,1.66,1.68,1.67,1.68	300	200	1

						0	0	
108	19	7.88	7.88	3.75	2.45,2.44,2.46,2.40,2.45,2.47,1.61,2.44,2.46,2.44,1.86,2.46,1.66,2.46,1.99,2.40,2.23,2.40,1.91,2.46,2.09,2.46,1.99,2.47,1.80,2.47	300	200	1
109	2	2.60	2.60	4.00	-	300	200	1
110	16	2.44	2.44	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.67,1.62,1.67,1.67,1.69,1.66,1.69,1.67,1.69,1.66,1.69	300	200	1
111	19	7.88	7.88	3.75	2.17,2.15,2.18,2.21,2.16,2.21,2.37,2.15,2.48,2.15,1.82,2.18,2.01,2.18,2.52,2.21,2.24,2.21,1.82,2.18,2.50,2.18,1.62,2.21,1.62,2.21	300	200	1
112	5	1.30	1.30	2.00	-	300	200	1
113	19	4.88	4.00	7.50	1.09,1.09,1.09,1.09,1.09,1.09,1.12,1.09,1.15,1.09,1.12,1.09,1.08,1.09,1.10,1.09,4.16,1.09,1.11,1.09,1.10,1.09,1.12,1.09,1.08,1.09	300	200	1
114	19	4.88	4.00	7.50	1.15,1.22,1.11,1.47,1.16,1.09,1.12,1.22,1.07,1.22,1.12,1.11,1.07,1.11,1.10,1.47,4.13,1.47,1.11,1.11,1.10,1.11,1.13,1.09,1.07,1.09	300	200	1
115	19	8.42	8.42	12.95	1.11,1.11,1.11,1.12,1.11,1.11,1.11,1.11,1.10,1.11,1.11,1.11,1.10,1.11,1.11,1.12,1.14,1.12,1.11,1.11,1.10,1.11,1.11,1.11,1.11	300	200	1
116	19	8.42	8.42	12.95	1.12,1.12,1.11,1.13,1.12,1.11,1.11,1.12,1.10,1.12,1.11,1.11,1.11,1.11,1.12,1.13,1.12,1.13,1.11,1.11,1.10,1.11,1.11,1.11,1.11	300	200	1

Member Design Capacity

Member ID	$\Phi_c P_n$ (kip)	$\Phi_t P_n$ (kip)	$\Phi_b M_{zn}$ (k-ft)	$\Phi_b M_{yn}$ (k-ft)	$\Phi_v V_{yn}$ (kip)	$\Phi_v V_{zn}$ (kip)
1	377.97	185.24	83.29	83.29	113.39	113.39
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	126.01	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	126.01	32.87	6.12	40.24	43.62
12	198.33	196.72	21.95	21.95	59.50	59.50
13	133.20	104.94	24.75	6.12	40.24	43.62
14	133.20	104.94	24.52	6.12	40.24	43.62
15	133.20	52.83	32.87	6.12	40.24	43.62
16	133.20	52.83	32.87	6.12	40.24	43.62
101	377.97	185.24	83.29	83.29	113.39	113.39
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	52.83	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	52.83	32.87	6.12	40.24	43.62
112	198.33	196.72	21.95	21.95	59.50	59.50
113	133.20	104.94	24.75	6.12	40.24	43.62
114	133.20	104.94	24.52	6.12	40.24	43.62

115	133.20	46.28	11.92	6.12	40.24	43.62
116	133.20	46.28	11.92	6.12	40.24	43.62

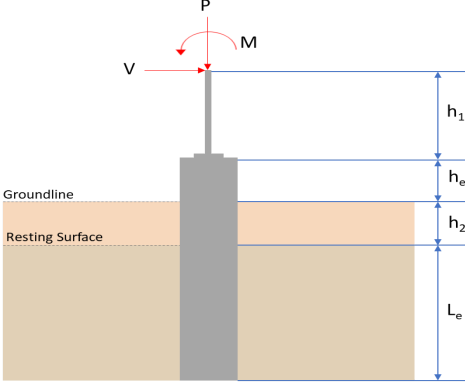
Design Ratio

Member ID	P	M _z	M _y	V _y	V _z	(P,M _z ,M _y)	Worst LC	KL/r	δ	Status
1	0.043	0.840	0.040	0.054	0.004	0.876	#13	0.494	Not Required	Pass
2	0.005	0.193	0.215	0.049	0.044	0.410	#13	0.035	Not Required	Pass
3	0.008	0.461	0.045	0.045	0.009	0.468	#13	0.045	Not Required	Pass
4	0.007	0.461	0.140	0.046	0.031	0.536	#13	0.080	Not Required	Pass
5	0.007	0.287	0.129	0.046	0.034	0.293	#13	0.074	Not Required	Pass
6	0.012	0.604	0.113	0.062	0.047	0.715	#13	0.045	Not Required	Pass
7	0.013	0.373	0.245	0.060	0.064	0.441	#13	0.074	Not Required	Pass
8	0.004	0.299	0.249	0.197	0.020	0.421	#21	0.095	Not Required	Pass
9	0.016	0.051	0.080	0.004	0.003	0.115	#13	0.204	Not Required	Pass
10	0.013	0.606	0.226	0.061	0.048	0.672	#13	0.080	Not Required	Pass
11	0.005	0.153	0.254	0.079	0.021	0.358	#23	0.095	Not Required	Pass
12	0.004	0.369	0.277	0.085	0.060	0.644	#13	0.035	Not Required	Pass
13	0.006	0.166	0.553	0.066	0.027	0.629	#23	0.286	Not Required	Pass
14	0.007	0.155	0.541	0.061	0.025	0.654	#21	0.286	Not Required	Pass
15	0.000	0.044	0.137	0.020	0.010	0.172	#23	0.562	Not Required	Pass
16	0.000	0.034	0.138	0.016	0.010	0.170	#23	0.562	Not Required	Pass
101	0.043	0.840	0.040	0.054	0.004	0.876	#13	0.494	Not Required	Pass
102	0.004	0.368	0.277	0.084	0.060	0.642	#13	0.035	Not Required	Pass
103	0.012	0.603	0.113	0.062	0.046	0.714	#13	0.045	Not Required	Pass
104	0.013	0.604	0.227	0.061	0.048	0.670	#13	0.080	Not Required	Pass
105	0.013	0.373	0.245	0.060	0.064	0.441	#13	0.074	Not Required	Pass
106	0.008	0.462	0.045	0.046	0.008	0.470	#13	0.045	Not Required	Pass
107	0.007	0.287	0.129	0.046	0.034	0.294	#13	0.074	Not Required	Pass
108	0.000	0.034	0.138	0.016	0.010	0.171	#23	0.562	Not Required	Pass
109	0.016	0.051	0.079	0.003	0.003	0.115	#13	0.204	Not Required	Pass
110	0.007	0.461	0.141	0.046	0.031	0.537	#13	0.080	Not Required	Pass
111	0.000	0.044	0.137	0.020	0.010	0.172	#23	0.562	Not Required	Pass
112	0.005	0.193	0.216	0.050	0.044	0.411	#13	0.035	Not Required	Pass
113	0.006	0.166	0.554	0.069	0.028	0.631	#23	0.286	Not Required	Pass
114	0.007	0.162	0.545	0.064	0.026	0.618	#23	0.286	Not Required	Pass
115	0.013	0.539	0.294	0.043	0.021	0.706	#21	0.601	Not Required	Pass
116	0.004	0.552	0.300	0.044	0.021	0.729	#21	0.601	Not Required	Pass

Definitions

Φ_t	Safety factor for tensile
Φ_c	Safety factor for compression
Φ_b	Safety factor for flexure
Φ_v	Safety factor for shear
E	Modulus of elasticity
F _y	Specified minimum yield stress
F _u	Specified minimum tensile strength
A	Cross-sectional area
J	Torsional constant
I _{yp}	Moment of inertia about the Y axes
I _{zp}	Moment of inertia about the Z axes
I _w	Warping constant
S _{yp}	Plastic section modulus about the Y axis
S _{zp}	Plastic section modulus about the Z axis
KL	Effective length
C _n	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																										
	<p>SkyCiv Foundation Design Pile Foundation</p> <p>Design Information : Design code : IBC 2021 (International Building Code) Unit System : Imperial</p>																											
	<p>Pile Input</p>  <p>Geometry Pile shape: rectangular $b = 48$ in - Pile width $D = 48$ in - Pile depth $L = 7.25$ ft - Total pile length $h_1 = 0$ ft - Lateral load height from the top of the pile, $h_2 = 0$ ft - Depth to resting surface $h_e = 0$ ft - Length of pile above the ground</p> <p>Tabulation of Soil Parameters</p> <table border="1"> <thead> <tr> <th>Layer</th> <th>Label</th> <th>Allowable Bearing Pressure (q_a) (psf)</th> <th>Allowable Lateral Pressure (R) (psf/ft)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Sand, silty sand, clayey sand, silty gravel & clayey gravel</td> <td>2000.000</td> <td>150.000</td> </tr> </tbody> </table> <p>Tabulation of Loads</p> <table border="1"> <thead> <tr> <th>Load Component</th> <th>ASD</th> <th>LRFD</th> </tr> </thead> <tbody> <tr> <td>P (kip)</td> <td>5.592</td> <td>8.061</td> </tr> <tr> <td>V_x (kip)</td> <td>-3.563</td> <td>-5.940</td> </tr> <tr> <td>V_z (kip)</td> <td>0.237</td> <td>0.378</td> </tr> <tr> <td>M_x (kipft)</td> <td>0.764</td> <td>1.165</td> </tr> <tr> <td>M_z (kipft)</td> <td>41.530</td> <td>69.955</td> </tr> </tbody> </table> <p>Material Properties $f'_{ck} = 3$ ksi - Concrete strength,</p>	Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) (psf/ft)	1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000	Load Component	ASD	LRFD	P (kip)	5.592	8.061	V_x (kip)	-3.563	-5.940	V_z (kip)	0.237	0.378	M_x (kipft)	0.764	1.165	M_z (kipft)	41.530	69.955	
Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) (psf/ft)																									
1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000																									
Load Component	ASD	LRFD																										
P (kip)	5.592	8.061																										
V_x (kip)	-3.563	-5.940																										
V_z (kip)	0.237	0.378																										
M_x (kipft)	0.764	1.165																										
M_z (kipft)	41.530	69.955																										
	<p>Required depth to resist lateral loads (ASD) H - Point of application of the lateral load</p> $H = h_1 + h_2 + h_e$ $H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})$ $H = 0 \text{ ft}$ <p>Considering x-direction: H_o - Lateral force per length of pile,</p> $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-3.563 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.56736 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$																											

$$M_o = \frac{(41.53 \text{ kipft}) + ((-3.563 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 6.6131 \text{ kipft/ft}$$

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:

$L_{e,x} = 6.7012 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.237 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.037739 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.764 \text{ kipft}) + ((0.237 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.12166 \text{ kipft/ft}$$

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:

$L_{e,z} = 2.4859 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = \text{MAX}[(6.7012 \text{ ft}), (2.4859 \text{ ft})]$$

$$L_{e,req} = 6.701 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (7.25 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$$

$$L_e = 7.25 \text{ ft}$$

Ratio - Embedded depth

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

$$\text{Ratio} = \frac{(6.701 \text{ ft})}{(7.25 \text{ ft})}$$

$$\text{Ratio} = 0.92428$$

Status: **PASS**
Ratio: **0.920**

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

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

$$q = \frac{(5.592 \text{ kip})}{(16 \text{ ft}^2)}$$

$$q = 0.3495 \text{ kip/ft}^2$$

$$q = 0.3495 \text{ kip/ft}$$

Check bearing capacity ratio:

Ratio - Capacity

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

$$\text{Ratio} = \frac{(0.3495 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$\text{Ratio} = 0.17475$$

Status: **PASS**
Ratio: **0.170**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(7.25 \text{ ft})}{(48 \text{ in})}$$

$$L/D = 1.8125$$

Since $L/D \leq 10$,

Pile is short.

Considering x-direction:

$H_o = -0.56736 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 6.6131 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (6.6131 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.56736 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (6.6131 \text{ kipft/ft})) + (4 \times (-0.56736 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 5.0104 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (6.6131 \text{ kipft/ft})) + (3 \times (-0.56736 \text{ kip/ft}) \times (7.25 \text{ ft}))]^2}{(7.25 \text{ ft})^2 \times [(3 \times (6.6131 \text{ kipft/ft})) + (2 \times (-0.56736 \text{ kip/ft}) \times (7.25 \text{ ft}))]}$$

$$p = 0.24471 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

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

$$s = \frac{6 \times [(2 \times (6.6131 \text{ kipft/ft})) + ((-0.56736 \text{ kip/ft}) \times (7.25 \text{ ft}))]}{(7.25 \text{ ft})^2}$$

$$s = 1.0402 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(5.0104 \text{ ft})}{2}$$

$$p_a = 0.37578 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.24471 \text{ kip/ft}^2)}{(0.37578 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.6512$$

p_a - Allowable lateral soil pressure at depth L_e ,

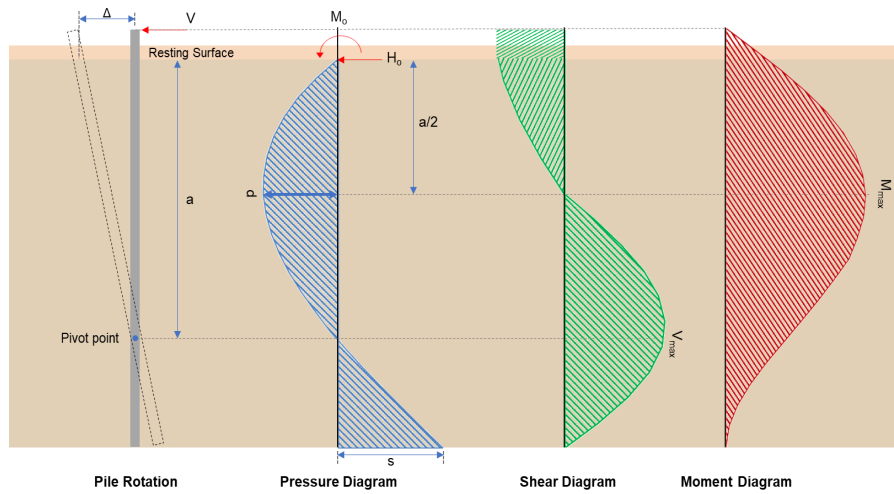
Status: **PASS**
Ratio: **0.650**

	$p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (7.25 \text{ ft})$ $p_s = 1.0875 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $\text{Ratio} = \frac{s}{p_s}$ $\text{Ratio} = \frac{(1.0402 \text{ kip/ft}^2)}{(1.0875 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.95653$	<p>Status: PASS Ratio: 0.960</p>
	<p>Considering z-direction:</p> <p>$H_o = 0.037739 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 0.12166 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.12166 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (0.037739 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (0.12166 \text{ kipft/ft})) + (4 \times (0.037739 \text{ kip/ft}) \times (7.25 \text{ ft}))}$ $a = 5.1958 \text{ ft}$ <p>p - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 [(4 \times (0.12166 \text{ kipft/ft})) + (3 \times (0.037739 \text{ kip/ft}) \times (7.25 \text{ ft}))]^2}{(7.25 \text{ ft})^2 [(3 \times (0.12166 \text{ kipft/ft})) + (2 \times (0.037739 \text{ kip/ft}) \times (7.25 \text{ ft}))]}$ $p = 0.026739 \text{ kip/ft}^2$ <p>s - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 [(2 \times (0.12166 \text{ kipft/ft})) + ((0.037739 \text{ kip/ft}) \times (7.25 \text{ ft}))]}{(7.25 \text{ ft})^2}$ $s = 0.059006 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p>p_a - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(5.1958 \text{ ft})}{2}$ $p_a = 0.38968 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $\text{Ratio} = \frac{p}{p_a}$ $\text{Ratio} = \frac{(0.026739 \text{ kip/ft}^2)}{(0.38968 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.068618$ <p>p_s - Allowable lateral soil pressure at depth L_e,</p> $p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (7.25 \text{ ft})$ $p_s = 1.0875 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $\text{Ratio} = \frac{s}{p_s}$	<p>Status: PASS Ratio: 0.070</p>

$$Ratio = \frac{(0.059006 \text{ kip/ft}^2)}{(1.0875 \text{ kip/ft}^2)}$$

$$Ratio = 0.054259$$

Status: **PASS**
Ratio: **0.050**



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-5.94 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.94586 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(69.955 \text{ kipft}) + ((-5.94 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 11.139 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(11.139 \text{ kipft/ft})}{(-0.94586 \text{ kip/ft})}$$

$$E = 11.777 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (11.139 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.94586 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (11.139 \text{ kipft/ft})) + (4 \times (-0.94586 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 5.0091 \text{ ft}$$

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

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

$$V_{max} = ((-0.94586 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (11.777 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left(\frac{(5.0091 \text{ ft})}{(7.25 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (11.777 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left(\frac{(5.0091 \text{ ft})}{(7.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 13.37 \text{ kip}$$

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

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

$$M_{max} = ((-0.94586 \text{ kip/ft}) \times (48 \text{ in}) \times (7.25 \text{ ft})) \times \left[\left(\frac{(11.777 \text{ ft})}{(7.25 \text{ ft})} + \frac{(5.0091 \text{ ft})}{2 \times (7.25 \text{ ft})} \right) - \left[\left(\frac{4 \times (11.777 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left(\frac{(5.0091 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (11.777 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left(\frac{(5.0091 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 45.978 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.378 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.060191 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(1.165 \text{ kipft}) + ((0.378 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.18551 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.18551 \text{ kipft/ft})}{(0.060191 \text{ kip/ft})}$$

$$E = 3.082 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.18551 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (0.060191 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (0.18551 \text{ kipft/ft})) + (4 \times (0.060191 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 5.2023 \text{ ft}$$

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

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

$$V_{max} = ((0.060191 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (3.082 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left(\frac{(5.2023 \text{ ft})}{(7.25 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (3.082 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left(\frac{(5.2023 \text{ ft})}{(7.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.34192 \text{ kip}$$

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

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

$$M_{max} = ((0.060191 \text{ kip/ft}) \times (48 \text{ in}) \times (7.25 \text{ ft})) \times \left[\left(\frac{(3.082 \text{ ft})}{(7.25 \text{ ft})} + \frac{(5.2023 \text{ ft})}{2 \times (7.25 \text{ ft})} \right) - \left[\left(\frac{4 \times (3.082 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left(\frac{(5.2023 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (3.082 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left(\frac{(5.2023 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 1.0841 \text{ kipft}$$

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,

Table 22.4.2.1

Longitudinal reinforcement:

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

22.4.2.2, 10.6.1.1

$A_{st,required}$

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

$$A_{st,required} = \text{Min} \left[\frac{\frac{(8.061 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (3 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$$

$$A_{st,required} = -102 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = \text{Max} [(-102 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$$

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

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

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

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

$$\text{Ratio} = 0.96556$$

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

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 No. 10: 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)**

Ties: #3(0.375 in) - 10 in

Axial Compression Strength (ACI 318-19, LRFD)

22.4.2.2

ϕP_N - Allowable axial compressive strength

$$\phi P_N = \phi 0.80 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st})]$$

$$\phi P_N = (0.65) \times 0.80 \times [(0.85 \times (3 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2))]$$

$$\phi P_N = 3183.4 \text{ kip}$$

Ratio - Capacity

$$\text{Ratio} = \frac{P}{\phi P_N}$$

$$\text{Ratio} = \frac{(8.061 \text{ kip})}{(3183.4 \text{ kip})}$$

$$\text{Ratio} = 0.0025322$$

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

Shear Strength (ACI 318-19, LRFD)

Parameters:

22.5.2.2

$b_w = 48 \text{ in}$ - 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 $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$, $P = 8.061 \text{ kip} \rightarrow 8061 \text{ lbf}$,
 $V_{c,a}$ - Shear strength of concrete (a)

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + \frac{(8061 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 130.87 \text{ kip}$$

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

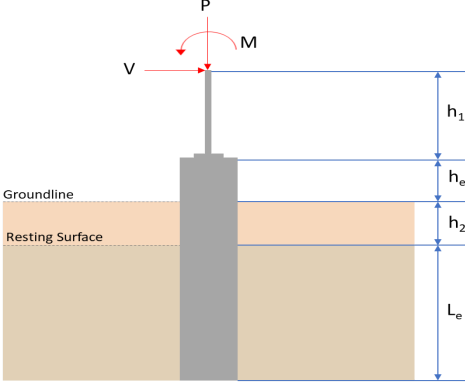
$$V_c = \text{Min}[V_{c,max}, V_{c,a}, V_{c,b}]$$

$$V_c = \text{Min}[(324.49 \text{ kip}), (130.87 \text{ kip}), (406.27 \text{ kip})]$$

$$V_c = 130.87 \text{ kip}$$

<p>22.5.1.2</p>	<p>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)</p> $V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$ $V_{s,a} = 8 \times \sqrt{(3000 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{s,a} = 807.65 \text{ kip}$ <p>A_v - Ties rebar area,</p> $A_v = \frac{\pi d_{ties}^2}{4}$ $A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$ $A_v = 0.11045 \text{ in}^2$ <p>22.5.8.5.3 $V_{s,b}$ - Shear strength of steel (b)</p> $V_{s,b} = \frac{2 A_v f_{yt} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$ <p>V_s - Governing shear strength of steel</p> $V_s = \text{MIN}[V_{s,a}, V_{s,b}]$ $V_s = \text{MIN}[(807.65 \text{ kip}), (50.894 \text{ kip})]$ $V_s = 50.894 \text{ kip}$ <p>22.5.1.1 ϕV_n - Allowable shear strength</p> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((130.87 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 118.15 \text{ kip}$ <p>Considering x-direction:</p> <p>$V_{max} = 13.37 \text{ kip}$ - Maximum shear force in the x-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{V_{max}}{\phi V_n}$ $\text{Ratio} = \frac{(13.37 \text{ kip})}{(118.15 \text{ kip})}$ $\text{Ratio} = 0.11317$ <p>Considering z-direction:</p> <p>$V_{max} = 0.34192 \text{ kip}$ - Maximum shear force in the z-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{V_{max}}{\phi V_n}$ $\text{Ratio} = \frac{(0.34192 \text{ kip})}{(118.15 \text{ kip})}$ $\text{Ratio} = 0.0028941$	<p>Status: PASS Ratio: 0.110</p> <p>Status: PASS Ratio: 0.000</p>
	<p>Flexural Strength (ACI 318-19, LRFD)</p> <p>S_m - 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>14.5.2.1b</p>	<p>$\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$</p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{3\text{ksi}} \times 18432.001\text{in}^3$ $\phi M_{n,1} = 273.423\text{kipft}$ <p>$\phi M_{n,2}$</p> $\phi M_{n,2} = \phi \times 0.85 \times f'_c \times S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (3\text{ksi}) \times (18432\text{in}^3)$ $\phi M_{n,2} = 2545.9\text{kipft}$ <p>Therefore, ϕM_n - Allowable flexural strength,</p> $\phi M_n = \text{MIN}[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = \text{MIN}[(273.42\text{kipft}), (2545.9\text{kipft})]$ $\phi M_n = 273.42\text{kipft}$ <p>Considering x-direction: $M_{max} = 45.978\text{kipft}$ - Maximum moment in the x-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(45.978\text{kipft})}{(273.42\text{kipft})}$ $\text{Ratio} = 0.16816$	<p>Status: PASS Ratio: 0.170</p>
	<p>Considering z-direction: $M_{max} = 1.0841\text{kipft}$ - Maximum moment in the z-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(1.0841\text{kipft})}{(273.42\text{kipft})}$ $\text{Ratio} = 0.003965$	<p>Status: PASS Ratio: 0.000</p>

REFERENCES	CALCULATIONS	RESULTS																										
	<p>SkyCiv Foundation Design Pile Foundation</p> <p>Design Information : Design code : IBC 2021 (International Building Code) Unit System : Imperial</p>																											
	<p>Pile Input</p>  <p>Geometry Pile shape: rectangular $b = 48$ in - Pile width $D = 48$ in - Pile depth $L = 7.25$ ft - Total pile length $h_1 = 0$ ft - Lateral load height from the top of the pile, $h_2 = 0$ ft - Depth to resting surface $h_e = 0$ ft - Length of pile above the ground</p> <p>Tabulation of Soil Parameters</p> <table border="1"> <thead> <tr> <th>Layer</th> <th>Label</th> <th>Allowable Bearing Pressure (q_a) (psf)</th> <th>Allowable Lateral Pressure (R) (psf/ft)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Sand, silty sand, clayey sand, silty gravel & clayey gravel</td> <td>2000.000</td> <td>150.000</td> </tr> </tbody> </table> <p>Tabulation of Loads</p> <table border="1"> <thead> <tr> <th>Load Component</th> <th>ASD</th> <th>LRFD</th> </tr> </thead> <tbody> <tr> <td>P (kip)</td> <td>5.592</td> <td>8.058</td> </tr> <tr> <td>V_x (kip)</td> <td>-3.563</td> <td>-5.938</td> </tr> <tr> <td>V_z (kip)</td> <td>-0.237</td> <td>-0.378</td> </tr> <tr> <td>M_x (kipft)</td> <td>-0.766</td> <td>-1.172</td> </tr> <tr> <td>M_z (kipft)</td> <td>41.530</td> <td>69.943</td> </tr> </tbody> </table> <p>Material Properties $f'_{ck} = 3$ ksi - Concrete strength,</p>	Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) (psf/ft)	1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000	Load Component	ASD	LRFD	P (kip)	5.592	8.058	V_x (kip)	-3.563	-5.938	V_z (kip)	-0.237	-0.378	M_x (kipft)	-0.766	-1.172	M_z (kipft)	41.530	69.943	
Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) (psf/ft)																									
1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000																									
Load Component	ASD	LRFD																										
P (kip)	5.592	8.058																										
V_x (kip)	-3.563	-5.938																										
V_z (kip)	-0.237	-0.378																										
M_x (kipft)	-0.766	-1.172																										
M_z (kipft)	41.530	69.943																										
	<p>Required depth to resist lateral loads (ASD) H - Point of application of the lateral load</p> $H = h_1 + h_2 + h_e$ $H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})$ $H = 0 \text{ ft}$ <p>Considering x-direction: H_o - Lateral force per length of pile,</p> $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-3.563 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.56736 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$																											

$$M_o = \frac{(41.53 \text{ kipft}) + ((-3.563 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 6.6131 \text{ kipft/ft}$$

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:

$L_{e,x} = 6.7012 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.237 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.037739 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.766 \text{ kipft}) + ((-0.237 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.12197 \text{ kipft/ft}$$

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:

$L_{e,z} = 1.7874 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = \text{MAX}[(6.7012 \text{ ft}), (1.7874 \text{ ft})]$$

$$L_{e,req} = 6.701 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (7.25 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$$

$$L_e = 7.25 \text{ ft}$$

Ratio - Embedded depth

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

$$\text{Ratio} = \frac{(6.701 \text{ ft})}{(7.25 \text{ ft})}$$

$$\text{Ratio} = 0.92428$$

Status: **PASS**
Ratio: **0.920**

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

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

$$q = \frac{(5.592 \text{ kip})}{(16 \text{ ft}^2)}$$

$$q = 0.3495 \text{ kip/ft}^2$$

$$q = 0.3495 \text{ kip/ft}$$

Check bearing capacity ratio:

Ratio - Capacity

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

$$Ratio = \frac{(0.3495 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$Ratio = 0.17475$$

Status: **PASS**
Ratio: **0.170**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(7.25 \text{ ft})}{(48 \text{ in})}$$

$$L/D = 1.8125$$

Since $L/D \leq 10$,

Pile is short.

Considering x-direction:

$H_o = -0.56736 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 6.6131 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (6.6131 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.56736 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (6.6131 \text{ kipft/ft})) + (4 \times (-0.56736 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 5.0104 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (6.6131 \text{ kipft/ft})) + (3 \times (-0.56736 \text{ kip/ft}) \times (7.25 \text{ ft}))]^2}{(7.25 \text{ ft})^2 \times [(3 \times (6.6131 \text{ kipft/ft})) + (2 \times (-0.56736 \text{ kip/ft}) \times (7.25 \text{ ft}))]}$$

$$p = 0.24471 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

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

$$s = \frac{6 \times [(2 \times (6.6131 \text{ kipft/ft})) + ((-0.56736 \text{ kip/ft}) \times (7.25 \text{ ft}))]}{(7.25 \text{ ft})^2}$$

$$s = 1.0402 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(5.0104 \text{ ft})}{2}$$

$$p_a = 0.37578 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$Ratio = \frac{(0.24471 \text{ kip/ft}^2)}{(0.37578 \text{ kip/ft}^2)}$$

$$Ratio = 0.6512$$

p_a - Allowable lateral soil pressure at depth L_e ,

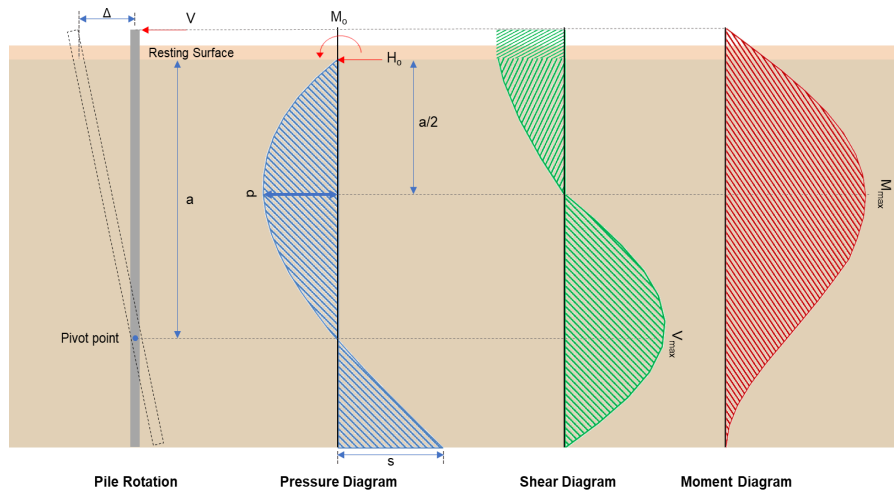
Status: **PASS**
Ratio: **0.650**

	$p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (7.25 \text{ ft})$ $p_s = 1.0875 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $\text{Ratio} = \frac{s}{p_s}$ $\text{Ratio} = \frac{(1.0402 \text{ kip/ft}^2)}{(1.0875 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.95653$	Status: PASS Ratio: 0.960
	<p>Considering z-direction:</p> <p>$H_o = -0.037739 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 0.12197 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.12197 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.037739 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (0.12197 \text{ kipft/ft})) + (4 \times (-0.037739 \text{ kip/ft}) \times (7.25 \text{ ft}))}$ $a = 5.1954 \text{ ft}$ <p>p - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 [(4 \times (0.12197 \text{ kipft/ft})) + (3 \times (-0.037739 \text{ kip/ft}) \times (7.25 \text{ ft}))]^2}{(7.25 \text{ ft})^2 [(3 \times (0.12197 \text{ kipft/ft})) + (2 \times (-0.037739 \text{ kip/ft}) \times (7.25 \text{ ft}))]}$ $p = -0.0087236 \text{ kip/ft}^2$ <p>s - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 [(2 \times (0.12197 \text{ kipft/ft})) + ((-0.037739 \text{ kip/ft}) \times (7.25 \text{ ft}))]}{(7.25 \text{ ft})^2}$ $s = -0.0033854 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p>p_a - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(5.1954 \text{ ft})}{2}$ $p_a = 0.38965 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $\text{Ratio} = \frac{p}{p_a}$ $\text{Ratio} = \frac{(-0.0087236 \text{ kip/ft}^2)}{(0.38965 \text{ kip/ft}^2)}$ $\text{Ratio} = -0.022388$ <p>p_s - Allowable lateral soil pressure at depth L_e,</p> $p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (7.25 \text{ ft})$ $p_s = 1.0875 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $\text{Ratio} = \frac{s}{p_s}$	Status: PASS Ratio: -0.020

$$Ratio = \frac{(-0.0033854 \text{ kip/ft}^2)}{(1.0875 \text{ kip/ft}^2)}$$

$$Ratio = -0.003113$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-5.938 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.94554 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(69.943 \text{ kipft}) + ((-5.938 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 11.137 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(11.137 \text{ kipft/ft})}{(-0.94554 \text{ kip/ft})}$$

$$E = 11.779 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (11.137 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.94554 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (11.137 \text{ kipft/ft})) + (4 \times (-0.94554 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 5.0091 \text{ ft}$$

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

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

$$V_{max} = ((-0.94554 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (11.779 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left(\frac{(5.0091 \text{ ft})}{(7.25 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (11.779 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left(\frac{(5.0091 \text{ ft})}{(7.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 13.367 \text{ kip}$$

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

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

$$M_{max} = ((-0.94554 \text{ kip/ft}) \times (48 \text{ in}) \times (7.25 \text{ ft})) \times \left[\left(\frac{(11.779 \text{ ft})}{(7.25 \text{ ft})} + \frac{(5.0091 \text{ ft})}{2 \times (7.25 \text{ ft})} \right) - \left[\left(\frac{4 \times (11.779 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left(\frac{(5.0091 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (11.779 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left(\frac{(5.0091 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 45.969 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.378 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.060191 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(1.172 \text{ kipft}) + ((-0.378 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.18662 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.18662 \text{ kipft/ft})}{(-0.060191 \text{ kip/ft})}$$

$$E = 3.1005 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.18662 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.060191 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (0.18662 \text{ kipft/ft})) + (4 \times (-0.060191 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 5.2014 \text{ ft}$$

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

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

$$V_{max} = ((-0.060191 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (3.1005 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left(\frac{(5.2014 \text{ ft})}{(7.25 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (3.1005 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left(\frac{(5.2014 \text{ ft})}{(7.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.343 \text{ kip}$$

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

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

$$M_{max} = ((-0.060191 \text{ kip/ft}) \times (48 \text{ in}) \times (7.25 \text{ ft})) \times \left[\left(\frac{(3.1005 \text{ ft})}{(7.25 \text{ ft})} + \frac{(5.2014 \text{ ft})}{2 \times (7.25 \text{ ft})} \right) - \left[\left(\frac{4 \times (3.1005 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left(\frac{(5.2014 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (3.1005 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left(\frac{(5.2014 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 1.088 \text{ kipft}$$

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,

Table 22.4.2.1

Longitudinal reinforcement:

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

22.4.2.2, 10.6.1.1

$A_{st,required}$

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

$$A_{st,required} = \text{Min} \left[\frac{\frac{(8.058 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (3 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$$

$$A_{st,required} = -102 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = \text{Max} [(-102 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$$

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

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

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

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

$$\text{Ratio} = 0.96556$$

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

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 No. 10: 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)**

Ties: #3(0.375 in) - 10 in

Axial Compression Strength (ACI 318-19, LRFD)

22.4.2.2

ϕP_N - Allowable axial compressive strength

$$\phi P_N = \phi 0.80 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st})]$$

$$\phi P_N = (0.65) \times 0.80 \times [(0.85 \times (3 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2))]$$

$$\phi P_N = 3183.4 \text{ kip}$$

Ratio - Capacity

$$\text{Ratio} = \frac{P}{\phi P_N}$$

$$\text{Ratio} = \frac{(8.058 \text{ kip})}{(3183.4 \text{ kip})}$$

$$\text{Ratio} = 0.0025312$$

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

Shear Strength (ACI 318-19, LRFD)

Parameters:

22.5.2.2

$b_w = 48 \text{ in}$ - 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 $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$, $P = 8.058 \text{ kip} \rightarrow 8058 \text{ lbf}$,
 $V_{c,a}$ - Shear strength of concrete (a)

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + \frac{(8058 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 130.87 \text{ kip}$$

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

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

$$V_c = \text{Min}[(324.49 \text{ kip}), (130.87 \text{ kip}), (406.27 \text{ kip})]$$

$$V_c = 130.87 \text{ kip}$$

<p>22.5.1.2</p>	<p>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)</p> $V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$ $V_{s,a} = 8 \times \sqrt{(3000 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{s,a} = 807.65 \text{ kip}$ <p>A_v - Ties rebar area,</p> $A_v = \frac{\pi d_{ties}^2}{4}$ $A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$ $A_v = 0.11045 \text{ in}^2$ <p>22.5.8.5.3 $V_{s,b}$ - Shear strength of steel (b)</p> $V_{s,b} = \frac{2 A_v f_{yt} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$ <p>V_s - Governing shear strength of steel</p> $V_s = \text{MIN}[V_{s,a}, V_{s,b}]$ $V_s = \text{MIN}[(807.65 \text{ kip}), (50.894 \text{ kip})]$ $V_s = 50.894 \text{ kip}$ <p>22.5.1.1 ϕV_n - Allowable shear strength</p> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((130.87 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 118.15 \text{ kip}$ <p>Considering x-direction:</p> <p>$V_{max} = 13.367 \text{ kip}$ - Maximum shear force in the x-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{V_{max}}{\phi V_n}$ $\text{Ratio} = \frac{(13.367 \text{ kip})}{(118.15 \text{ kip})}$ $\text{Ratio} = 0.11314$ <p>Considering z-direction:</p> <p>$V_{max} = 0.343 \text{ kip}$ - Maximum shear force in the z-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{V_{max}}{\phi V_n}$ $\text{Ratio} = \frac{(0.343 \text{ kip})}{(118.15 \text{ kip})}$ $\text{Ratio} = 0.0029032$	<p>Status: PASS Ratio: 0.110</p> <p>Status: PASS Ratio: 0.000</p>
	<p>Flexural Strength (ACI 318-19, LRFD)</p> <p>S_m - 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>14.5.2.1b</p>	<p>$\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$</p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{3\text{ksi}} \times 18432.001\text{in}^3$ $\phi M_{n,1} = 273.423\text{kipft}$ <p>$\phi M_{n,2}$</p> $\phi M_{n,2} = \phi \times 0.85 \times f'_c \times S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (3\text{ksi}) \times (18432\text{in}^3)$ $\phi M_{n,2} = 2545.9\text{kipft}$ <p>Therefore, ϕM_n - Allowable flexural strength,</p> $\phi M_n = \text{MIN}[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = \text{MIN}[(273.42\text{kipft}), (2545.9\text{kipft})]$ $\phi M_n = 273.42\text{kipft}$ <p>Considering x-direction: $M_{max} = 45.969\text{kipft}$ - Maximum moment in the x-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(45.969\text{kipft})}{(273.42\text{kipft})}$ $\text{Ratio} = 0.16812$	<p>Status: PASS Ratio: 0.170</p>
	<p>Considering z-direction: $M_{max} = 1.088\text{kipft}$ - Maximum moment in the z-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(1.088\text{kipft})}{(273.42\text{kipft})}$ $\text{Ratio} = 0.0039792$	<p>Status: PASS Ratio: 0.000</p>