Your Project Calculations

Project Name: 201 FOX STAGE 1_rev.cu.b

S3D Model Link:
https://platform.skyciv.com/structural?preload_name=201%20FOX%20STAGE%201_rev.cu.b&preload_path=Shared%20Enterprise%20Folder/MT_Solar_Projects/3_2023

Public Model Link:
https://platform.skyciv.com/structural-viewer?project_id=dTenQPrraVZ2ka3QA0UeIb2KCjdaOleAz3KuAEp1DcnQpd03mtvY78NXHzTNRtpJ

Array Specification

Product:	Beam
Unique ID:	2P-15-8TOP-XD-45-L-5Hx5W-EJ9H
Duty Classification:	XD
Module Width:	40.00 in
Module Length:	71.70in
Number of Rows:	5
Number of Columns:	5
Total Number of Modules:	25
Desired Tilt Angle:	35
Front Edge Clearance:	8
Total Array Height at Tilt:	17.62 ft
Total Frame Length:	30.00 ft
Frame Weight:	1998 lbs
Array Dimensions N/S:	16.88 ft
Array Dimensions E/W:	30.29 ft
Rail Length:	202.50 in
Rail Spacing:	2.99 ft
Rail Check:	Not Checked

Support Specifications

Pole Size:	8in Pipe Sch 40
Pole Length above Grade:	12.84 ft
Number of Poles:	2
Pole Spacing:	15 ft

Foundation Specifications

Foundation Type:	Square
Foundation Dimensions:	48 x 48 in
Foundation Depth (below grade):	Pile 1: 6.25 ft Pile 2: 6.25 ft
Foundation Volume:	7.407 y^3
Foundation Result:	PASSED

Site Info

Risk Category:	I
Exposure:	B
Soil Classification:	sand
Site Location:	201 Fox St, Madawaska, ME 04756, USA
Wind Speed:	95 mph
Snow Load:	100 psf
Design Uplift Pressure:	Multiple pressures
Design Downforce Pressure:	Multiple pressures
Design Snow Pressure:	0.031527 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":"201 FOX STAGE 1_rev.cu.b","site_address":"201 Fox St, Madawaska, ME 04756, USA","module_width":40,"module_length":71.7,"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":35,"ground_clearance":8,"risk_category":"I","exposure_category":"B","frame_duty_override":"auto","pole_override":"auto","soil_type":"sand","foundation_type":"Square","foundation_size":48,"check_rails":false}
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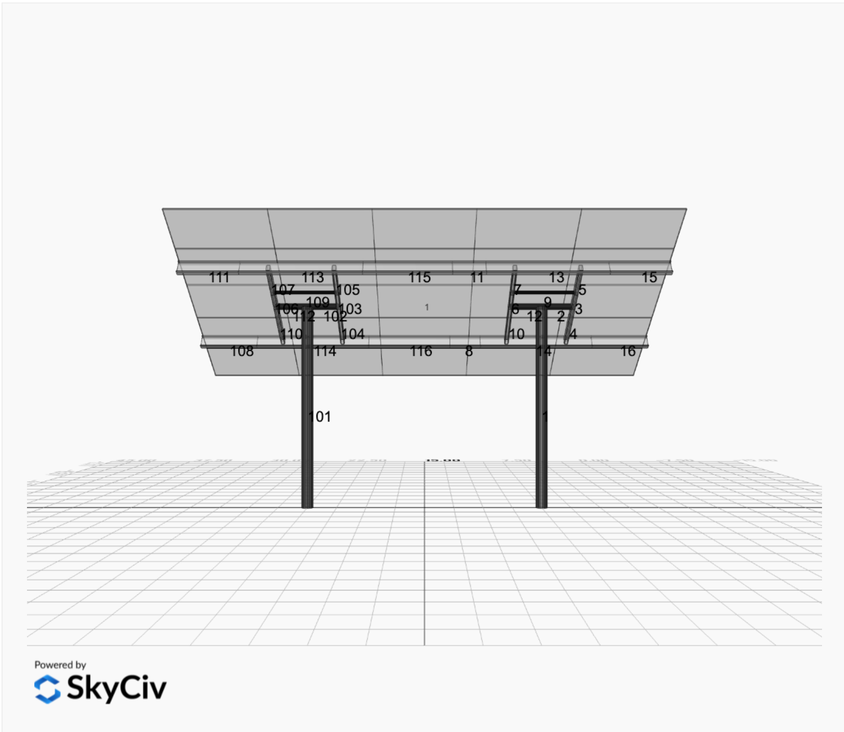
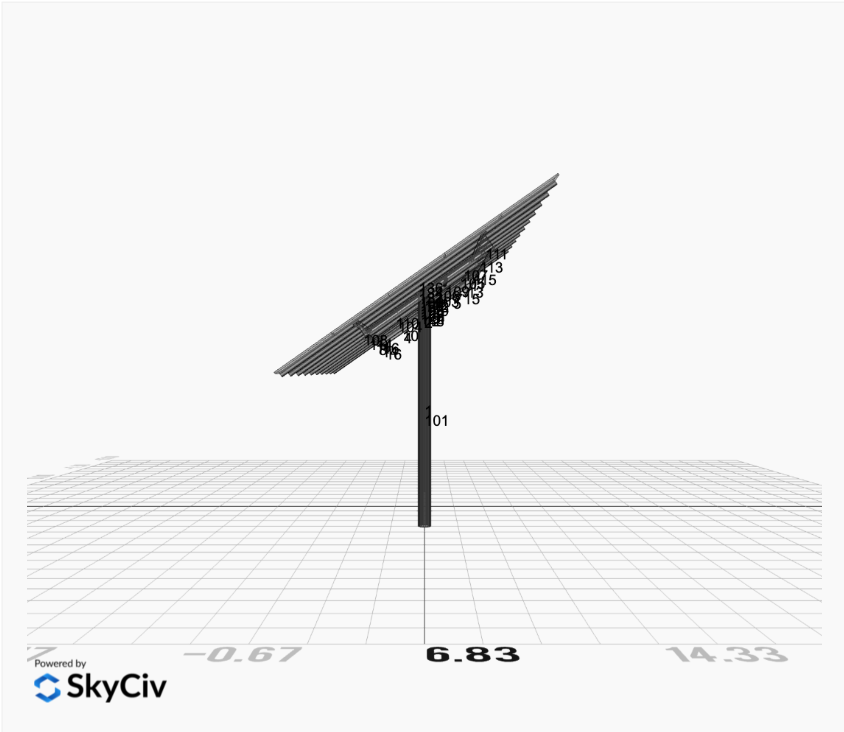
Design Notes:

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

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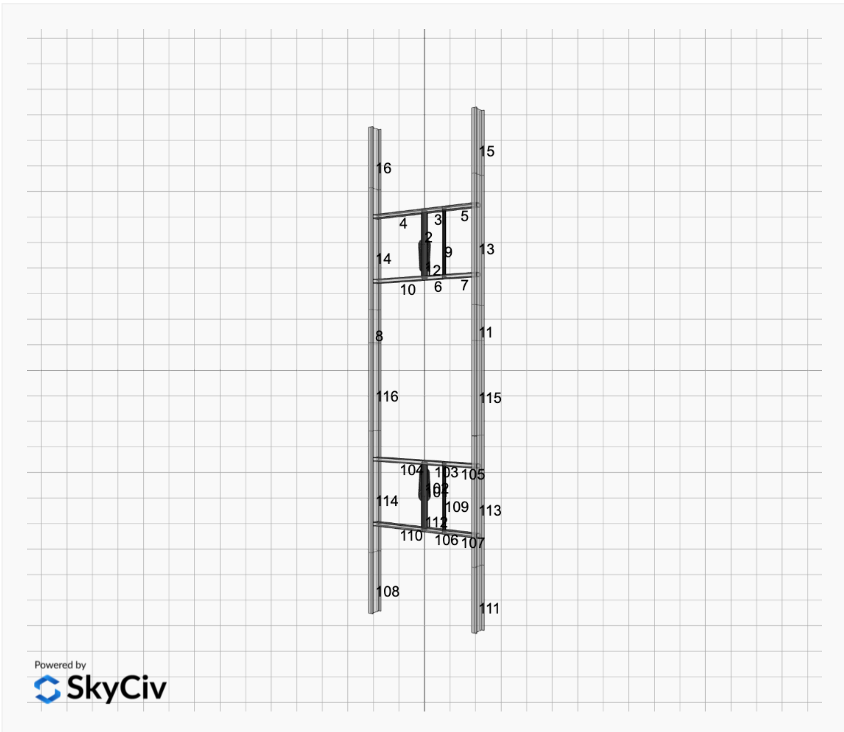
Powered by SkyCiv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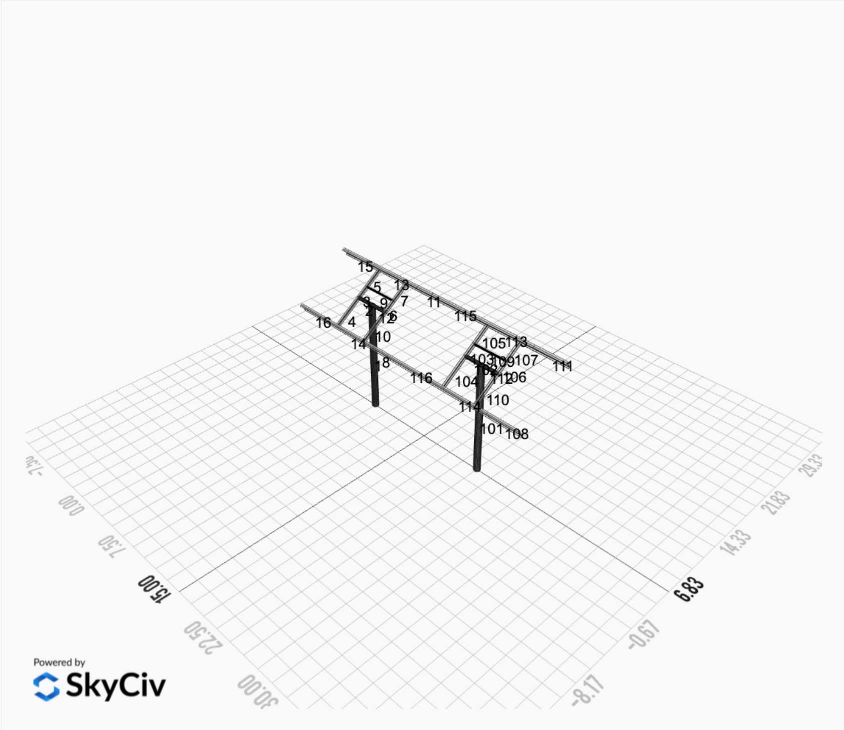
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14
10
18
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105
113
107
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110
101
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22.50
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29.33
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14.33
6.83
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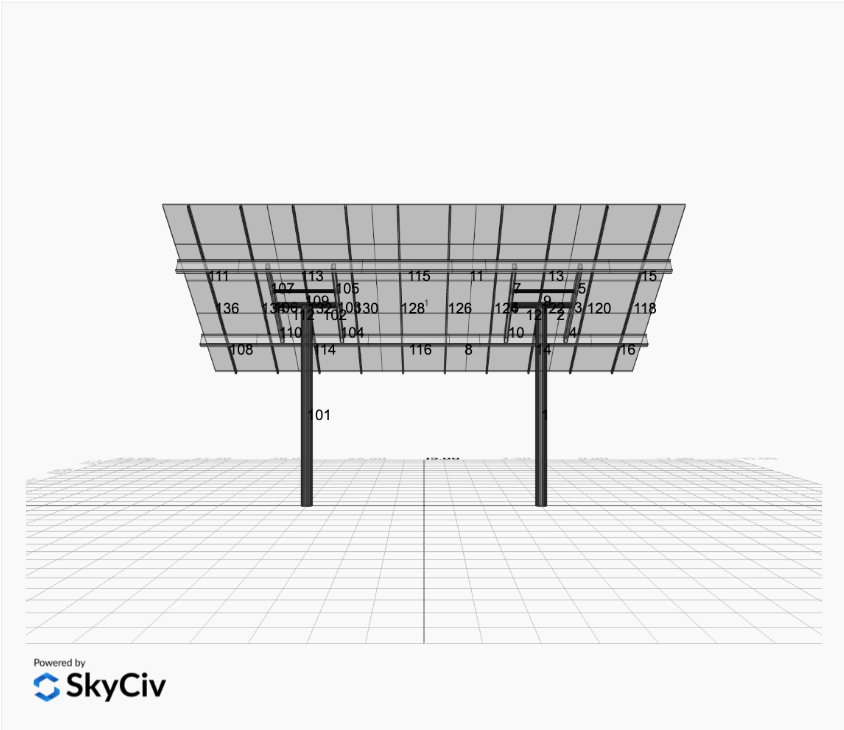
-8.17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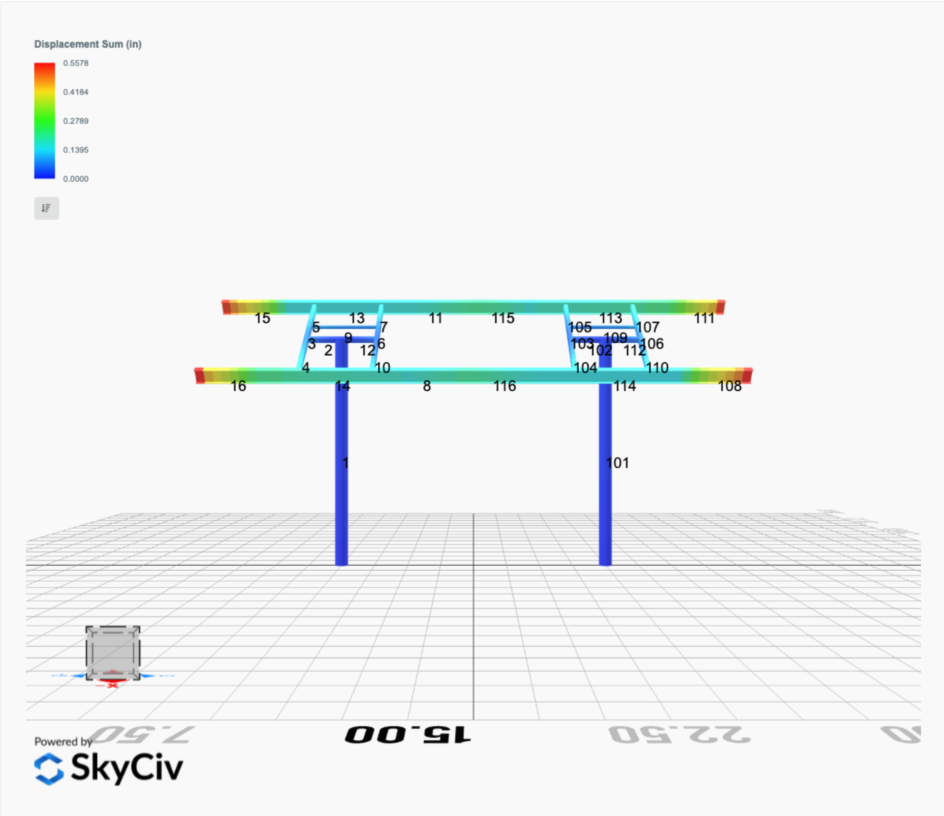
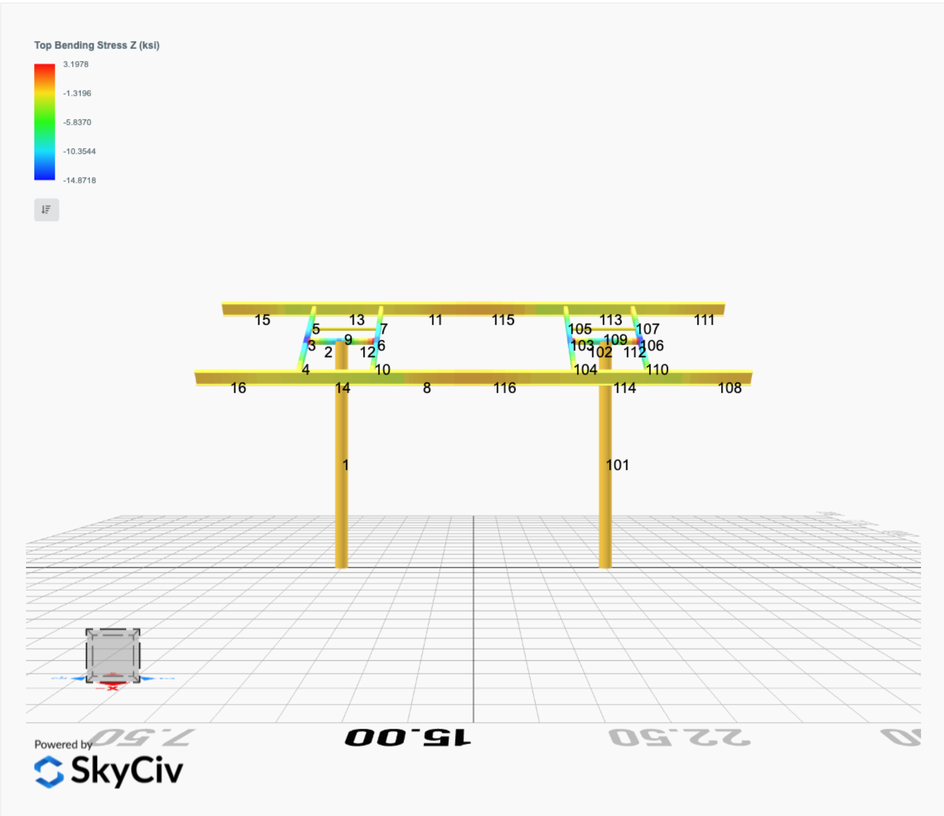
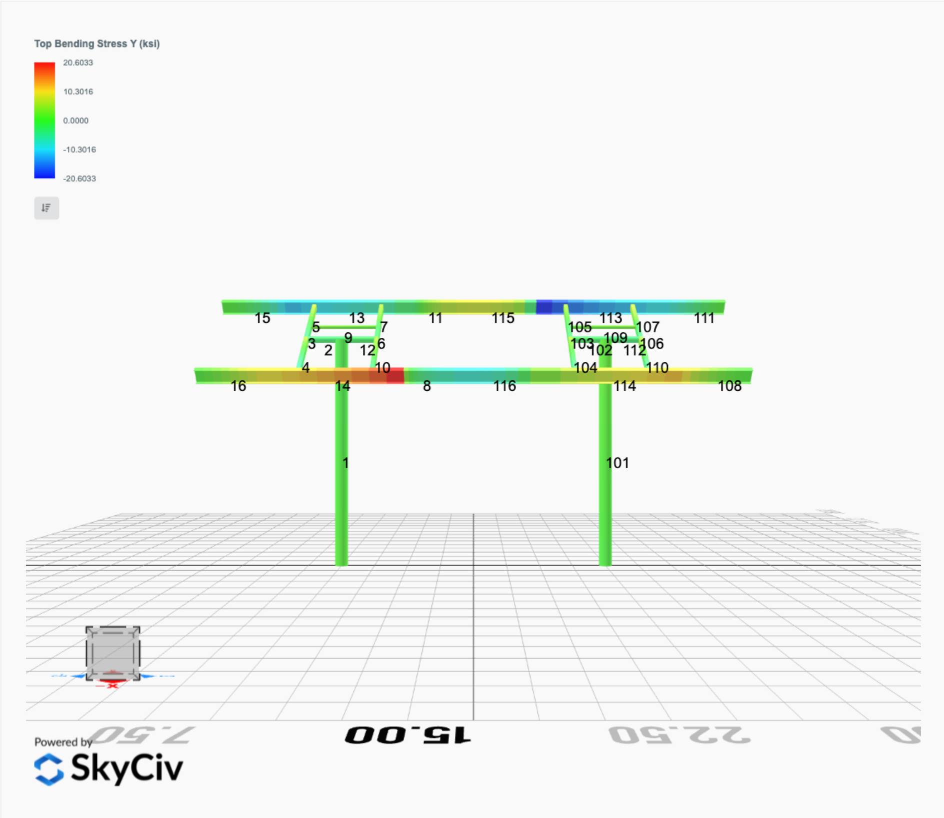
114
116
8
16
101

FEM Results (Envelope Worst Case for each member)






Top Bending Stress Y (ksi)
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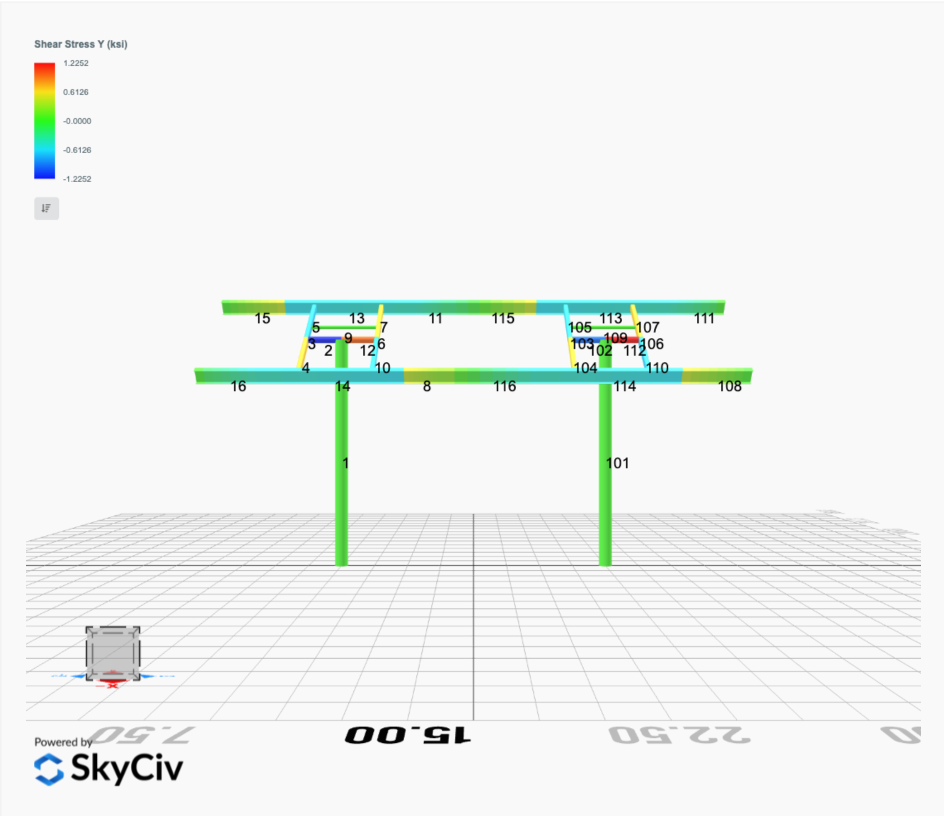
10.3016
0.0000
-10.3016
-20.6033
15
13
11
115
113
111
5
7
105
107
3
9
6
103
109
106
2
12
102
112
4
10
104
110
16
14
8
116
114
108
1
101
15.00
22.50
7.50
Powered by
SkyCiv


Shear Stress Y (ksi)
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0.6126
-0.0000
-0.6126
-1.2252
15
13
11
115
113
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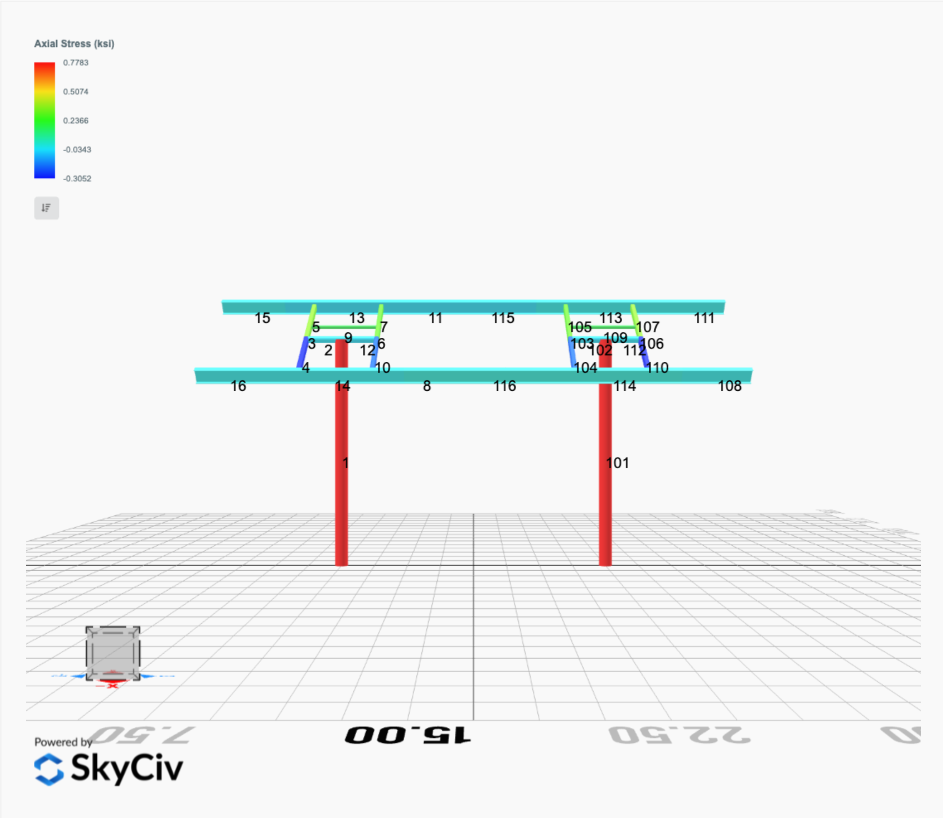
5
7
105
107
3
9
6
103
109
106
2
12
102
112
4
10
104
110
16
14
8
116
114
108
1
101
15.00
22.50
7.50
Powered by
SkyCiv


Axial Stress (ksi)
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0.2366
-0.0343
-0.3052
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13
11
115
113
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7
105
107
9
109
3
2
12
6
103
102
112
106
4
10
104
110
16
14
8
116
114
108
1
101
7.50
15.00
22.50
Powered by
SkyCiv

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

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	0.0000	2.1713	-0.0225	-0.0890	0.0453	0.0280
ULS: 2. D + L	0.0000	2.1713	-0.0225	-0.0890	0.0453	0.0280
ULS: 3. D + (S or Lr or R)	-0.0000	8.7084	-0.1178	-0.4665	0.2367	0.0707
ULS: 3. D + (S or Lr or R)	0.0000	2.1713	-0.0225	-0.0890	0.0453	0.0280
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0000	7.0741	-0.0940	-0.3722	0.1888	0.0600
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	2.1713	-0.0225	-0.0890	0.0453	0.0280
ULS: 5b. D + 0.7E	0.0000	2.1713	-0.0225	-0.0890	0.0453	0.0280
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0000	7.0741	-0.0940	-0.3722	0.1888	0.0600
ULS: 8. 0.6D + 0.7E	0.0000	1.3028	-0.0135	-0.0534	0.0272	0.0168
ULS: 5a. D + 0.6W_Wind downforce Case A only	-1.7614	4.6868	-0.0728	-0.2855	0.1818	23.1910
ULS: 5a. D + 0.6W_Wind downforce Case B only	-1.7614	4.6868	-0.0728	-0.2855	0.1818	23.1910
ULS: 5a. D + 0.6W_Wind uplift Case A only	1.4861	0.0489	0.0199	0.0762	-0.0699	-18.8032
ULS: 5a. D + 0.6W_Wind uplift Case B only	1.2384	0.4026	0.0131	0.0497	-0.0513	-20.6543
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.3210	8.9607	-0.1318	-0.5196	0.2912	17.4323
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.3210	8.9607	-0.1318	-0.5196	0.2912	17.4323
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.1146	5.4823	-0.0622	-0.2483	0.1024	-14.0634
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.9288	5.7476	-0.0673	-0.2681	0.1163	-15.4517
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.3210	4.0579	-0.0602	-0.2364	0.1477	17.4003
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.3210	4.0579	-0.0602	-0.2364	0.1477	17.4003
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.1146	0.5795	0.0093	0.0349	-0.0411	-14.0954
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.9288	0.8448	0.0042	0.0150	-0.0272	-15.4838
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-1.7614	3.8183	-0.0638	-0.2499	0.1637	23.1798
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-1.7614	3.8183	-0.0638	-0.2499	0.1637	23.1798
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	1.4861	-0.8196	0.0289	0.1118	-0.0880	-18.8145
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	1.2384	-0.4659	0.0221	0.0853	-0.0695	-20.6656

Worst Case Reactions LRFD

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

Result	Value
Axial	15.1611
Shear X	-2.9356
Shear Z	-0.2218
Moment X	-0.8788
Moment Z	39.6004

Worst Case Reactions ASD

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

Result	Value
Axial	8.9607
Shear X	-1.7614
Shear Z	-0.1318
Moment X	-0.5196
Moment Z	23.1910

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	2.1713	0.0225	0.0890	-0.0453	0.0280
ULS: 2. D + L	-0.0000	2.1713	0.0225	0.0890	-0.0453	0.0280
ULS: 3. D + (S or Lr or R)	0.0000	8.7084	0.1178	0.4666	-0.2367	0.0707
ULS: 3. D + (S or Lr or R)	-0.0000	2.1713	0.0225	0.0890	-0.0453	0.0280
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	7.0741	0.0940	0.3722	-0.1888	0.0600
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0000	2.1713	0.0225	0.0890	-0.0453	0.0280
ULS: 5b. D + 0.7E	-0.0000	2.1713	0.0225	0.0890	-0.0453	0.0280
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0000	7.0741	0.0940	0.3722	-0.1888	0.0600

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 8. 0.6D + 0.7E	-0.0000	1.3028	0.0135	0.0534	-0.0272	0.0168
ULS: 5a. D + 0.6W_Wind downforce Case A only	-1.7614	4.6868	0.0728	0.2855	-0.1818	23.1910
ULS: 5a. D + 0.6W_Wind downforce Case B only	-1.7614	4.6868	0.0728	0.2855	-0.1818	23.1910
ULS: 5a. D + 0.6W_Wind uplift Case A only	1.4861	0.0489	-0.0199	-0.0762	0.0699	-18.8032
ULS: 5a. D + 0.6W_Wind uplift Case B only	1.2384	0.4026	-0.0131	-0.0497	0.0513	-20.6543
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.3210	8.9607	0.1318	0.5196	-0.2912	17.4323
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.3210	8.9607	0.1318	0.5196	-0.2912	17.4323
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.1146	5.4823	0.0622	0.2483	-0.1024	-14.0634
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.9288	5.7476	0.0673	0.2682	-0.1163	-15.4517
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.3210	4.0579	0.0602	0.2364	-0.1477	17.4003
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.3210	4.0579	0.0602	0.2364	-0.1477	17.4003
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.1146	0.5795	-0.0093	-0.0349	0.0411	-14.0954
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.9288	0.8448	-0.0042	-0.0150	0.0272	-15.4838
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-1.7614	3.8183	0.0638	0.2499	-0.1637	23.1798
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-1.7614	3.8183	0.0638	0.2499	-0.1637	23.1798
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	1.4861	-0.8196	-0.0289	-0.1118	0.0880	-18.8145
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	1.2384	-0.4659	-0.0221	-0.0853	0.0695	-20.6656

Worst Case Reactions LRFD

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

Result	Value
Axial	15.1611
Shear X	-2.9356
Shear Z	0.2218
Moment X	0.8790
Moment Z	39.6010

Worst Case Reactions ASD

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

Result	Value
Axial	8.9607
Shear X	-1.7614
Shear Z	0.1318
Moment X	0.5196
Moment Z	23.1910

Project Details

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

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

Design Input Information

Design Factors			
Φ_t	Φ_c	Φ_b	Φ_v
0.9	0.9	0.9	0.9

Design Materials			
ID	E (ksi)	F_y (ksi)	F_u (ksi)
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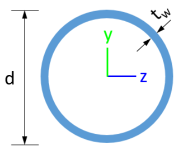
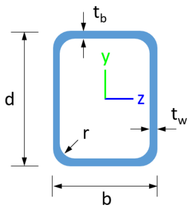
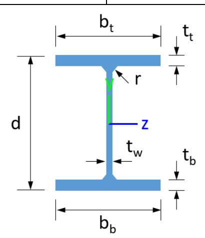
Section Dimensions



ID	Name	d (in)	t_w (in)					
3	2in Pipe Sch 120	2.38	0.25					
6	4in Pipe Sch 120	4.50	0.44					
9	8in Pipe Sch 40	8.63	0.32					



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



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

Section Properties								
ID	Name	A (in^2)	J (in^4)	I_{yp} (in^4)	I_{zp} (in^4)	I_w (in^6)	S_{yp} (in^3)	S_{zp} (in^3)
3	2in Pipe Sch 120	1.67	1.91	0.96	0.96	0.00	1.13	1.13
6	4in Pipe Sch 120	5.58	23.29	11.64	11.64	0.00	7.24	7.24
9	8in Pipe Sch 40	8.40	144.98	72.49	72.49	0.00	22.21	22.21

17	HSS5x3x1/4	3.37	11.00	4.81	10.70	62.42	3.77	5.38
20	W10x12	3.54	0.05	2.18	53.80	50.90	1.74	12.60

Member Properties								
Member ID	Section ID	K_zL (ft)	K_yL (ft)	L_b(ft)	C_b	LST	LSC	LD
1	9	26.96	26.96	12.84	-	300	200	1
2	6	2.00	2.00	2.00	-	300	200	1
3	17	1.42	1.42	1.42	1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.18,1.00,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.15,1.17,1.18,1.18,1.18,1.18	300	200	1
4	17	3.75	3.75	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.32,1.68,1.67,1.67,1.65,1.97,1.67,1.67,1.67,1.67,1.68,1.68,1.60,1.71,1.67,1.67,1.66,1.56	300	200	1
5	17	2.33	2.33	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.49,1.65,1.67,1.67,1.66,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.63,1.65,1.67,1.67,1.66,1.66	300	200	1
6	17	1.42	1.42	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.01,1.16,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.14,1.16,1.18,1.18,1.17,1.17	300	200	1
7	17	2.33	2.33	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.48,1.65,1.67,1.67,1.66,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.62,1.65,1.67,1.67,1.66,1.66	300	200	1
8	20	2.05	2.05	2.05	2.18,2.18,2.18,2.17,2.18,2.18,2.15,2.15,1.54,2.31,2.14,2.14,2.12,1.49,2.16,2.16,2.19,2.20,2.15,2.15,2.04,2.33,2.14,2.14,2.12,1.49	300	200	1
9	3	4.00	4.00	4.00	-	300	200	1
10	17	3.75	3.75	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.32,1.68,1.67,1.67,1.65,1.84,1.67,1.67,1.67,1.67,1.68,1.68,1.60,1.71,1.67,1.67,1.66,1.44	300	200	1
11	20	2.05	2.05	2.05	2.20,2.19,2.20,2.19,2.20,2.20,2.17,2.17,1.55,2.25,2.17,2.17,2.13,2.22,2.18,2.18,2.20,2.19,2.17,2.17,2.06,2.23,2.17,2.17,2.14,2.21	300	200	1
12	6	2.00	2.00	2.00	-	300	200	1
13	20	1.75	1.75	1.75	1.37,1.37,1.37,1.37,1.37,1.37,1.37,1.37,1.29,1.38,1.37,1.37,1.37,1.38,1.37,1.37,1.37,1.37,1.37,1.37,1.36,1.38,1.37,1.37,1.37,1.38	300	200	1
14	20	1.75	1.75	1.75	1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30	300	200	1
15	20	3.75	3.75	3.75	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	1
16	20	3.75	3.75	3.75	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	1
17	20	4.00	4.00	4.00	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.11,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	1
18	20	1.75	1.75	1.75	1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30	300	200	1
19	20	4.00	4.00	4.00	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.13,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	1
20	20	1.75	1.75	1.75	1.37,1.37,1.37,1.37,1.37,1.37,1.37,1.37,1.29,1.38,1.37,1.37,1.37,1.77,1.37,1.37,1.37,1.37,1.37,1.37,1.36,1.39,1.37,1.37,1.37,1.28	300	200	1
21	20	4.00	4.00	4.00	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.12,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	1
22	20	1.75	1.75	1.75	1.37,1.37,1.37,1.37,1.37,1.37,1.37,1.37,1.29,1.38,1.37,1.37,1.37,1.38,1.37,1.37,1.37,1.37,1.37,1.37,1.36,1.38,1.37,1.37,1.37,1.38	300	200	1
23	20	4.00	4.00	4.00	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.12,1.14,1.14,1.14,1.14,1.15,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	1

24	20	1.75	1.75	1.75	1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30	300	200	1
101	9	26.96	26.96	12.84	-	300	200	1
102	6	2.00	2.00	2.00	-	300	200	1
103	17	1.42	1.42	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.01,1.16,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.14,1.16,1.18,1.18,1.17,1.17	300	200	1
104	17	3.75	3.75	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.32,1.68,1.67,1.67,1.65,1.84,1.67,1.67,1.67,1.67,1.68,1.68,1.60,1.71,1.67,1.67,1.66,1.44	300	200	1
105	17	2.33	2.33	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.48,1.65,1.67,1.67,1.66,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.62,1.65,1.67,1.67,1.66,1.66	300	200	1
106	17	1.42	1.42	1.42	1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.18,1.00,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.15,1.17,1.18,1.18,1.18,1.18	300	200	1
107	17	2.33	2.33	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.49,1.65,1.67,1.67,1.66,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.63,1.65,1.67,1.67,1.66,1.66	300	200	1
108	20	3.75	3.75	3.75	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	1
109	3	4.00	4.00	4.00	-	300	200	1
110	17	3.75	3.75	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.32,1.68,1.67,1.67,1.65,1.97,1.67,1.67,1.67,1.67,1.68,1.68,1.60,1.71,1.67,1.67,1.66,1.56	300	200	1
111	20	3.75	3.75	3.75	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	1
112	6	2.00	2.00	2.00	-	300	200	1
113	20	1.75	1.75	1.75	1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30	300	200	1
114	20	1.75	1.75	1.75	1.37,1.37,1.37,1.37,1.37,1.37,1.37,1.37,1.29,1.38,1.37,1.37,1.37,1.75,1.37,1.37,1.37,1.37,1.37,1.37,1.36,1.39,1.37,1.37,1.37,1.28	300	200	1
115	20	5.45	5.45	5.45	2.18,2.18,2.18,2.19,2.18,2.18,2.21,2.21,2.88,2.13,2.21,2.21,2.25,2.16,2.19,2.19,2.17,2.19,2.21,2.21,2.34,2.15,2.22,2.22,2.24,2.16	300	200	1
116	20	5.45	5.45	5.45	2.19,2.20,2.19,2.21,2.20,2.19,2.23,2.23,2.82,2.05,2.24,2.24,2.27,1.14,2.22,2.22,2.19,2.18,2.23,2.23,2.37,1.95,2.24,2.24,2.26,2.55	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	377.97	155.69	83.29	83.29	113.39	113.39
2	251.01	246.00	27.16	27.16	75.30	75.30
3	151.65	149.42	20.17	14.14	54.12	28.95
4	151.65	136.71	20.17	14.14	54.12	28.95
5	151.65	145.68	20.17	14.14	54.12	28.95
6	151.65	149.42	20.17	14.14	54.12	28.95
7	151.65	145.68	20.17	14.14	54.12	28.95
8	159.30	137.63	46.90	6.46	56.26	44.91
9	75.10	55.95	4.25	4.25	22.53	22.53
10	151.65	136.71	20.17	14.14	54.12	28.95
11	159.30	137.63	46.90	6.46	56.26	44.91
12	251.01	246.00	27.16	27.16	75.30	75.30
13	159.30	139.89	46.90	6.46	56.26	44.91
14	159.30	139.89	46.90	6.46	56.26	44.91

15	159.30	119.60	46.90	6.46	56.26	44.91
16	159.30	119.60	46.90	6.46	56.26	44.91
17	159.30	116.35	46.90	6.46	56.26	44.91
18	159.30	139.89	46.90	6.46	56.26	44.91
19	159.30	116.35	46.90	6.46	56.26	44.91
20	159.30	139.89	46.90	6.46	56.26	44.91
21	159.30	116.35	46.90	6.46	56.26	44.91
22	159.30	139.89	46.90	6.46	56.26	44.91
23	159.30	116.35	46.90	6.46	56.26	44.91
24	159.30	139.89	46.90	6.46	56.26	44.91
101	377.97	155.69	83.29	83.29	113.39	113.39
102	251.01	246.00	27.16	27.16	75.30	75.30
103	151.65	149.42	20.17	14.14	54.12	28.95
104	151.65	136.71	20.17	14.14	54.12	28.95
105	151.65	145.68	20.17	14.14	54.12	28.95
106	151.65	149.42	20.17	14.14	54.12	28.95
107	151.65	145.68	20.17	14.14	54.12	28.95
108	159.30	119.60	46.90	6.46	56.26	44.91
109	75.10	55.95	4.25	4.25	22.53	22.53
110	151.65	136.71	20.17	14.14	54.12	28.95
111	159.30	119.60	46.90	6.46	56.26	44.91
112	251.01	246.00	27.16	27.16	75.30	75.30
113	159.30	139.89	46.90	6.46	56.26	44.91
114	159.30	139.89	46.90	6.46	56.26	44.91
115	159.30	95.70	46.90	6.46	56.26	44.91
116	159.30	95.70	43.09	6.46	56.26	44.91

Design Ratio

Member ID	P	M_z	M_y	V_y	V_z	(P,M_z,M_y)	Worst LC	KL/r	δ	Status
1	0.097	0.475	0.024	0.026	0.002	0.515	#13	0.551	Not Required	Pass
2	0.002	0.469	0.127	0.104	0.020	0.585	#21	0.083	Not Required	Pass
3	0.013	0.631	0.101	0.063	0.026	0.738	#21	0.071	Not Required	Pass
4	0.013	0.622	0.179	0.062	0.039	0.741	#21	0.126	Not Required	Pass
5	0.013	0.391	0.187	0.062	0.046	0.430	#21	0.117	Not Required	Pass
6	0.011	0.567	0.071	0.056	0.014	0.643	#21	0.071	Not Required	Pass
7	0.011	0.352	0.129	0.056	0.034	0.390	#21	0.117	Not Required	Pass
8	0.001	0.043	0.148	0.028	0.020	0.155	#21	0.157	Not Required	Pass
9	0.010	0.051	0.060	0.001	0.001	0.116	#21	0.317	Not Required	Pass
10	0.011	0.558	0.136	0.056	0.033	0.679	#21	0.126	Not Required	Pass
11	0.002	0.043	0.147	0.028	0.020	0.156	#21	0.104	Not Required	Pass
12	0.002	0.397	0.113	0.092	0.019	0.495	#21	0.055	Not Required	Pass
13	0.002	0.116	0.350	0.041	0.029	0.467	#21	0.089	Not Required	Pass
14	0.000	0.135	0.551	0.041	0.029	0.686	#21	Not Required	Not Required	Pass
15	0.000	0.063	0.256	0.028	0.020	0.319	#21	Not Required	Not Required	Pass
16	0.000	0.063	0.256	0.028	0.020	0.319	#21	Not Required	Not Required	Pass
17	0.008	0.146	0.141	0.018	0.013	0.291	#21	0.204	Not Required	Pass
18	0.000	0.136	0.551	0.041	0.029	0.687	#21	Not Required	Not Required	Pass
19	0.010	0.148	0.167	0.018	0.015	0.319	#21	0.306	Not Required	Pass
20	0.001	0.116	0.351	0.041	0.029	0.467	#21	0.134	Not Required	Pass
21	0.008	0.146	0.141	0.018	0.013	0.291	#21	0.204	Not Required	Pass
22	0.002	0.116	0.350	0.041	0.029	0.467	#21	0.089	Not Required	Pass
23	0.010	0.148	0.167	0.018	0.015	0.319	#21	0.306	Not Required	Pass

24	0.000	0.135	0.551	0.041	0.029	0.686	#21	Not Required	Not Required	Pass
101	0.097	0.475	0.024	0.026	0.002	0.515	#13	0.551	Not Required	Pass
102	0.002	0.397	0.113	0.092	0.019	0.495	#21	0.055	Not Required	Pass
103	0.011	0.567	0.071	0.056	0.014	0.643	#21	0.071	Not Required	Pass
104	0.011	0.558	0.136	0.056	0.033	0.679	#21	0.126	Not Required	Pass
105	0.011	0.352	0.129	0.056	0.034	0.390	#21	0.117	Not Required	Pass
106	0.013	0.631	0.101	0.063	0.026	0.738	#21	0.071	Not Required	Pass
107	0.013	0.391	0.187	0.062	0.046	0.430	#21	0.117	Not Required	Pass
108	0.000	0.063	0.256	0.028	0.020	0.319	#21	Not Required	Not Required	Pass
109	0.010	0.051	0.060	0.001	0.001	0.116	#21	0.317	Not Required	Pass
110	0.013	0.622	0.179	0.062	0.039	0.741	#21	0.126	Not Required	Pass
111	0.000	0.063	0.256	0.028	0.020	0.319	#21	Not Required	Not Required	Pass
112	0.002	0.469	0.127	0.104	0.020	0.585	#21	0.083	Not Required	Pass
113	0.000	0.136	0.551	0.041	0.029	0.687	#21	Not Required	Not Required	Pass
114	0.001	0.116	0.351	0.041	0.029	0.467	#21	0.134	Not Required	Pass
115	0.002	0.043	0.198	0.028	0.020	0.219	#21	0.278	Not Required	Pass
116	0.002	0.043	0.199	0.028	0.020	0.218	#21	0.417	Not Required	Pass

Definitions

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

REFERENCES	CALCULATIONS	RESULTS

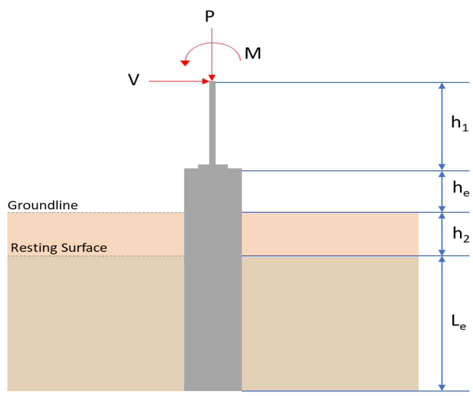
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: rectangular
$b = 48\ \mathrm{in}$ - Pile width
$D = 48\ \mathrm{in}$ - Pile depth
$L = 6.25\ \mathrm{ft}$ - Total pile length
$h_1 = 0\ \mathrm{ft}$ - Lateral load height from the top of the pile,
$h_2 = 0\ \mathrm{ft}$ - Depth to resisting surface
$h_e = 0\ \mathrm{ft}$ - Length of pile above the ground

Tabulation of Soil Parameters

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

Tabulation of Loads

Load Component	ASD	LRFD
P (kip)	8.961	15.161
V_x (kip)	-1.761	-2.936
V_z (kip)	-0.132	-0.222
M_x (kipft)	-0.520	-0.879
M_z (kipft)	23.191	39.600

Material Properties

$f'_{ck} = 3\ \mathrm{ksi}$ - Concrete strength,

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

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

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

Considering x-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-1.761\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.28041\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(23.191\ \mathrm{kipft}) + ((-1.761\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 3.6928\ \mathrm{kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:
$L_{e,x} = 5.8231\ \mathrm{ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.132\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.021019\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.52\ \mathrm{kipft}) + ((-0.132\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 0.082803\ \mathrm{kipft/ft}$$

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:
$L_{e,z} = 1.6554\ \mathrm{ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(5.8231\ \mathrm{ft}), (1.6554\ \mathrm{ft})]$$

$$L_{e,req} = 5.823\ \mathrm{ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (6.25\ \mathrm{ft}) - (0\ \mathrm{ft}) - (0\ \mathrm{ft})$$

$$L_e = 6.25\ \mathrm{ft}$$

$Ratio$ - Embedded depth

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

$$Ratio = \frac{(5.823\ \mathrm{ft})}{(6.25\ \mathrm{ft})}$$

$$Ratio = 0.93168$$

Status: **PASS**
Ratio: **0.930**

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = b\, D$$

$$A = (48\ \mathrm{in}) \times (48\ \mathrm{in})$$

$$A = 16\ \mathrm{ft}^2$$

q - End-bearing pressure

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

$$q = \frac{(8.961\ \mathrm{kip})}{(16\ \mathrm{ft}^2)}$$

$$q = 0.56006\ \mathrm{kip/ft}^2$$

$q = 0.56006\ \text{kip/ft}^2$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{\left(0.56006\ \text{kip/ft}^2\right)}{(2000\ \text{psf})}$$

$$Ratio = 0.28003$$

Status: **PASS**
Ratio: **0.280**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(6.25\ \text{ft})}{(48\ \text{in})}$$

$$L/D = 1.5625$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.28041\ \text{kip/ft}$ - Lateral force per length of pile,
$M_o = 3.6928\ \text{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (3.6928\ \text{kipft/ft}) \times (6.25\ \text{ft})) + \left(3 \times (-0.28041\ \text{kip/ft}) \times (6.25\ \text{ft})^2\right)}{(6 \times (3.6928\ \text{kipft/ft})) + (4 \times (-0.28041\ \text{kip/ft}) \times (6.25\ \text{ft}))}$$

$$a = 4.2918\ \text{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (3.6928\ \text{kipft/ft})) + (3 \times (-0.28041\ \text{kip/ft}) \times (6.25\ \text{ft}))]^{\ 2}}{(6.25\ \text{ft})^2 \times [(3 \times (3.6928\ \text{kipft/ft})) + (2 \times (-0.28041\ \text{kip/ft}) \times (6.25\ \text{ft}))]}$$

$$p = 0.22946\ \text{kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (3.6928\ \text{kipft/ft})) + ((-0.28041\ \text{kip/ft}) \times (6.25\ \text{ft}))]}{(6.25\ \text{ft})^2}$$

$$s = 0.86524\ \text{kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \text{psf/ft}) \times \frac{(4.2918\ \text{ft})}{2}$$

$$p_a = 0.32189\ \text{kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.22946\ \text{kip/ft}^2\right)}{\left(0.32189\ \text{kip/ft}^2\right)}$$

$$Ratio = 0.71285$$

Status: **PASS**
Ratio: **0.710**

p_s - Allowable lateral soil pressure at depth L_e,

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$$p_s = R\,L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (6.25\ \mathrm{ft})$$

$$p_s = 0.9375\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.86524\ \mathrm{kip/ft^2}\right)}{\left(0.9375\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.92292$$

Status: PASS
Ratio: 0.920

Considering z-direction:

$H_o = -0.021019\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 0.082803\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.082803\ \mathrm{kipft/ft}) \times (6.25\ \mathrm{ft})) + \left(3 \times (-0.021019\ \mathrm{kip/ft}) \times (6.25\ \mathrm{ft})^2\right)}{(6 \times (0.082803\ \mathrm{kipft/ft})) + (4 \times (-0.021019\ \mathrm{kip/ft}) \times (6.25\ \mathrm{ft}))}$$

$$a = 4.4344\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.082803\ \mathrm{kipft/ft})) + (3 \times (-0.021019\ \mathrm{kip/ft}) \times (6.25\ \mathrm{ft}))]^2}{(6.25\ \mathrm{ft})^2 \times [(3 \times (0.082803\ \mathrm{kipft/ft})) + (2 \times (-0.021019\ \mathrm{kip/ft}) \times (6.25\ \mathrm{ft}))]}$$

$$p = -0.0053002\ \mathrm{kip/ft^2}$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (0.082803\ \mathrm{kipft/ft})) + ((-0.021019\ \mathrm{kip/ft}) \times (6.25\ \mathrm{ft}))]}{(6.25\ \mathrm{ft})^2}$$

$$s = 0.0052586\ \mathrm{kip/ft^2}$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \mathrm{psf/ft}) \times \frac{(4.4344\ \mathrm{ft})}{2}$$

$$p_a = 0.33258\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(-0.0053002\ \mathrm{kip/ft^2}\right)}{\left(0.33258\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = -0.015937$$

Status: PASS
Ratio: -0.020

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (6.25\ \mathrm{ft})$$

$$p_s = 0.9375\ \mathrm{kip/ft^2}$$

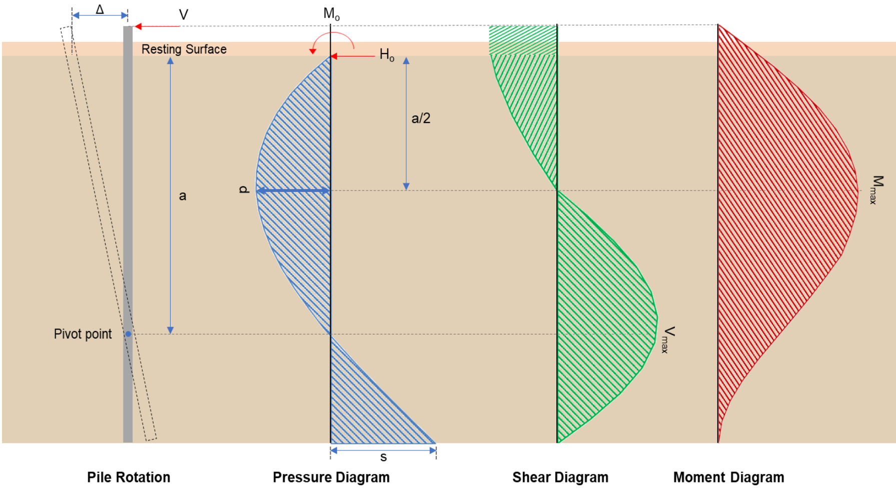
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.0052586\ \text{kip/ft}^2)}{(0.9375\ \text{kip/ft}^2)}$$

$$Ratio = 0.0056092$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-2.936\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = -0.46752\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(39.6\ \text{kipft}) + ((-2.936\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 6.3057\ \text{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(6.3057\ \text{kipft/ft})}{(-0.46752\ \text{kip/ft})}$$

$$E = 13.488\ \text{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (6.3057\ \text{kipft/ft}) \times (6.25\ \text{ft})) + \left(3 \times (-0.46752\ \text{kip/ft}) \times (6.25\ \text{ft})^2\right)}{(6 \times (6.3057\ \text{kipft/ft})) + (4 \times (-0.46752\ \text{kip/ft}) \times (6.25\ \text{ft}))}$$

$$a = 4.2896\ \text{ft}$$

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

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

$$V_{max} = ((-0.46752\ \text{kip/ft}) \times (48\ \text{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (13.488\ \text{ft})}{(6.25\ \text{ft})} + 3\right) \times \left(\frac{(4.2896\ \text{ft})}{(6.25\ \text{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (13.488\ \text{ft})}{(6.25\ \text{ft})} + 2\right) \times \left(\frac{(4.2896\ \text{ft})}{(6.25\ \text{ft})}\right)^3\right]\right]$$

$$V_{max} = 8.3767\ \text{kip}$$

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

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

$$M_{max} = ((-0.46752\text{ kip/ft})\times(48\text{ in})\times(6.25\text{ ft}))\times\left[\left(\frac{(13.488\text{ ft})}{(6.25\text{ ft})}+\frac{(4.2896\text{ ft})}{2\times(6.25\text{ ft})}\right) - \left[\left(\frac{4\times(13.488\text{ ft})}{(6.25\text{ ft})}+3\right)\times\left(\frac{(4.2896\text{ ft})}{2\times(6.25\text{ ft})}\right)^3\right]+\left[\left(\frac{3\times(13.488\text{ ft})}{(6.25\text{ ft})}+2\right)\times\left(\frac{(4.2896\text{ ft})}{2\times(6.25\text{ ft})}\right)^4\right]\right]$$

$$M_{max} = 25.113\text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.222\text{ kip})}{1.57\times(48\text{ in})}$$

$$H_o = -0.03535\text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.879\text{ kipft})+((-0.222\text{ kip})\times(0\text{ ft}))}{1.57\times(48\text{ in})}$$

$$M_o = 0.13997\text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.13997\text{ kipft/ft})}{(-0.03535\text{ kip/ft})}$$

$$E = 3.9595\text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4\times(0.13997\text{ kipft/ft})\times(6.25\text{ ft}))+\left(3\times(-0.03535\text{ kip/ft})\times(6.25\text{ ft})^2\right)}{(6\times(0.13997\text{ kipft/ft}))+(4\times(-0.03535\text{ kip/ft})\times(6.25\text{ ft}))}$$

$$a = 4.4337\text{ ft}$$

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

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

$$V_{max} = ((-0.03535\text{ kip/ft})\times(48\text{ in}))\times\left[1-\left[3\times\left(\frac{4\times(3.9595\text{ ft})}{(6.25\text{ ft})}+3\right)\times\left(\frac{(4.4337\text{ ft})}{(6.25\text{ ft})}\right)^2\right]+\left[4\times\left(\frac{3\times(3.9595\text{ ft})}{(6.25\text{ ft})}+2\right)\times\left(\frac{(4.4337\text{ ft})}{(6.25\text{ ft})}\right)^3\right]\right]$$

$$V_{max} = 0.2524\text{ kip}$$

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

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

$$M_{max} = ((-0.03535\text{ kip/ft})\times(48\text{ in})\times(6.25\text{ ft}))\times\left[\left(\frac{(3.9595\text{ ft})}{(6.25\text{ ft})}+\frac{(4.4337\text{ ft})}{2\times(6.25\text{ ft})}\right) - \left[\left(\frac{4\times(3.9595\text{ ft})}{(6.25\text{ ft})}+3\right)\times\left(\frac{(4.4337\text{ ft})}{2\times(6.25\text{ ft})}\right)^3\right]+\left[\left(\frac{3\times(3.9595\text{ ft})}{(6.25\text{ ft})}+2\right)\times\left(\frac{(4.4337\text{ ft})}{2\times(6.25\text{ ft})}\right)^4\right]\right]$$

$$M_{max} = 0.70965\ \text{kipft}$$

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,
Table 22.4.2.1 $\alpha = 0.8$ - Alpha factor for axial strength,
$A_g = 2304\ \text{in}^2$ - Gross area of concrete,

Longitudinal reinforcement:

Required reinforcement due to axial load, $A_{st,required}$
22.4.2.2, 10.6.1.1 $A_{st,required}$

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

$$A_{st,required} = Min\left[\frac{\frac{(15.161\ \text{kip})}{(0.65)\times(0.8)} - \left(0.85\times(3\ \text{ksi})\times\left(2304\ \text{in}^2\right)\right)}{(60\ \text{ksi}) - (0.85\times(3\ \text{ksi}))}, \left(0.08\times\left(2304\ \text{in}^2\right)\right)\right]$$

$$A_{st,required} = -101.76\ \text{in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[\left(-101.76\ \text{in}^2\right), \left(0.0018\times\left(2304\ \text{in}^2\right)\right)\right]$$

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

n_{rebar} - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

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

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

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

$$Ratio = 0.96556$$

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

25.2.3 s_{rebar} - Minimum spacing of reinforcement,

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

$$s_{rebar} = Max\left[1.5, (1.5\times(0.625\ \text{in}))\right]$$

$$s_{rebar} = 1.5\ \text{in}$$

Ties:

25.7.2.2 Since longitudinal reinforcement is $\leq$ No. 10ø: Use #3(0.375 in)
25.7.2.1 s_{ties} - Maximum spacing of ties,

$$s_{ties} = Min\left[(16\ d_{bar}), (48\ d_{ties}), Min(D, b)\right]$$

$$s_{ties} = Min\left[(16\times(0.625\ \text{in})), (48\times(0.375\ \text{in})), Min((48\ \text{in}), (48\ \text{in}))\right]$$

$$s_{ties} = 10\ \text{in}$$

Summary:

Main reinforcement: **14 - #5 (0.625 in)**

Ties: **#3(0.375 in) - 10 in**

Axial Compression Strength (ACI 318-19, LRFD)

22.4.2.2 ϕP_N - Allowable axial compressive strength

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

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

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

$Ratio$ - Capacity

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

$$Ratio = \frac{(15.161\ \text{kip})}{(3183.4\ \text{kip})}$$

$$Ratio = 0.0047625$$

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

Shear Strength (ACI 318-19, LRFD)

Parameters:

$b_w = 48\ \text{in}$ - Effective width,

22.5.2.2 d - Effective depth

$$d = 0.80\, D$$

$$d = 0.80 \times (48\ \text{in})$$

$$d = 38.4\ \text{in}$$

22.5.5.1.3 λ_s - size effect modification factor

$$\lambda_s = MIN\left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1\right]$$

$$\lambda_s = MIN\left[\sqrt{\frac{2}{1 + \frac{(38.4\ \text{in})}{10}}}, 1\right]$$

$$\lambda_s = 0.64282$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\ \text{ksi} \rightarrow 3000\ \text{psi}$,

22.5.5.1.1 $V_{c,max}$ - Max shear strength of concrete

$$V_{c,max} = 5\, \lambda_s\, \sqrt{f'_{ck}}\, b_w\, d$$

$$V_{c,max} = 5 \times (0.64282) \times \sqrt{(3000\ \text{psi})} \times (48\ \text{in}) \times (38.4\ \text{in})$$

$$V_{c,max} = 324.49\ \text{kip}$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\ \text{ksi} \rightarrow 3000\ \text{psi}$, $P = 15.161\ \text{kip} \rightarrow 15161\ \text{lbf}$,

22.5.5.1.1(a) $V_{c,a}$ - Shear strength of concrete (a)

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000\ \text{psi})} + \frac{(15161\ \text{lbf})}{6 \times \left(2304\ \text{in}^2\right)}\right] \times (48\ \text{in}) \times (38.4\ \text{in})$$

$$V_{c,a} = 131.82\ \text{kip}$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\ \text{ksi} \rightarrow 3000\ \text{psi}$,

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

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

$$V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(3000\ \text{psi})} + (0.05 \times (3000\ \text{psi}))\right] \times (48\ \text{in}) \times (38.4\ \text{in})$$

$$V_{c,b} = 406.27\ \text{kip}$$

V_c - Governing shear strength of concrete

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

$$V_c = Min\left[(324.49\ \text{kip}), (131.82\ \text{kip}), (406.27\ \text{kip})\right]$$

$$V_c = 131.82\ \text{kip}$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\ \mathrm{ksi} \rightarrow 3000\ \mathrm{psi}$,

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

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

$$V_{s,a} = 8 \times \sqrt{(3000\ \mathrm{psi})} \times (48\ \mathrm{in}) \times (38.4\ \mathrm{in})$$

$$V_{s,a} = 807.65\ \mathrm{kip}$$

A_v - Ties rebar area,

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

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

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

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

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

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

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

V_s - Governing shear strength of steel

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

$$V_s = MIN\left[(807.65\ \mathrm{kip}), (50.894\ \mathrm{kip})\right]$$

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

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((131.82\ \mathrm{kip}) + (50.894\ \mathrm{kip}))$$

$$\phi V_n = 118.76\ \mathrm{kip}$$

Considering x-direction:

$V_{max} = 8.3767\ \mathrm{kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(8.3767\ \mathrm{kip})}{(118.76\ \mathrm{kip})}$$

$$Ratio = 0.070534$$

Status: **PASS**
Ratio: **0.070**

Considering z-direction:

$V_{max} = 0.2524\ \mathrm{kip}$ - Maximum shear force in the z-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(0.2524\ \mathrm{kip})}{(118.76\ \mathrm{kip})}$$

$$Ratio = 0.0021252$$

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

Flexural Strength (ACI 318-19, LRFD)

S_m - Section modulus

$$S_m = \frac{b\, D^2}{6}$$

$$S_m = \frac{(48\ \mathrm{in}) \times (48\ \mathrm{in})^2}{6}$$

$$S_m = 18432\ \mathrm{in}^3$$

$\lambda = 1$ - Concrete modification factor (Normal concrete),
Allowable flexural strength:
M_n shall be the lesser of:
$\phi M_{n,1}$

$$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f_c')} \times S_m$$

$$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(3ksi)} \times 18432.001 in^3$$

$$\phi M_{n,1} = 273.423 kipft$$

14.5.2.1b $\phi M_{n,2}$

$$\phi M_{n,2} = \phi \, 0.85 \, f_{ck}' \, S_m$$

$$\phi M_{n,2} = (0.65) \times 0.85 \times (3 \text{ ksi}) \times \left(18432 \text{ in}^3\right)$$

$$\phi M_{n,2} = 2545.9 \text{ kipft}$$

Therefore,
ϕM_n - Allowable flexural strength,

$$\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$$

$$\phi M_n = MIN[(273.42 \text{ kipft}), (2545.9 \text{ kipft})]$$

$$\phi M_n = 273.42 \text{ kipft}$$

Considering x-direction:

$M_{max} = 25.113 \text{ kipft}$ - Maximum moment in the x-direction,
$Ratio$ - Capacity

$$Ratio = \frac{M_{max}}{\phi M_n}$$

$$Ratio = \frac{(25.113 \text{ kipft})}{(273.42 \text{ kipft})}$$

$$Ratio = 0.091847$$

Status: **PASS**
Ratio: **0.090**

Considering z-direction:

$M_{max} = 0.70965 \text{ kipft}$ - Maximum moment in the z-direction,
$Ratio$ - Capacity

$$Ratio = \frac{M_{max}}{\phi M_n}$$

$$Ratio = \frac{(0.70965 \text{ kipft})}{(273.42 \text{ kipft})}$$

$$Ratio = 0.0025954$$

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

REFERENCES	CALCULATIONS	RESULTS

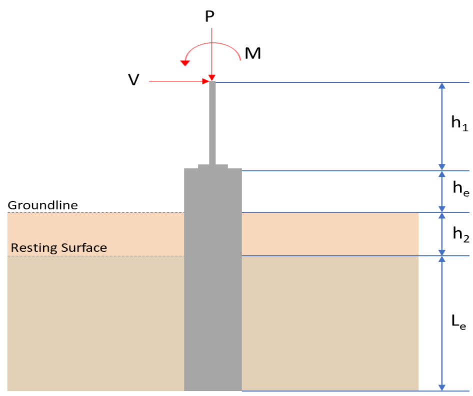
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: rectangular
$b = 48\ \mathrm{in}$ - Pile width
$D = 48\ \mathrm{in}$ - Pile depth
$L = 6.25\ \mathrm{ft}$ - Total pile length
$h_1 = 0\ \mathrm{ft}$ - Lateral load height from the top of the pile,
$h_2 = 0\ \mathrm{ft}$ - Depth to resisting surface
$h_e = 0\ \mathrm{ft}$ - Length of pile above the ground

Tabulation of Soil Parameters

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

Tabulation of Loads

Load Component	ASD	LRFD
P (kip)	8.961	15.161
V_x (kip)	-1.761	-2.936
V_z (kip)	0.132	0.222
M_x (kipft)	0.520	0.879
M_z (kipft)	23.191	39.601

Material Properties

$f'_{ck} = 3\ \mathrm{ksi}$ - Concrete strength,

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

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

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

Considering x-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-1.761\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.28041\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(23.191\ \text{kipft}) + ((-1.761\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 3.6928\ \text{kipft/ft}$$

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:
$L_{e,x} = 5.8231\ \text{ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.132\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = 0.021019\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.52\ \text{kipft}) + ((0.132\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 0.082803\ \text{kipft/ft}$$

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:
$L_{e,z} = 2.101\ \text{ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(5.8231\ \text{ft}), (2.101\ \text{ft})]$$

$$L_{e,req} = 5.823\ \text{ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (6.25\ \text{ft}) - (0\ \text{ft}) - (0\ \text{ft})$$

$$L_e = 6.25\ \text{ft}$$

$Ratio$ - Embedded depth

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

$$Ratio = \frac{(5.823\ \text{ft})}{(6.25\ \text{ft})}$$

$$Ratio = 0.93168$$

Status: **PASS**
Ratio: **0.930**

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

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

$$q = \frac{(8.961\ \text{kip})}{(16\ \text{ft}^2)}$$

$$q = 0.56006\ \text{kip/ft}^2$$

$q = 0.56006 \text{ kip/ft}^2$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{(0.56006 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$Ratio = 0.28003$$

Status: **PASS**
Ratio: **0.280**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(6.25 \text{ ft})}{(48 \text{ in})}$$

$$L/D = 1.5625$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.28041 \text{ kip/ft}$ - Lateral force per length of pile,
$M_o = 3.6928 \text{ kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (3.6928 \text{ kipft/ft}) \times (6.25 \text{ ft})) + \left(3 \times (-0.28041 \text{ kip/ft}) \times (6.25 \text{ ft})^2\right)}{(6 \times (3.6928 \text{ kipft/ft})) + (4 \times (-0.28041 \text{ kip/ft}) \times (6.25 \text{ ft}))}$$

$$a = 4.2918 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (3.6928 \text{ kipft/ft})) + (3 \times (-0.28041 \text{ kip/ft}) \times (6.25 \text{ ft}))]^2}{(6.25 \text{ ft})^2 \times [(3 \times (3.6928 \text{ kipft/ft})) + (2 \times (-0.28041 \text{ kip/ft}) \times (6.25 \text{ ft}))]}$$

$$p = 0.22946 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (3.6928 \text{ kipft/ft})) + ((-0.28041 \text{ kip/ft}) \times (6.25 \text{ ft}))]}{(6.25 \text{ ft})^2}$$

$$s = 0.86524 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(4.2918 \text{ ft})}{2}$$

$$p_a = 0.32189 \text{ kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.22946 \text{ kip/ft}^2)}{(0.32189 \text{ kip/ft}^2)}$$

$$Ratio = 0.71285$$

Status: **PASS**
Ratio: **0.710**

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \text{psf/ft}) \times (6.25\ \text{ft})$$

$$p_s = 0.9375\ \text{kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.86524\ \text{kip/ft}^2\right)}{\left(0.9375\ \text{kip/ft}^2\right)}$$

$$Ratio = 0.92292$$

Status: PASS
Ratio: 0.920

Considering z-direction:

$H_o = 0.021019\ \text{kip/ft}$ - Lateral force per length of pile,
$M_o = 0.082803\ \text{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.082803\ \text{kipft/ft}) \times (6.25\ \text{ft})) + \left(3 \times (0.021019\ \text{kip/ft}) \times (6.25\ \text{ft})^2\right)}{(6 \times (0.082803\ \text{kipft/ft})) + (4 \times (0.021019\ \text{kip/ft}) \times (6.25\ \text{ft}))}$$

$$a = 4.4344\ \text{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.082803\ \text{kipft/ft})) + (3 \times (0.021019\ \text{kip/ft}) \times (6.25\ \text{ft}))]^2}{(6.25\ \text{ft})^2 \times [(3 \times (0.082803\ \text{kipft/ft})) + (2 \times (0.021019\ \text{kip/ft}) \times (6.25\ \text{ft}))]}$$

$$p = 0.019761\ \text{kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (0.082803\ \text{kipft/ft})) + ((0.021019\ \text{kip/ft}) \times (6.25\ \text{ft}))]}{(6.25\ \text{ft})^2}$$

$$s = 0.045615\ \text{kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \text{psf/ft}) \times \frac{(4.4344\ \text{ft})}{2}$$

$$p_a = 0.33258\ \text{kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.019761\ \text{kip/ft}^2\right)}{\left(0.33258\ \text{kip/ft}^2\right)}$$

$$Ratio = 0.059418$$

Status: PASS
Ratio: 0.060

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \text{psf/ft}) \times (6.25\ \text{ft})$$

$$p_s = 0.9375\ \text{kip/ft}^2$$

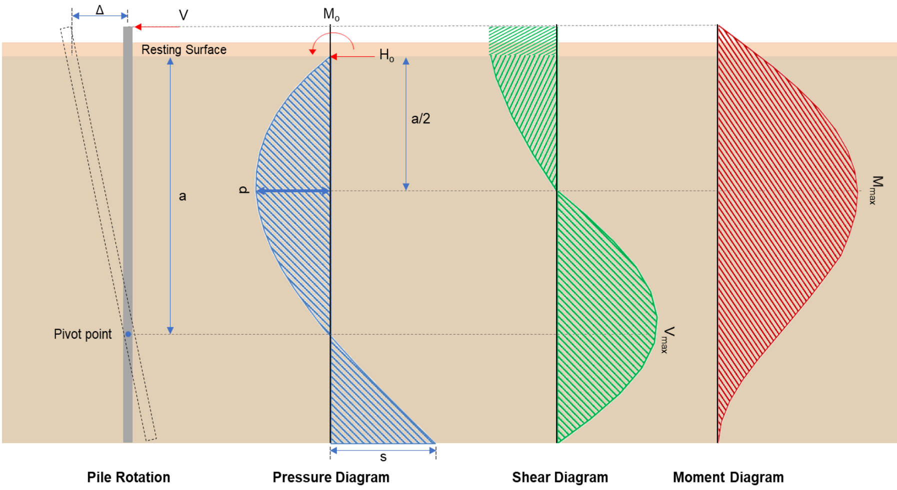
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.045615\ \mathrm{kip/ft^2}\right)}{\left(0.9375\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.048656$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-2.936\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.46752\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(39.601\ \mathrm{kipft}) + ((-2.936\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 6.3059\ \mathrm{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(6.3059\ \mathrm{kipft/ft})}{(-0.46752\ \mathrm{kip/ft})}$$

$$E = 13.488\ \mathrm{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (6.3059\ \mathrm{kipft/ft}) \times (6.25\ \mathrm{ft})) + \left(3 \times (-0.46752\ \mathrm{kip/ft}) \times (6.25\ \mathrm{ft})^2\right)}{(6 \times (6.3059\ \mathrm{kipft/ft})) + (4 \times (-0.46752\ \mathrm{kip/ft}) \times (6.25\ \mathrm{ft}))}$$

$$a = 4.2896\ \mathrm{ft}$$

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

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

$$V_{max} = ((-0.46752\ \mathrm{kip/ft}) \times (48\ \mathrm{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (13.488\ \mathrm{ft})}{(6.25\ \mathrm{ft})} + 3\right) \times \left(\frac{(4.2896\ \mathrm{ft})}{(6.25\ \mathrm{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (13.488\ \mathrm{ft})}{(6.25\ \mathrm{ft})} + 2\right) \times \left(\frac{(4.2896\ \mathrm{ft})}{(6.25\ \mathrm{ft})}\right)^3\right]\right]$$

$$V_{max} = 8.3769\ \mathrm{kip}$$

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

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

$$M_{max} = ((-0.46752 \text{ kip/ft}) \times (48 \text{ in}) \times (6.25 \text{ ft})) \times \left[\left(\frac{(13.488 \text{ ft})}{(6.25 \text{ ft})} + \frac{(4.2896 \text{ ft})}{2 \times (6.25 \text{ ft})} \right) - \left[\left(\frac{4 \times (13.488 \text{ ft})}{(6.25 \text{ ft})} + 3 \right) \times \left(\frac{(4.2896 \text{ ft})}{2 \times (6.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (13.488 \text{ ft})}{(6.25 \text{ ft})} + 2 \right) \times \left(\frac{(4.2896 \text{ ft})}{2 \times (6.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 25.114 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.222 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.03535 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.879 \text{ kipft}) + ((0.222 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.13997 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.13997 \text{ kipft/ft})}{(0.03535 \text{ kip/ft})}$$

$$E = 3.9595 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.13997 \text{ kipft/ft}) \times (6.25 \text{ ft})) + \left(3 \times (0.03535 \text{ kip/ft}) \times (6.25 \text{ ft})^2\right)}{(6 \times (0.13997 \text{ kipft/ft})) + (4 \times (0.03535 \text{ kip/ft}) \times (6.25 \text{ ft}))}$$

$$a = 4.4337 \text{ ft}$$

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

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

$$V_{max} = ((0.03535 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (3.9595 \text{ ft})}{(6.25 \text{ ft})} + 3 \right) \times \left(\frac{(4.4337 \text{ ft})}{(6.25 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (3.9595 \text{ ft})}{(6.25 \text{ ft})} + 2 \right) \times \left(\frac{(4.4337 \text{ ft})}{(6.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.2524 \text{ kip}$$

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

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

$$M_{max} = ((0.03535 \text{ kip/ft}) \times (48 \text{ in}) \times (6.25 \text{ ft})) \times \left[\left(\frac{(3.9595 \text{ ft})}{(6.25 \text{ ft})} + \frac{(4.4337 \text{ ft})}{2 \times (6.25 \text{ ft})} \right) - \left[\left(\frac{4 \times (3.9595 \text{ ft})}{(6.25 \text{ ft})} + 3 \right) \times \left(\frac{(4.4337 \text{ ft})}{2 \times (6.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (3.9595 \text{ ft})}{(6.25 \text{ ft})} + 2 \right) \times \left(\frac{(4.4337 \text{ ft})}{2 \times (6.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.70965 \text{ kipft}$$

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,
Table 22.4.2.1 $\alpha = 0.8$ - Alpha factor for axial strength,
$A_g = 2304 \text{ in}^2$ - Gross area of concrete,

Longitudinal reinforcement:

Required reinforcement due to axial load, $A_{st,required}$
22.4.2.2, 10.6.1.1 $A_{st,required}$

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

$$A_{st,required} = Min\left[\frac{\frac{(15.161 \text{ kip})}{(0.65)\times(0.8)} - (0.85 \times (3 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2))\right]$$

$$A_{st,required} = -101.76 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[(-101.76 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))\right]$$

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

n_{rebar} - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

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

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

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

$Ratio$ - Capacity

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

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

$$Ratio = 0.96556$$

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

25.2.3 s_{rebar} - Minimum spacing of reinforcement,

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

$$s_{rebar} = Max\left[1.5, (1.5 \times (0.625 \text{ in}))\right]$$

$$s_{rebar} = 1.5 \text{ in}$$

Ties:

25.7.2.2 Since longitudinal reinforcement is $\leq$ No. 10ø: Use #3(0.375 in)
25.7.2.1 s_{ties} - Maximum spacing of ties,

$$s_{ties} = Min\left[(16\ d_{bar}), (48\ d_{ties}), Min(D, b)\right]$$

$$s_{ties} = Min\left[(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), Min((48 \text{ in}), (48 \text{ in}))\right]$$

$$s_{ties} = 10 \text{ in}$$

Summary:

Main reinforcement: **14 - #5 (0.625 in)**

	Ties: **#3(0.375 in) - 10 in**	

Axial Compression Strength (ACI 318-19, LRFD)

22.4.2.2 ϕP_N - Allowable axial compressive strength

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

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

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

$Ratio$ - Capacity

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

$$Ratio = \frac{(15.161\ \mathrm{kip})}{(3183.4\ \mathrm{kip})}$$

$$Ratio = 0.0047625$$

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

Shear Strength (ACI 318-19, LRFD)

Parameters:

$b_w = 48\ \mathrm{in}$ - Effective width,

22.5.2.2 d - Effective depth

$$d = 0.80\, D$$

$$d = 0.80 \times (48\ \mathrm{in})$$

$$d = 38.4\ \mathrm{in}$$

22.5.5.1.3 λ_s - size effect modification factor

$$\lambda_s = MIN\left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1\right]$$

$$\lambda_s = MIN\left[\sqrt{\frac{2}{1 + \frac{(38.4\ \mathrm{in})}{10}}}, 1\right]$$

$$\lambda_s = 0.64282$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\ \mathrm{ksi} \rightarrow 3000\ \mathrm{psi}$,

22.5.5.1.1 $V_{c,max}$ - Max shear strength of concrete

$$V_{c,max} = 5\,\lambda_s\,\sqrt{f'_{ck}}\,b_w\,d$$

$$V_{c,max} = 5 \times (0.64282) \times \sqrt{(3000\ \mathrm{psi})} \times (48\ \mathrm{in}) \times (38.4\ \mathrm{in})$$

$$V_{c,max} = 324.49\ \mathrm{kip}$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\ \mathrm{ksi} \rightarrow 3000\ \mathrm{psi}$, $P = 15.161\ \mathrm{kip} \rightarrow 15161\ \mathrm{lbf}$,

22.5.5.1.1(a) $V_{c,a}$ - Shear strength of concrete (a)

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000\ \mathrm{psi})} + \frac{(15161\ \mathrm{lbf})}{6 \times (2304\ \mathrm{in}^2)}\right] \times (48\ \mathrm{in}) \times (38.4\ \mathrm{in})$$

$$V_{c,a} = 131.82\ \mathrm{kip}$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\ \mathrm{ksi} \rightarrow 3000\ \mathrm{psi}$,

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

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

$$V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(3000\ \mathrm{psi})} + (0.05 \times (3000\ \mathrm{psi}))\right] \times (48\ \mathrm{in}) \times (38.4\ \mathrm{in})$$

$$V_{c,b} = 406.27\ \mathrm{kip}$$

V_c - Governing shear strength of concrete

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

$$V_c = Min\left[(324.49\ \mathrm{kip}), (131.82\ \mathrm{kip}), (406.27\ \mathrm{kip})\right]$$

$$V_c = 131.82\ \mathrm{kip}$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$,

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

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

$$V_{s,a} = 8 \times \sqrt{(3000 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{s,a} = 807.65 \text{ kip}$$

A_v - Ties rebar area,

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

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

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

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

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

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

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

V_s - Governing shear strength of steel

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

$$V_s = MIN\left[(807.65 \text{ kip}), (50.894 \text{ kip})\right]$$

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

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((131.82 \text{ kip}) + (50.894 \text{ kip}))$$

$$\phi V_n = 118.76 \text{ kip}$$

Considering x-direction:

$V_{max} = 8.3769 \text{ kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(8.3769 \text{ kip})}{(118.76 \text{ kip})}$$

$$Ratio = 0.070536$$

Status: **PASS**
Ratio: **0.070**

Considering z-direction:

$V_{max} = 0.2524 \text{ kip}$ - Maximum shear force in the z-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(0.2524 \text{ kip})}{(118.76 \text{ kip})}$$

$$Ratio = 0.0021252$$

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

Flexural Strength (ACI 318-19, LRFD)

S_m - Section modulus

$$S_m = \frac{b\, D^2}{6}$$

$$S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$$

$$S_m = 18432 \text{ in}^3$$

	$\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$ $$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f_c')} \times S_m$$ $$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(3ksi)} \times 18432.001in^3$$ $$\phi M_{n,1} = 273.423kipft$$	
14.5.2.1b	$\phi M_{n,2}$ $$\phi M_{n,2} = \phi\, 0.85\, f'_{ck}\, S_m$$ $$\phi M_{n,2} = (0.65) \times 0.85 \times (3 \text{ ksi}) \times \left(18432 \text{ in}^3\right)$$ $$\phi M_{n,2} = 2545.9 \text{ kipft}$$ Therefore, ϕM_n - Allowable flexural strength, $$\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$$ $$\phi M_n = MIN[(273.42 \text{ kipft}), (2545.9 \text{ kipft})]$$ $$\phi M_n = 273.42 \text{ kipft}$$ **Considering x-direction:** $M_{max} = 25.114 \text{ kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(25.114 \text{ kipft})}{(273.42 \text{ kipft})}$$ $$Ratio = 0.091849$$	Status: **PASS** Ratio: **0.090**
	Considering z-direction: $M_{max} = 0.70965 \text{ kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(0.70965 \text{ kipft})}{(273.42 \text{ kipft})}$$ $$Ratio = 0.0025954$$	Status: **PASS** Ratio: **0.000**