Project Details

Project Name: Uthmann Family Feeders - 5x5 - V1Jb

Location: 5200 N County Rd 19, Fort Collins, CO 80524, USA

Unique ID: 2P-19.75-10TOP-XD-57-L-5Hx5W-9FC7

Dealer: ______________________________

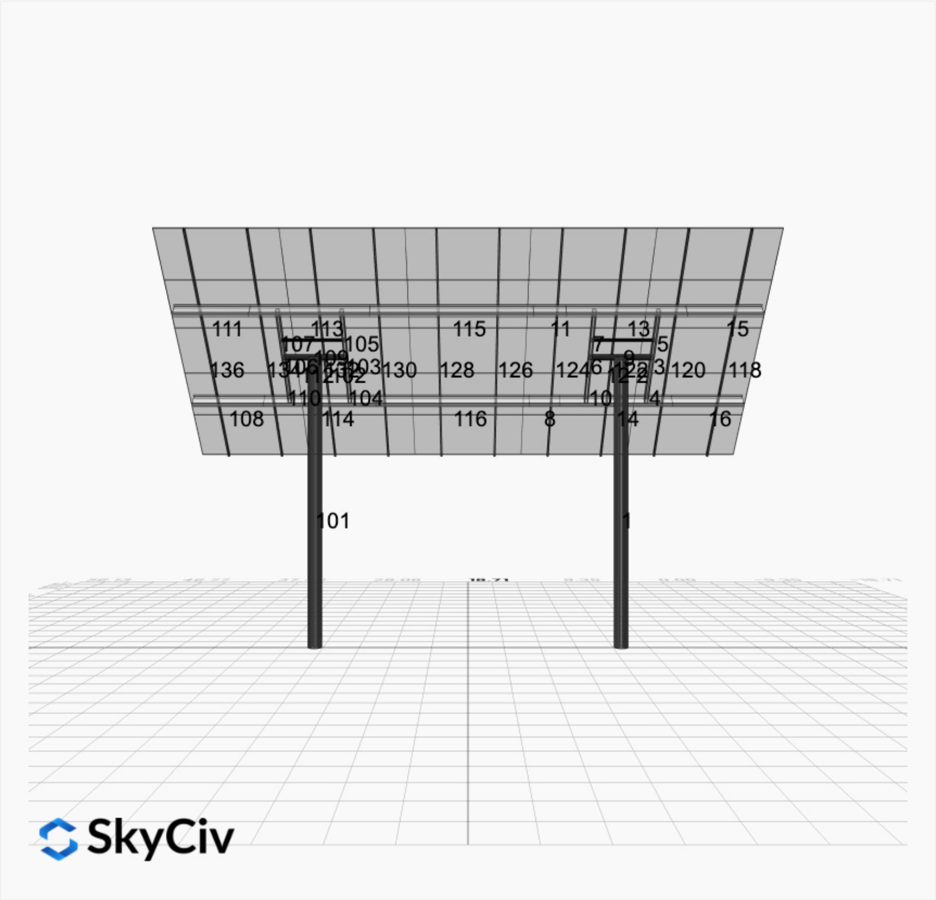
Date: Thu Jan 16 2025

Number of Modules: 25

Number of Poles: 2

Date Sold:

____



Array Dimensions N/S	18.75 ft
Array Dimensions E/W	37.42 ft
Winter Tilt Angle	46
Front Edge Clearance	12 ft

MT Solar Bill of Materials (2P-19.75-10TOP-XD-57-L-5Hx5W-9FC7)

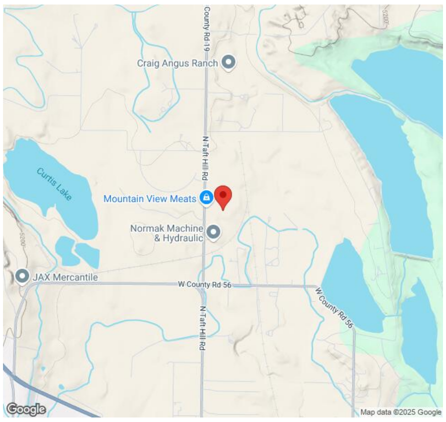
Part	Short Description	BOM Qty
MTS-PC-10	10IN Pole Cap Assembly	2
MTS-HF-XD	H-Frame Assembly-XD	2
MTS-XD-Wing-57	57IN XD Wing	4
MTS-XD-Splice-90	90IN XD Splice	2
MTS-XD-Splice-57	57IN XD Splice	2
MTS-CLAMP-ANGLE-4PK	Angle Clamp	5

Rail Bill of Materials

Part	Qty
Rails (223in)	10
Rail Attachment	40

Part	Qty
Module Mid Clamp	40
Module End Clamp	20
Ground Lug	5

Site Details:



Site Address: 5200 N County Rd 19, Fort Collins, CO 80524, USA

Array Specification

Duty Classification:	XD
Module Width:	44.50 in
Module Length:	88.80in
Number of Rows:	5
Number of Columns:	5
Total Number of Modules:	25
Winter Tilt Angle:	46
Front Edge Clearance:	12
Total Array Height at Tilt:	25.49 ft
Total Frame Length:	36.75 ft
Frame Weight:	4368 lbs
Array Dimensions N/S:	18.75 ft
Array Dimensions E/W:	37.42 ft
Rail Length:	225.00 in
Rail Spacing:	3.74 ft

Support Specifications

Pole Size:	10in Pipe Sch 80
Pole Length above Grade:	18.74 ft
Number of Poles:	2
Pole Spacing:	19.75 ft

Foundation Specifications

Foundation Type:	Square
Foundation Dimensions:	48 x 48 in
Foundation Depth (below grade):	Pile 1: 10.25 ft Pile 2: 10.25 ft
Foundation Volume:	12.148 y^3

Site Info

Risk Category:	I
Exposure:	C
Soil Classification:	sand
Site Location:	5200 N County Rd 19, Fort Collins, CO 80524, USA
Wind Speed:	145 mph
Snow Load:	45 psf

Design Disclaimer

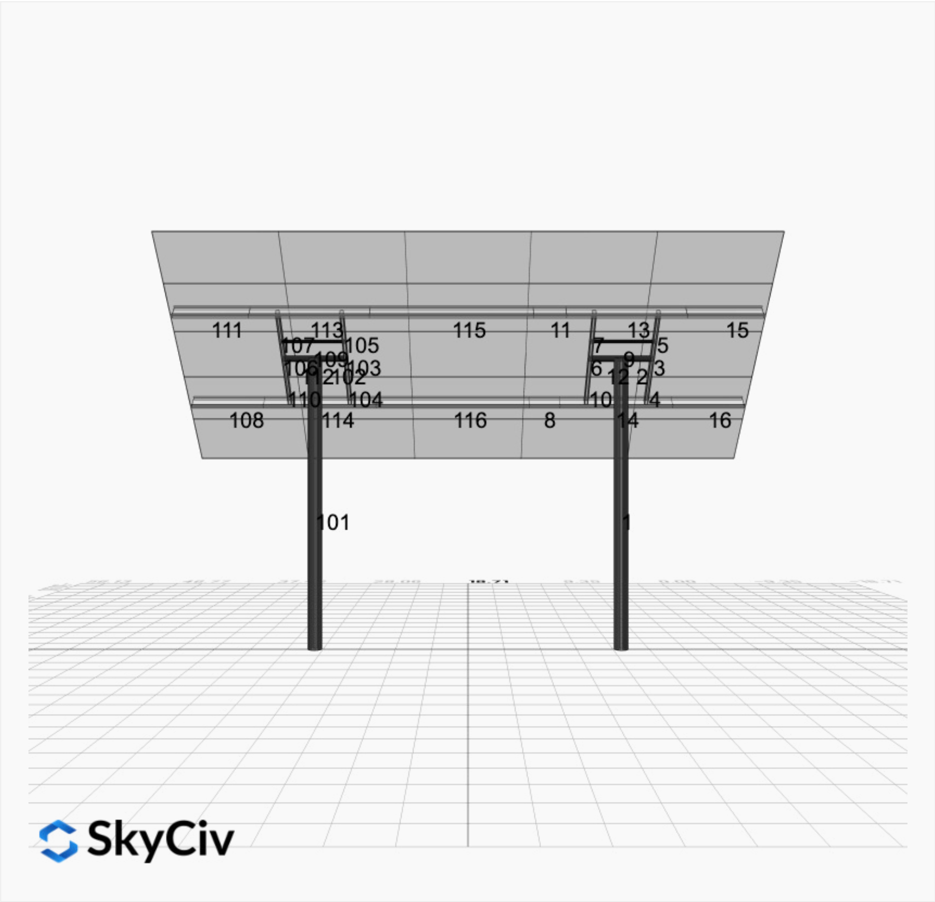
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

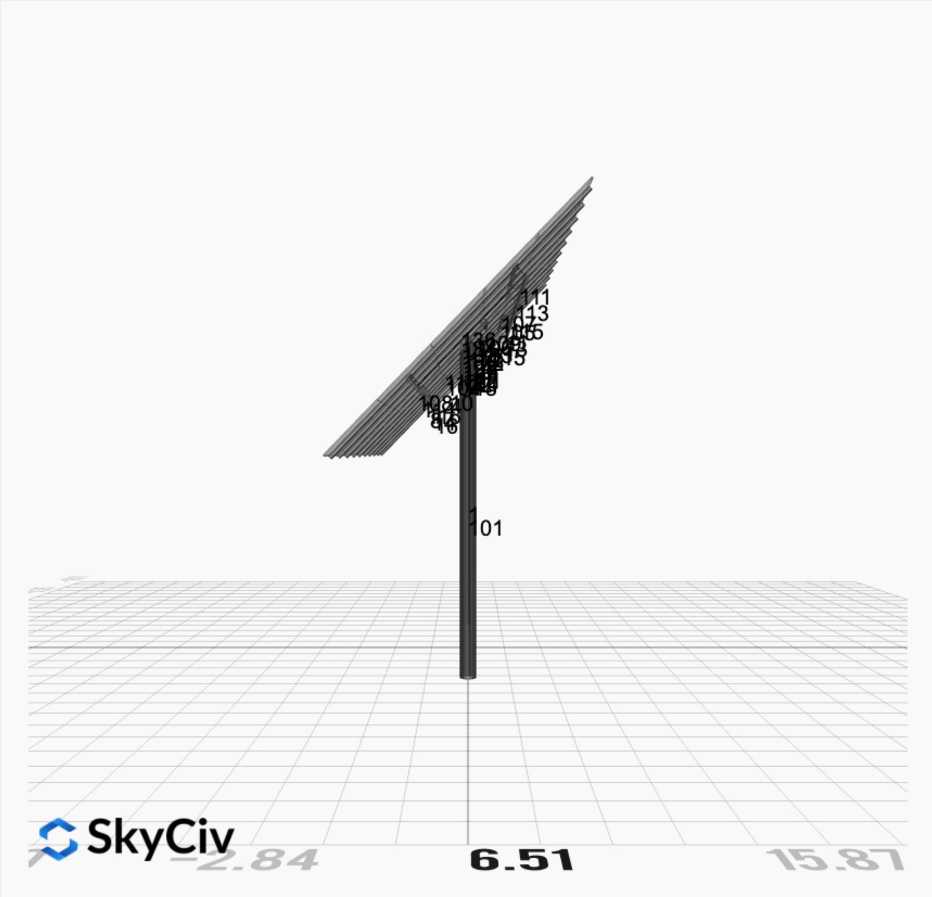
AutoDesigner Input

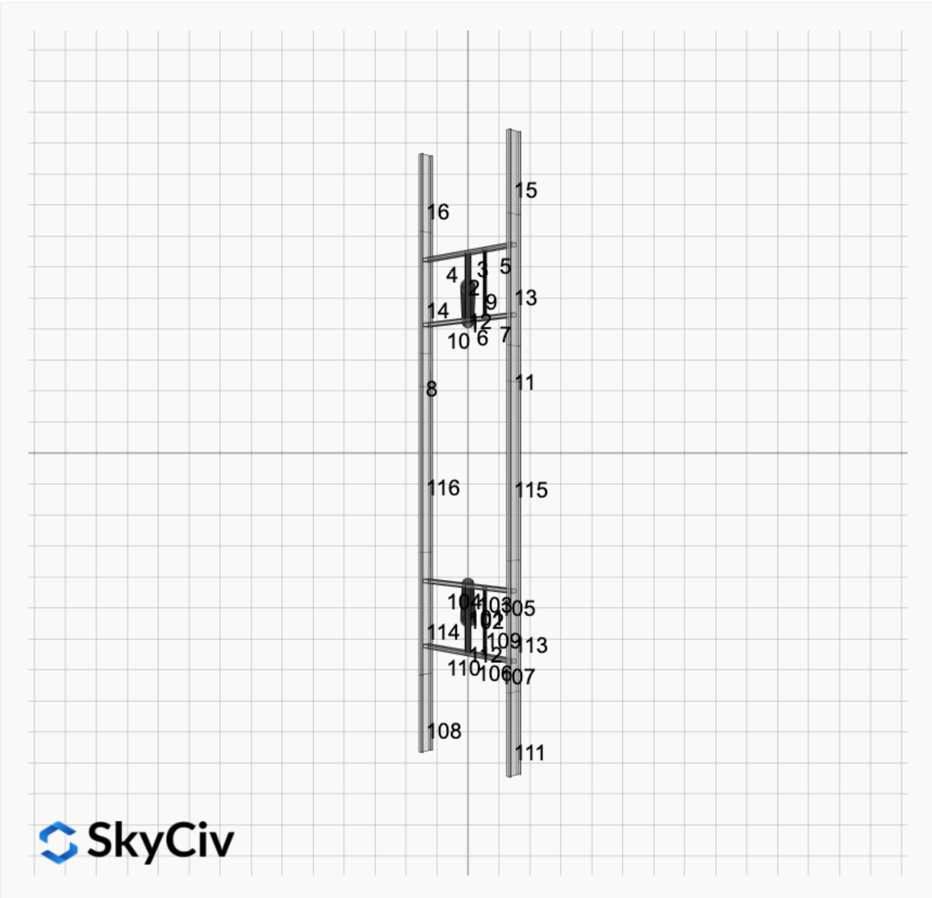

```
{"product_type":"Beam","designer_name":"","designer_email":"","designer_phone":"","project_id":"Uthmann Family Feeders - 5x5 - V1Jb","site_address":"5200 N County Rd 19, Fort Collins, CO 80524, USA","module_width":44.5,"module_length":88.8,"number_rows":"5","number_columns":5,"pole_mount_section":"4_40","core_pipe_width":65,"core_pipe_section":"2_40","adjuster_section":"2_40","core_beam_height":65,"core_beam_section":"HSS3x2x1/8","main_pipe_section":"2_12GA","pole_spacing":"15","tilt_angle":46,"ground_clearance":12,"risk_category":"I","exposure_category":"C","frame_duty_override":"auto","pole_override":"auto","soil_type":"sand","customer_foundation_override":"48_Square","foundation_type":"Square","foundation_size":48,"check_rails":true,"wind_speed_override":145,"snow_load_override":45,"direct_snow_load":false,"add_angle_brace":false}
```

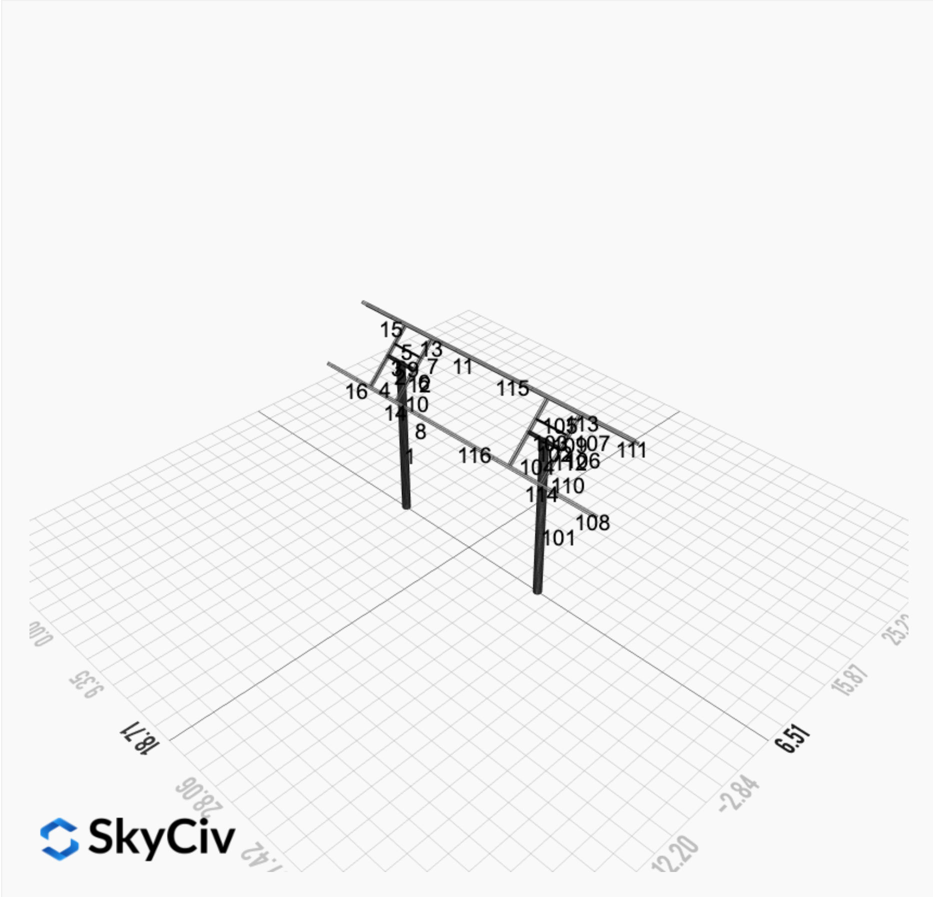

Design Notes:

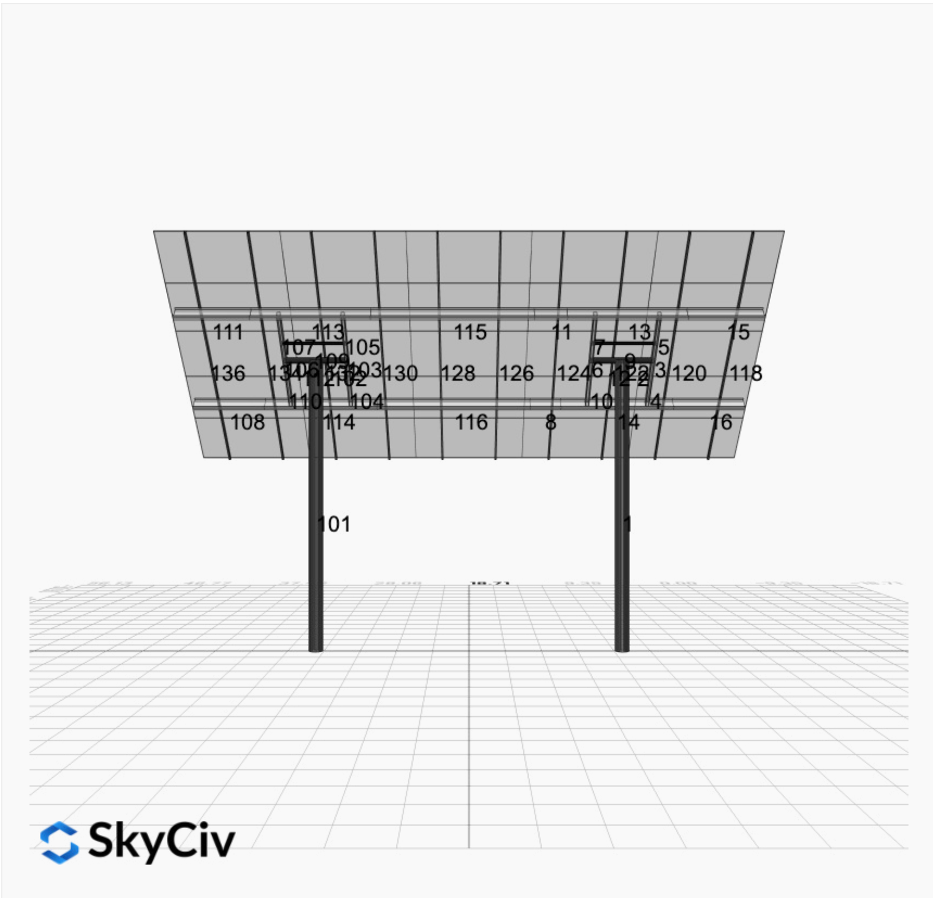
- AISC Deflection checks are set to L/1 due to structure design intent
- Foundation Soil Parameters used in this Autodesign are all estimates, proper geotechnical reports are required to confirm soil profiles
- Wind speeds, snow loads and other site specific results are based on ASCE 7 2016
- Steel frame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




101
-2.84
6.51
15.87

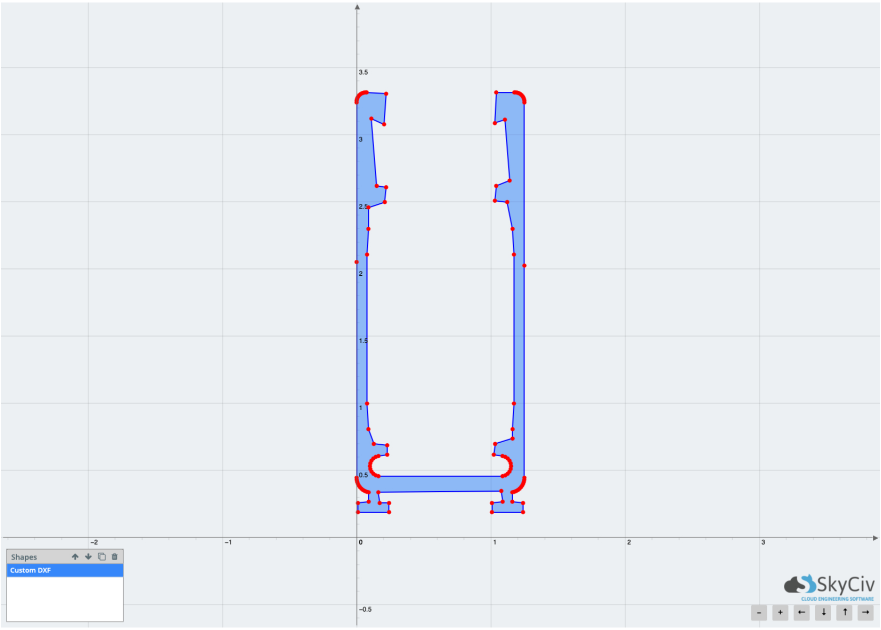

15
16
4
3
5
2
9
13
14
12
10
6
7
11
8
116
115
104
103
105
102
114
109
113
112
110
106
107
108
111


15
13
11
115
16
14
10
8
1
116
113
107
111
126
110
114
108
101
0.00
9.35
18.71
28.06
6.51
15.87
-2.84
12.20
SkyCiv

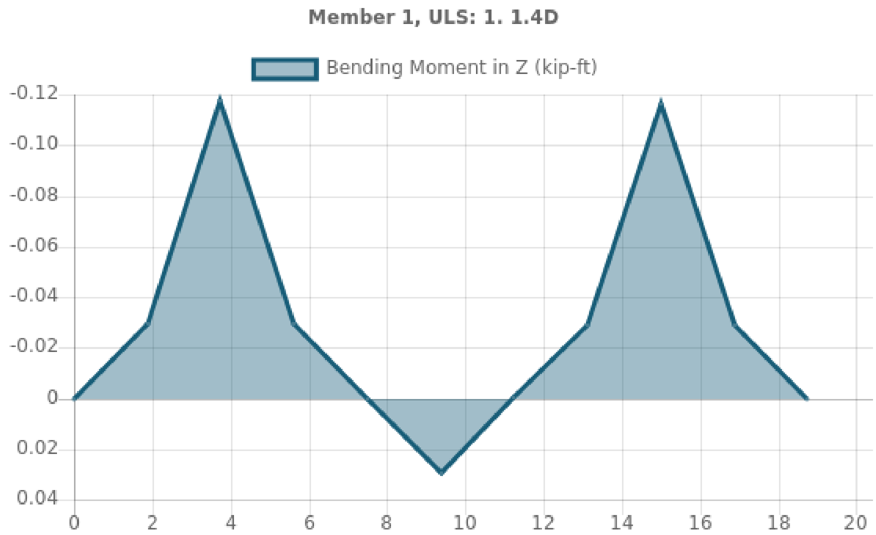

111
113
105
115
11
13
15
107
7
5
136
130
128
126
124
120
118
110
104
10
4
108
114
116
8
14
16
101
1
SkyCiv

Rail Design Check

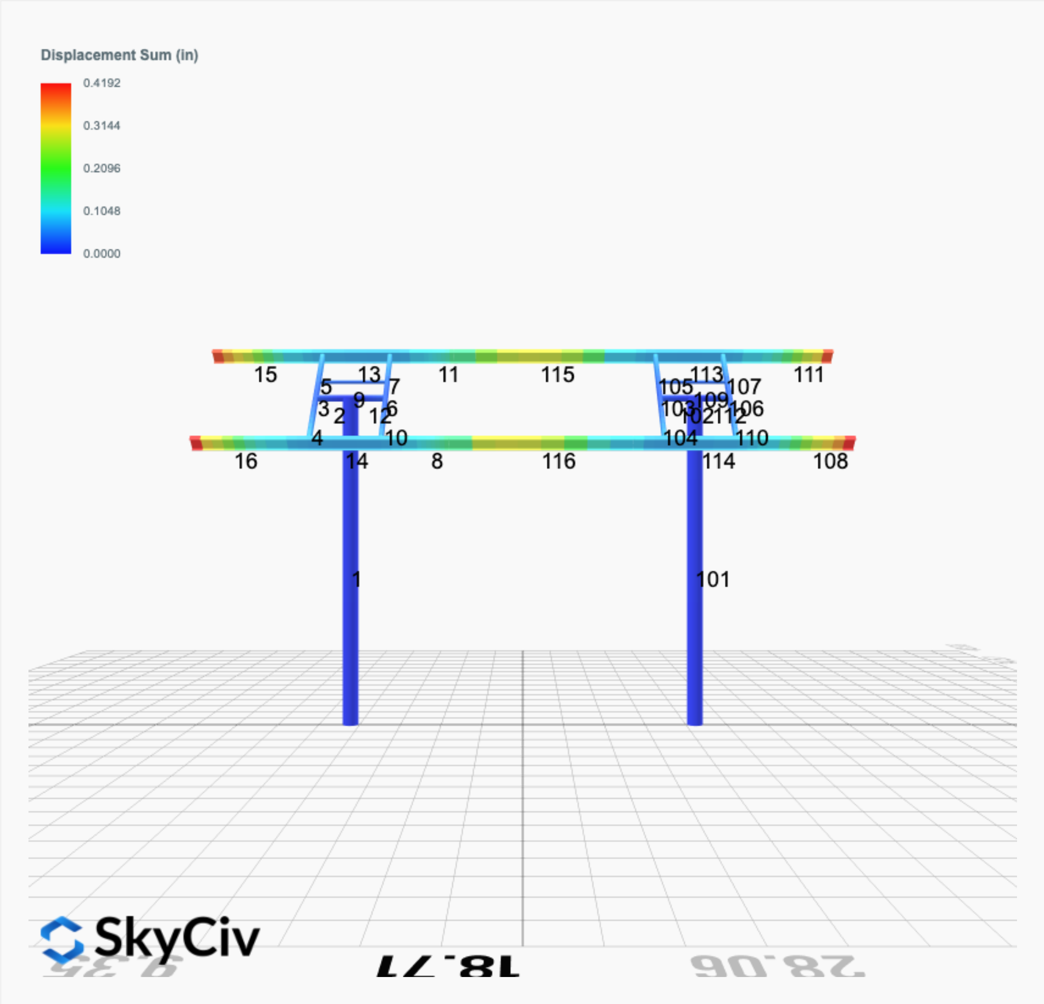
Rail Length: 18.75 ft
Additional Restraints Required: 4ft Spread Clamps
Tributary Width: 3.7416666666666667 ft
Material: Aluminium
Density: 169 lb/ft^3
Elasticity Modulus: 10000 ksi
Fy: 34.5 ksi
Fu: 37 ksi
Snow (X): 0.0309 kip/ft
Snow (Y): -0.0320 kip/ft
Wind uplift Case A: 0.1450 kip/ft
Wind downforce Case A: 0.1450 kip/ft
Dead (Panel load) (X): 0.0115 kip/ft
Dead (Panel load) (Y): -0.0119 kip/ft

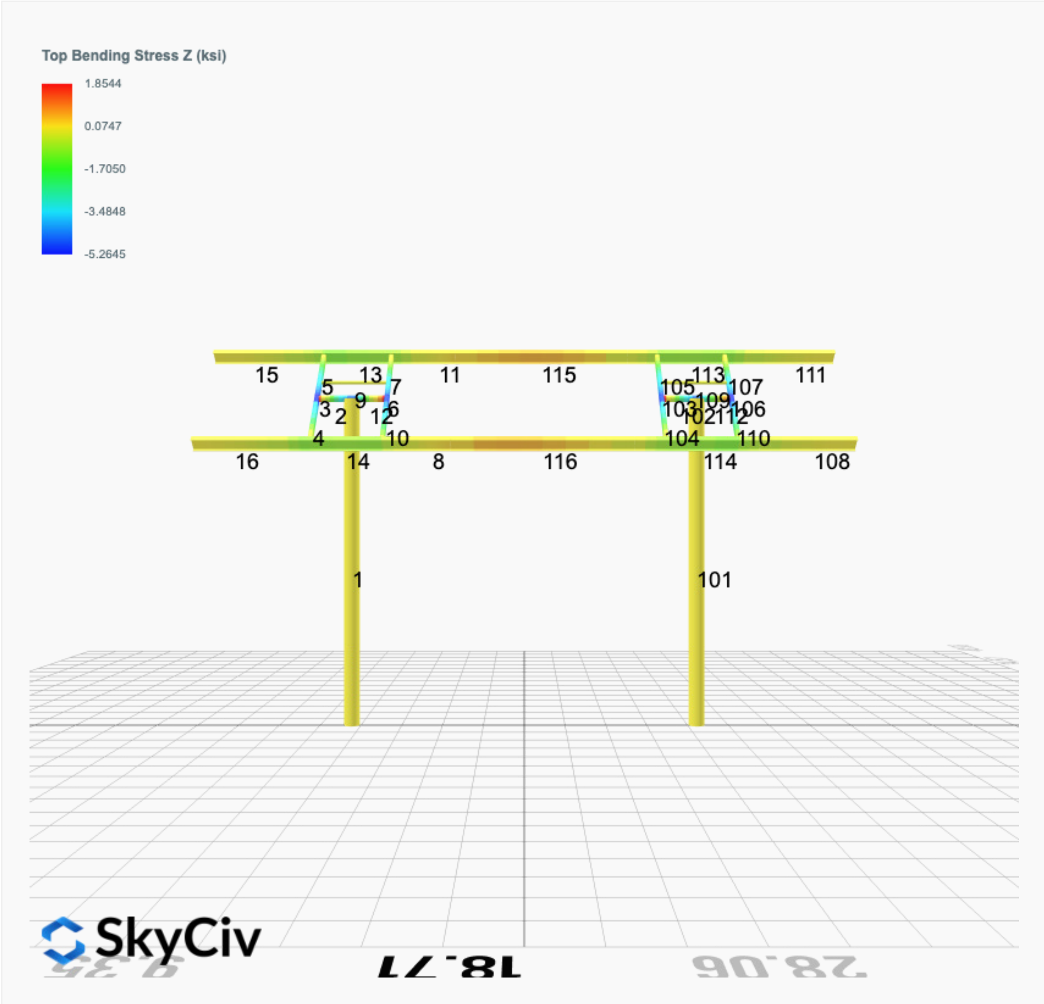


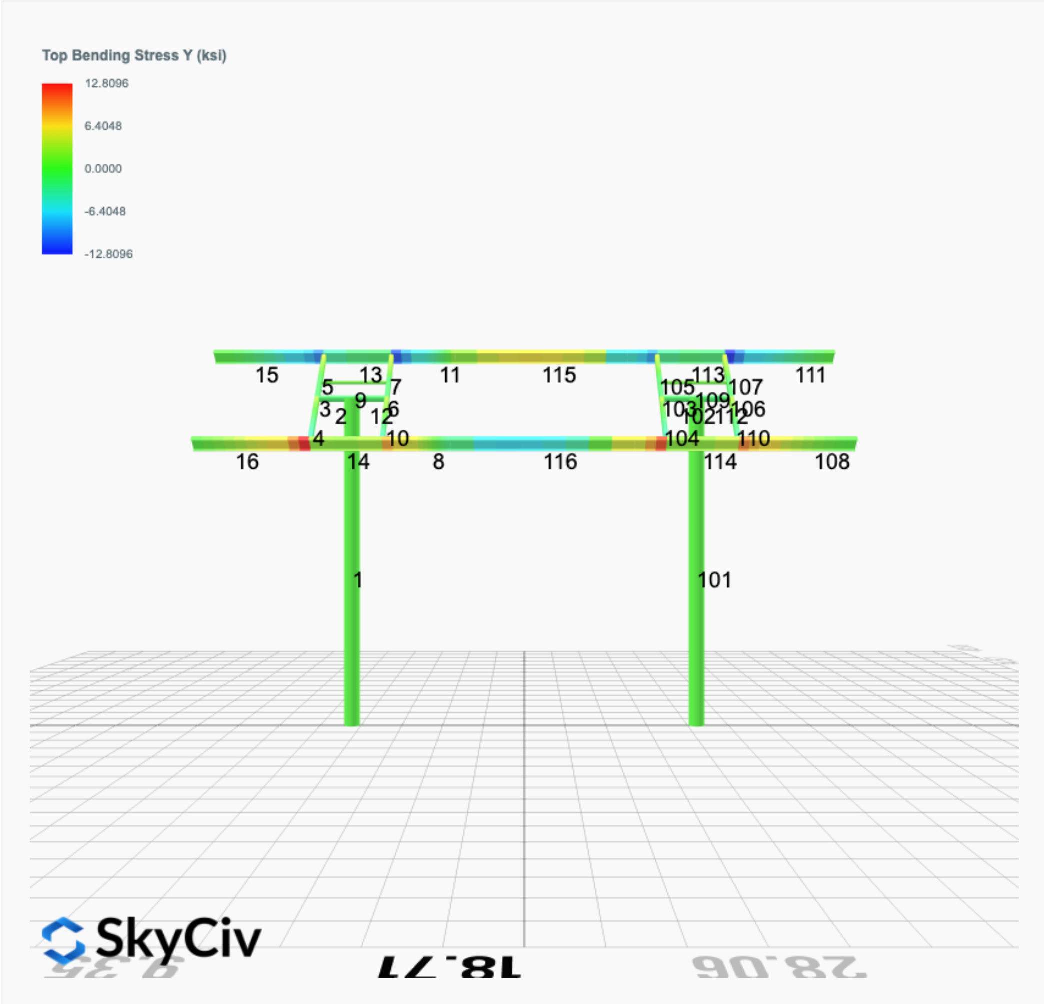
Result Check	Max Limit	Max Value	Utility	Status
Custom Stress Limit	34.5	26.64235539	0.772	PASS
Material Yield	34.5	26.64235539	0.772	PASS
Material Strength	37	26.64235539	0.720	PASS

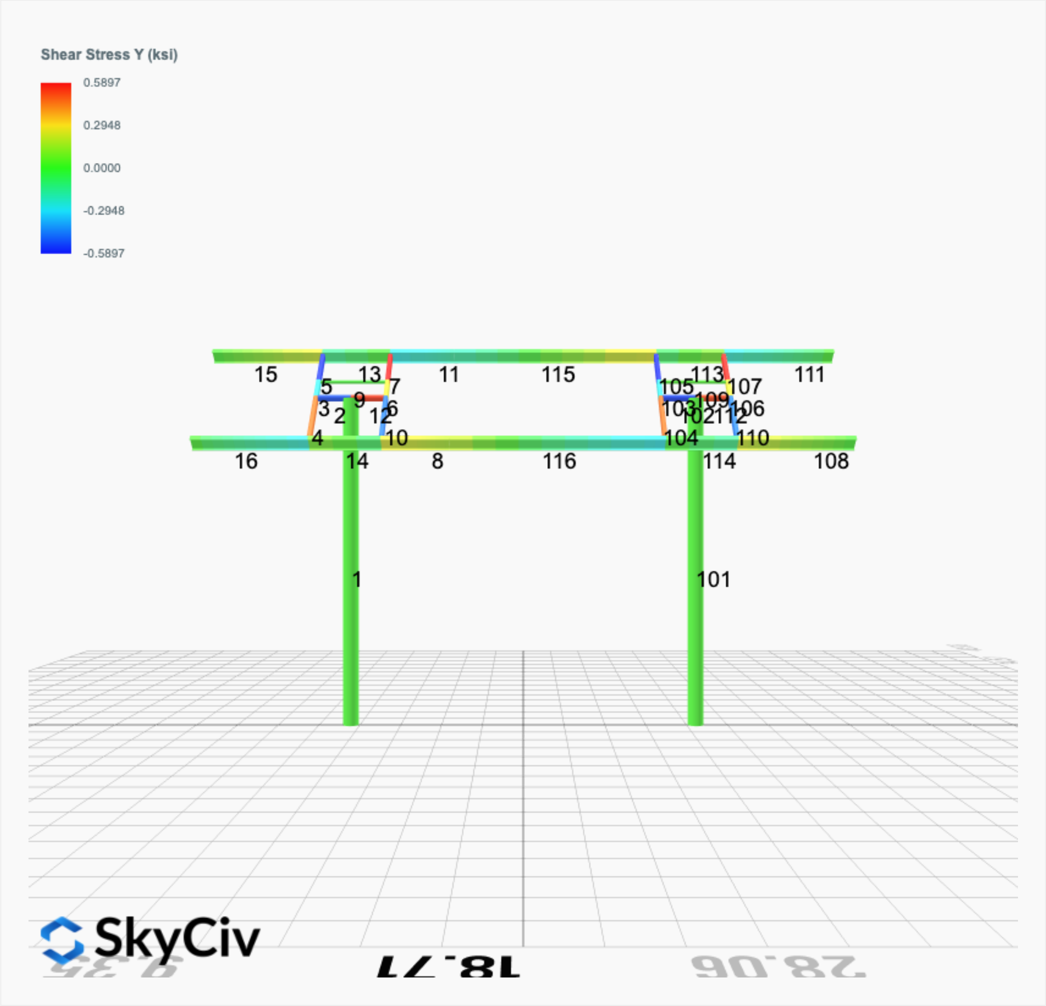


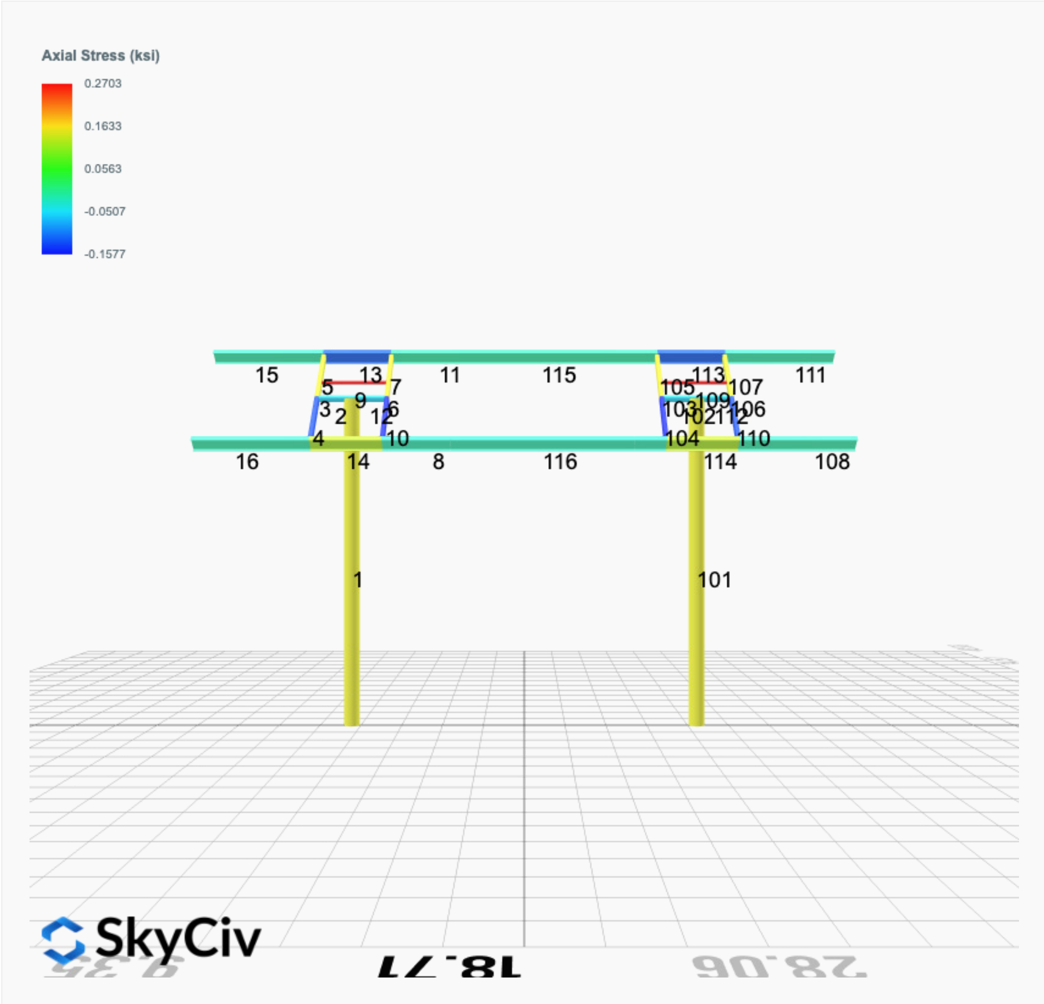
FEM Results (Envelope Worst Case for each member)




Top Bending Stress Z (ksi)
1.8544
0.0747
-1.7050
-3.4848
-5.2645
15
13
7
11
115
105
113
107
111
5
3
2
9
12
6
103
109
102
112
106
4
10
104
110
16
14
8
116
114
108
1
101
SkyCiv
18.71


Top Bending Stress Y (ksi)
12.8096
6.4048
0.0000
-6.4048
-12.8096
15
13
7
11
115
105
113
107
111
5
9
3
2
12
6
103
109
102
112
106
4
10
104
110
16
14
8
116
114
108
1
101
SkyCiv
18.71
28.06


Shear Stress Y (ksi)
0.5897
0.2948
0.0000
-0.2948
-0.5897
15
13
11
115
113
111
5
7
105
107
3
2
9
12
6
103
109
102
112
106
4
10
104
110
16
14
8
116
114
108
1
101
SkyCiv
18.71
28.06


Axial Stress (ksi)
0.2703
0.1633
0.0563
-0.0507
-0.1577
15
13
11
115
113
111
5
7
105
107
3
2
9
12
6
103
109
102
112
106
4
10
104
110
16
14
8
116
114
108
1
101
SkyCiv
18.71
28.06

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

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	0.0000	3.4733	-0.0002	0.0015	0.0705	0.0252
ULS: 2. D + L	0.0000	3.4733	-0.0002	0.0015	0.0705	0.0252
ULS: 3. D + (S or Lr or R)	0.0000	6.3156	-0.0004	0.0047	0.1698	0.0336
ULS: 3. D + (S or Lr or R)	0.0000	3.4733	-0.0002	0.0015	0.0705	0.0252
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	5.6051	-0.0003	0.0039	0.1450	0.0315
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	3.4733	-0.0002	0.0015	0.0705	0.0252
ULS: 5b. D + 0.7E	0.0000	3.4733	-0.0002	0.0015	0.0705	0.0252
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0000	5.6051	-0.0003	0.0039	0.1450	0.0315
ULS: 8. 0.6D + 0.7E	0.0000	2.0840	-0.0001	0.0009	0.0423	0.0151
ULS: 5a. D + 0.6W_Wind downforce Case A only	-5.8673	9.1393	-0.0253	-0.1396	0.2684	112.5358
ULS: 5a. D + 0.6W_Wind downforce Case B only	0.0000	3.4733	-0.0002	0.0015	0.0705	0.0252
ULS: 5a. D + 0.6W_Wind uplift Case A only	5.8673	-2.1927	0.0248	0.1418	-0.1277	-107.5486
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.0000	3.4733	-0.0002	0.0015	0.0705	0.0252
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-4.4005	9.8546	-0.0192	-0.1020	0.2934	84.4144
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0000	5.6051	-0.0003	0.0039	0.1450	0.0315
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	4.4005	1.3556	0.0184	0.1091	-0.0037	-80.6489
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0000	5.6051	-0.0003	0.0039	0.1450	0.0315
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-4.4005	7.7228	-0.0190	-0.1043	0.2189	84.4082
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0000	3.4733	-0.0002	0.0015	0.0705	0.0252
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	4.4005	-0.7762	0.0185	0.1067	-0.0782	-80.6551
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0000	3.4733	-0.0002	0.0015	0.0705	0.0252
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-5.8673	7.7500	-0.0252	-0.1402	0.2402	112.5257
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	0.0000	2.0840	-0.0001	0.0009	0.0423	0.0151
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	5.8673	-3.5820	0.0249	0.1412	-0.1559	-107.5587
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.0000	2.0840	-0.0001	0.0009	0.0423	0.0151

Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	15.0325
Shear X	-9.7789
Shear Z	-0.0424
Moment X	0.2386
Moment Y (Twist)	0.4654
Moment Z	190.2581

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	9.8546
Shear X	-5.8673
Shear Z	-0.0253
Moment X	0.1418
Moment Y (Twist)	0.2934
Moment Z	112.5358

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	3.4733	0.0002	-0.0015	-0.0705	0.0253
ULS: 2. D + L	-0.0000	3.4733	0.0002	-0.0015	-0.0705	0.0253
ULS: 3. D + (S or Lr or R)	-0.0000	6.3157	0.0004	-0.0047	-0.1698	0.0336
ULS: 3. D + (S or Lr or R)	-0.0000	3.4733	0.0002	-0.0015	-0.0705	0.0253
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0000	5.6051	0.0003	-0.0039	-0.1450	0.0315

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0000	3.4733	0.0002	-0.0015	-0.0705	0.0253
ULS: 5b. D + 0.7E	-0.0000	3.4733	0.0002	-0.0015	-0.0705	0.0253
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0000	5.6051	0.0003	-0.0039	-0.1450	0.0315
ULS: 8. 0.6D + 0.7E	-0.0000	2.0840	0.0001	-0.0009	-0.0423	0.0152
ULS: 5a. D + 0.6W_Wind downforce Case A only	-5.8673	9.1393	0.0253	0.1396	-0.2684	112.5358
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.0000	3.4733	0.0002	-0.0015	-0.0705	0.0253
ULS: 5a. D + 0.6W_Wind uplift Case A only	5.8673	-2.1927	-0.0248	-0.1418	0.1277	-107.5485
ULS: 5a. D + 0.6W_Wind uplift Case B only	-0.0000	3.4733	0.0002	-0.0015	-0.0705	0.0253
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-4.4005	9.8546	0.0192	0.1020	-0.2934	84.4144
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0000	5.6051	0.0003	-0.0039	-0.1450	0.0315
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	4.4005	1.3556	-0.0184	-0.1090	0.0037	-80.6489
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0000	5.6051	0.0003	-0.0039	-0.1450	0.0315
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-4.4005	7.7228	0.0190	0.1043	-0.2189	84.4082
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0000	3.4733	0.0002	-0.0015	-0.0705	0.0253
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	4.4005	-0.7762	-0.0185	-0.1067	0.0782	-80.6551
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0000	3.4733	0.0002	-0.0015	-0.0705	0.0253
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-5.8673	7.7500	0.0252	0.1402	-0.2402	112.5257
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.0000	2.0840	0.0001	-0.0009	-0.0423	0.0152
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	5.8673	-3.5820	-0.0249	-0.1411	0.1559	-107.5587
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	-0.0000	2.0840	0.0001	-0.0009	-0.0423	0.0152

Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	15.0325
Shear X	-9.7789
Shear Z	0.0424
Moment X	-0.2383
Moment Y (Twist)	0.4658
Moment Z	190.2596

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	9.8546
Shear X	-5.8673
Shear Z	0.0253
Moment X	-0.1418
Moment Y (Twist)	0.2934
Moment Z	112.5358

Project Details

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

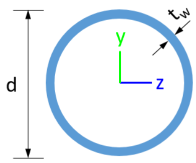
User Name: sales@mtsolar.us
Project Name: Uthmann Family Feeders - 5x5 - V1Jb
Unit System: imperial

Design Input Information

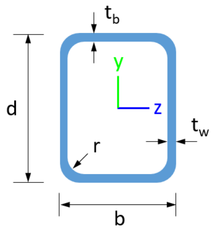
Design Factors			
Φ_t	Φ_c	Φ_b	Φ_v
0.9	0.9	0.9	0.9

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

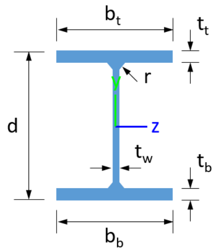
Section Dimensions



ID	Name	d (in)	t_w (in)					
3	2in Pipe Sch 120	2.38	0.25					
6	4in Pipe Sch 120	4.50	0.44					
12	10in Pipe Sch 80	10.75	0.59					



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
12	10in Pipe Sch 80	18.92	489.69	244.84	244.84	0.00	61.25	61.25
17	HSS5x3x1/4	3.37	11.00	4.81	10.70	0.93	3.77	5.38
20	W10x12	3.54	0.05	2.18	53.80	50.90	1.74	12.60

Member Properties								
Member ID	Section ID	K_zL (ft)	K_yL (ft)	L_b(ft)	C_b	LST	LSC	LD
1	12	39.36	39.36	18.74	-	300	200	1
2	6	1.30	1.30	2.00	-	300	200	1
3	17	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.19,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19	300	200	1
4	17	2.44	2.44	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.67,1.65,1.67,1.67,1.69,1.66,1.69,1.67,1.69,1.66,1.69	300	200	1
5	17	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.67,1.68	300	200	1
6	17	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.19,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.17,1.19,1.18,1.19,1.18,1.19	300	200	1
7	17	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.67,1.68	300	200	1
8	20	1.33	1.33	2.05	2.20,2.21,2.20,2.21,2.21,2.20,2.16,2.21,2.13,2.21,2.16,2.20,2.14,2.20,2.18,2.21,2.11,2.21,2.16,2.20,2.13,2.20,2.15,2.20,2.14,2.20	300	200	1
9	3	2.60	2.60	4.00	-	300	200	1
10	17	2.44	2.44	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.67,1.65,1.67,1.67,1.69,1.66,1.69,1.67,1.69,1.66,1.69	300	200	1
11	20	1.33	1.33	2.05	2.21,2.21,2.21,2.21,2.21,2.21,2.16,2.21,2.13,2.21,2.15,2.21,2.14,2.21,2.17,2.21,2.11,2.21,2.16,2.21,2.13,2.21,2.15,2.21,2.14,2.21	300	200	1
12	6	1.30	1.30	2.00	-	300	200	1
13	20	4.88	4.00	7.50	1.09,1.09,1.09,1.09,1.09,1.09,1.10,1.09,1.10,1.09,1.10,1.09,1.10,1.09,1.09,1.09,1.10,1.09,1.10,1.09,1.10,1.09,1.10,1.09,1.10,1.09	300	200	1
14	20	4.88	4.00	7.50	1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.10,1.09,1.09,1.09,1.10,1.09,1.09,1.09,1.10,1.09,1.09,1.09,1.10,1.09,1.09,1.09,1.10,1.09	300	200	1
15	20	9.97	9.97	4.75	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	9.97	9.97	4.75	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
101	12	39.36	39.36	18.74	-	300	200	1
102	6	1.30	1.30	2.00	-	300	200	1
103	17	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.19,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.17,1.19,1.18,1.19,1.18,1.19	300	200	1
104	17	2.44	2.44	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.67,1.65,1.67,1.67,1.69,1.66,1.69,1.67,1.69,1.66,1.69	300	200	1
105	17	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.67,1.68	300	200	1
106	17	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.19,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19	300	200	1
107	17	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.67,1.68	300	200	1
108	20	9.97	9.97	4.75	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
109	3	2.60	2.60	4.00	-	300	200	1
110	17	2.44	2.44	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.67,1.65,1.67,1.67,1.69,1.66,1.69,1.67,1.69,1.66,1.69	300	200	1
111	20	9.97	9.97	4.75	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
112	6	1.30	1.30	2.00	-	300	200	1

113	20	4.88	4.00	7.50	1.09,1.09,1.09,1.09,1.09,1.09,1.10,1.09,1.10,1.09,1.10,1.09,1.10,1.09,1.09,1.09,1.10,1.09,1.10,1.09,1.10,1.09,1.10,1.09,1.10,1.09	300	200	1
114	20	4.88	4.00	7.50	1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.10,1.09,1.09,1.09,1.10,1.09,1.09,1.09,1.10,1.09,1.09,1.09,1.10,1.09,1.09,1.09,1.10,1.09	300	200	1
115	20	6.63	6.63	10.20	1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17	300	200	1
116	20	6.63	6.63	10.20	1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17	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	851.50	247.92	229.67	229.67	255.45	255.45
2	251.01	248.88	27.16	27.16	75.30	75.30
3	151.65	150.70	20.17	14.14	54.12	28.95
4	151.65	145.15	20.17	14.14	54.12	28.95
5	151.65	149.10	20.17	14.14	54.12	28.95
6	151.65	150.70	20.17	14.14	54.12	28.95
7	151.65	149.10	20.17	14.14	54.12	28.95
8	159.30	140.46	46.90	6.46	56.26	44.91
9	75.10	66.32	4.25	4.25	22.53	22.53
10	151.65	145.15	20.17	14.14	54.12	28.95
11	159.30	140.46	46.90	6.46	56.26	44.91
12	251.01	248.88	27.16	27.16	75.30	75.30
13	159.30	97.43	33.40	6.46	56.26	44.91
14	159.30	97.43	33.37	6.46	56.26	44.91
15	159.30	34.37	46.90	6.46	56.26	44.91
16	159.30	34.37	46.90	6.46	56.26	44.91
101	851.50	247.92	229.67	229.67	255.45	255.45
102	251.01	248.88	27.16	27.16	75.30	75.30
103	151.65	150.70	20.17	14.14	54.12	28.95
104	151.65	145.15	20.17	14.14	54.12	28.95
105	151.65	149.10	20.17	14.14	54.12	28.95
106	151.65	150.70	20.17	14.14	54.12	28.95
107	151.65	149.10	20.17	14.14	54.12	28.95
108	159.30	34.37	46.90	6.46	56.26	44.91
109	75.10	66.32	4.25	4.25	22.53	22.53
110	151.65	145.15	20.17	14.14	54.12	28.95
111	159.30	34.37	46.90	6.46	56.26	44.91
112	251.01	248.88	27.16	27.16	75.30	75.30
113	159.30	97.43	33.40	6.46	56.26	44.91
114	159.30	97.43	33.37	6.46	56.26	44.91
115	159.30	75.13	22.45	6.46	56.26	44.91
116	159.30	75.13	22.45	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	0.061	0.828	0.002	0.038	0.000	0.860	#13	0.657	Not Required	Pass
2	0.003	0.427	0.347	0.091	0.067	0.776	#13	0.036	Not Required	Pass
3	0.008	0.776	0.046	0.077	0.004	0.806	#13	0.046	Not Required	Pass
4	0.008	0.774	0.155	0.077	0.033	0.826	#13	0.082	Not Required	Pass

4	0.008	0.774	0.155	0.077	0.033	0.826	#13	0.082	Not Required	Pass
5	0.008	0.482	0.160	0.077	0.041	0.503	#13	0.076	Not Required	Pass
6	0.009	0.753	0.052	0.075	0.005	0.785	#13	0.046	Not Required	Pass
7	0.009	0.468	0.160	0.074	0.042	0.492	#13	0.076	Not Required	Pass
8	0.000	0.050	0.161	0.048	0.019	0.197	#21	0.102	Not Required	Pass
9	0.016	0.061	0.064	0.001	0.000	0.128	#13	0.206	Not Required	Pass
10	0.009	0.750	0.156	0.075	0.034	0.814	#13	0.082	Not Required	Pass
11	0.000	0.050	0.164	0.048	0.019	0.200	#21	0.102	Not Required	Pass
12	0.003	0.407	0.330	0.089	0.065	0.738	#13	0.036	Not Required	Pass
13	0.007	0.299	0.445	0.062	0.024	0.644	#21	0.306	Not Required	Pass
14	0.010	0.303	0.445	0.062	0.024	0.644	#21	0.204	Not Required	Pass
15	0.000	0.106	0.237	0.037	0.014	0.313	#21	Not Required	Not Required	Pass
16	0.000	0.106	0.237	0.037	0.014	0.313	#21	Not Required	Not Required	Pass
101	0.061	0.828	0.002	0.038	0.000	0.860	#13	0.657	Not Required	Pass
102	0.003	0.407	0.330	0.089	0.065	0.738	#13	0.036	Not Required	Pass
103	0.009	0.753	0.052	0.075	0.005	0.785	#13	0.046	Not Required	Pass
104	0.009	0.750	0.156	0.075	0.034	0.814	#13	0.082	Not Required	Pass
105	0.009	0.468	0.160	0.074	0.042	0.492	#13	0.076	Not Required	Pass
106	0.008	0.776	0.046	0.077	0.004	0.806	#13	0.046	Not Required	Pass
107	0.008	0.482	0.160	0.077	0.041	0.503	#13	0.076	Not Required	Pass
108	0.000	0.106	0.237	0.037	0.014	0.313	#21	Not Required	Not Required	Pass
109	0.016	0.061	0.064	0.001	0.000	0.128	#13	0.206	Not Required	Pass
110	0.008	0.774	0.155	0.077	0.033	0.826	#13	0.082	Not Required	Pass
111	0.000	0.106	0.237	0.037	0.014	0.313	#21	Not Required	Not Required	Pass
112	0.003	0.427	0.347	0.091	0.067	0.776	#13	0.036	Not Required	Pass
113	0.007	0.299	0.445	0.062	0.024	0.644	#21	0.204	Not Required	Pass
114	0.010	0.303	0.445	0.062	0.024	0.644	#21	0.306	Not Required	Pass
115	0.000	0.263	0.231	0.048	0.019	0.419	#21	0.507	Not Required	Pass
116	0.000	0.263	0.233	0.048	0.019	0.421	#21	0.507	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

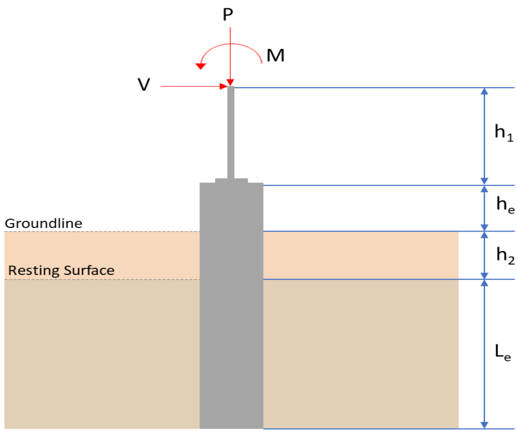
SkyCiv Foundation Design

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
$L = 10.25\ \mathrm{ft}$ - 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)	9.855	15.032
V_x (kip)	-5.867	-9.779
V_z (kip)	-0.025	-0.042
M_x (kipft)	0.142	0.239
M_z (kipft)	112.536	190.258

Material Properties

$f'_{ck} = 2.5\ \mathrm{ksi}$ - 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,

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

$$H_o = \frac{(-5.867\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.93424\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(112.54\text{ kipft}) + ((-5.867\text{ kip}) \times (0\text{ ft}))}{1.57 \times (48\text{ in})}$$

$$M_o = 17.92\text{ kipft/ft}$$

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:
$L_{e,x} = 9.6322\text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.025\text{ kip})}{1.57 \times (48\text{ in})}$$

$$H_o = -0.0039809\text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.142\text{ kipft}) + ((-0.025\text{ kip}) \times (0\text{ ft}))}{1.57 \times (48\text{ in})}$$

$$M_o = 0.022611\text{ kipft/ft}$$

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:
$L_{e,z} = 1.1532\text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(9.6322\text{ ft}), (1.1532\text{ ft})]$$

$$L_{e,req} = 9.632\text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (10.25\text{ ft}) - (0\text{ ft}) - (0\text{ ft})$$

$$L_e = 10.25\text{ ft}$$

$Ratio$ - Embedded depth

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

$$Ratio = \frac{(9.632\text{ ft})}{(10.25\text{ ft})}$$

$$Ratio = 0.93971$$

Status: **PASS**
Ratio: **0.940**

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

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

$$q = \frac{(9.855\ \mathrm{kip})}{(16\ \mathrm{ft}^2)}$$

$$q = 0.61594\ \mathrm{kip/ft}^2$$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{\left(0.61594\ \mathrm{kip/ft}^2\right)}{(2000\ \mathrm{psf})}$$

$$Ratio = 0.30797$$

Status: **PASS**
Ratio: **0.310**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(10.25\ \mathrm{ft})}{(48\ \mathrm{in})}$$

$$L/D = 2.5625$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.93424\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 17.92\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (17.92\ \mathrm{kipft/ft}) \times (10.25\ \mathrm{ft})) + \left(3 \times (-0.93424\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft})^2\right)}{(6 \times (17.92\ \mathrm{kipft/ft})) + (4 \times (-0.93424\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft}))}$$

$$a = 7.0577\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (17.92\ \mathrm{kipft/ft})) + (3 \times (-0.93424\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft})]^{\ 2}}{(10.25\ \mathrm{ft})^2 \times [(3 \times (17.92\ \mathrm{kipft/ft})) + (2 \times (-0.93424\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft})]}$$

$$p = 0.38054\ \mathrm{kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (17.92\ \mathrm{kipft/ft})) + ((-0.93424\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft})]}{(10.25\ \mathrm{ft})^2}$$

$$s = 1.5\ \mathrm{kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \mathrm{psf/ft}) \times \frac{(7.0577\ \mathrm{ft})}{2}$$

$$p_a = 0.52933\ \mathrm{kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.38054\ \mathrm{kip/ft^2}\right)}{\left(0.52933\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.7189$$

Status: **PASS**
Ratio: **0.720**

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (10.25\ \mathrm{ft})$$

$$p_s = 1.5375\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(1.5\ \mathrm{kip/ft^2}\right)}{\left(1.5375\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.97553$$

Status: **PASS**
Ratio: **0.980**

Considering z-direction:

$H_o = -0.0039809\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 0.022611\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.022611\ \mathrm{kipft/ft}) \times (10.25\ \mathrm{ft})) + \left(3 \times (-0.0039809\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft})^2\right)}{(6 \times (0.022611\ \mathrm{kipft/ft})) + (4 \times (-0.0039809\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft}))}$$

$$a = 7.2998\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.022611\ \mathrm{kipft/ft})) + (3 \times (-0.0039809\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft}))]^{\,2}}{(10.25\ \mathrm{ft})^2 \times [(3 \times (0.022611\ \mathrm{kipft/ft})) + (2 \times (-0.0039809\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft}))]}$$

$$p = -0.0005296\ \mathrm{kip/ft^2}$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (0.022611\ \mathrm{kipft/ft})) + ((-0.0039809\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft}))]}{(10.25\ \mathrm{ft})^2}$$

$$s = 0.00025235\ \mathrm{kip/ft^2}$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \mathrm{psf/ft}) \times \frac{(7.2998\ \mathrm{ft})}{2}$$

$$p_a = 0.54748\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(-0.0005296\ \mathrm{kip/ft^2}\right)}{\left(0.54748\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = -0.00096734$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (10.25\ \mathrm{ft})$$

$$p_s = 1.5375\ \mathrm{kip/ft^2}$$

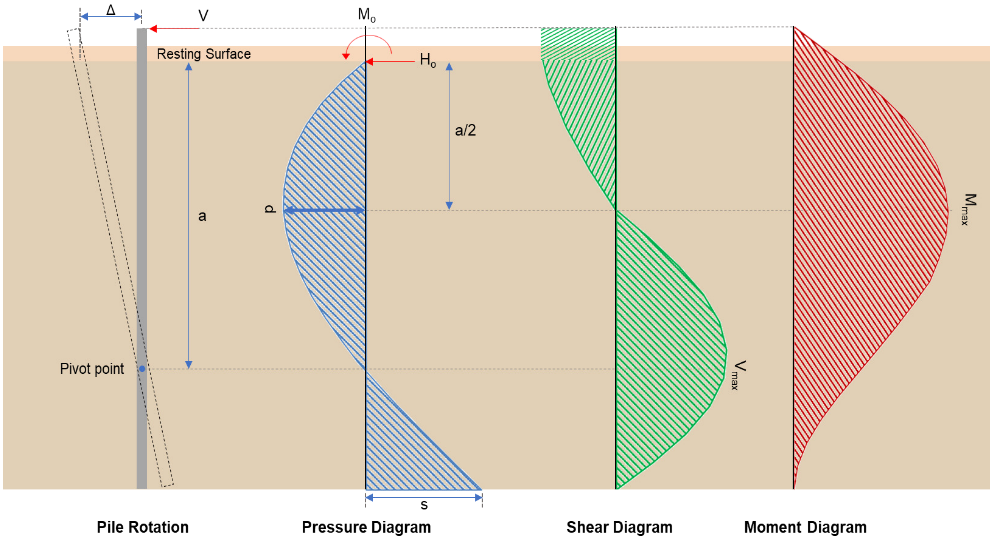
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.00025235\ \mathrm{kip/ft^2})}{(1.5375\ \mathrm{kip/ft^2})}$$

$$Ratio = 0.00016413$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-9.779\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -1.5572\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(190.26\ \mathrm{kipft}) + ((-9.779\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 30.296\ \mathrm{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(30.296\ \mathrm{kipft/ft})}{(-1.5572\ \mathrm{kip/ft})}$$

$$E = 19.456\ \mathrm{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (30.296\ \mathrm{kipft/ft}) \times (10.25\ \mathrm{ft})) + \left(3 \times (-1.5572\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft})^2\right)}{}$$

$$a = \frac{}{(6 \times (30.296\ \mathrm{kipft/ft})) + (4 \times (-1.5572\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft}))}$$

$$a = 7.0554\ \mathrm{ft}$$

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

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

$$V_{max} = ((-1.5572\ \mathrm{kip/ft}) \times (48\ \mathrm{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (19.456\ \mathrm{ft})}{(10.25\ \mathrm{ft})} + 3\right) \times \left(\frac{(7.0554\ \mathrm{ft})}{(10.25\ \mathrm{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (19.456\ \mathrm{ft})}{(10.25\ \mathrm{ft})} + 2\right) \times \left(\frac{(7.0554\ \mathrm{ft})}{(10.25\ \mathrm{ft})}\right)^3\right]\right]$$

$$V_{max} = 25.031\ \mathrm{kip}$$

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

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

$$M_{max} = ((-1.5572\ \mathrm{kip/ft}) \times (48\ \mathrm{in}) \times (10.25\ \mathrm{ft})) \times \left[\left(\frac{(19.456\ \mathrm{ft})}{(10.25\ \mathrm{ft})} + \frac{(7.0554\ \mathrm{ft})}{2 \times (10.25\ \mathrm{ft})}\right) - \left[\left(\frac{4 \times (19.456\ \mathrm{ft})}{(10.25\ \mathrm{ft})} + 3\right) \times \left(\frac{(7.0554\ \mathrm{ft})}{2 \times (10.25\ \mathrm{ft})}\right)^3\right] + \left[\left(\frac{3 \times (19.456\ \mathrm{ft})}{(10.25\ \mathrm{ft})} + 2\right) \times \left(\frac{(7.0554\ \mathrm{ft})}{2 \times (10.25\ \mathrm{ft})}\right)^4\right]\right]$$

$$M_{max} = 122.48\ \mathrm{kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.042\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.0066879\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.239\ \mathrm{kipft}) + ((-0.042\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 0.038057\ \mathrm{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.038057\ \mathrm{kipft/ft})}{(-0.0066879\ \mathrm{kip/ft})}$$

$$E = 5.6905\ \mathrm{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.038057\ \mathrm{kipft/ft}) \times (10.25\ \mathrm{ft})) + \left(3 \times (-0.0066879\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft})^2\right)}{(6 \times (0.038057\ \mathrm{kipft/ft})) + (4 \times (-0.0066879\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft}))}$$

$$a = 7.2994\ \mathrm{ft}$$

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

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

$$V_{max} = ((-0.0066879\ \text{kip/ft}) \times (48\ \text{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (5.6905\ \text{ft})}{(10.25\ \text{ft})} + 3\right) \times \left(\frac{(7.2994\ \text{ft})}{(10.25\ \text{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (5.6905\ \text{ft})}{(10.25\ \text{ft})} + 2\right) \times \left(\frac{(7.2994\ \text{ft})}{(10.25\ \text{ft})}\right)^3\right]\right]$$

$$V_{max} = 0.044076\ \text{kip}$$

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

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

$$M_{max} = ((-0.0066879\ \text{kip/ft}) \times (48\ \text{in}) \times (10.25\ \text{ft})) \times \left[\left(\frac{(5.6905\ \text{ft})}{(10.25\ \text{ft})} + \frac{(7.2994\ \text{ft})}{2 \times (10.25\ \text{ft})}\right) - \left[\left(\frac{4 \times (5.6905\ \text{ft})}{(10.25\ \text{ft})} + 3\right) \times \left(\frac{(7.2994\ \text{ft})}{2 \times (10.25\ \text{ft})}\right)^3\right] + \left[\left(\frac{3 \times (5.6905\ \text{ft})}{(10.25\ \text{ft})} + 2\right) \times \left(\frac{(7.2994\ \text{ft})}{2 \times (10.25\ \text{ft})}\right)^4\right]\right]$$

$$M_{max} = 0.2014\ \text{kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

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

Longitudinal reinforcement:

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

22.4.2.2, 10.6.1.1 $A_{st,required}$

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

$$A_{st,required} = Min\left[\frac{\frac{(15.032\ \text{kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5\ \text{ksi}) \times (2304\ \text{in}^2))}{(60\ \text{ksi}) - (0.85 \times (2.5\ \text{ksi}))}, (0.08 \times (2304\ \text{in}^2))\right]$$

$$A_{st,required} = -84.097\ \text{in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[(-84.097\ \text{in}^2), (0.0018 \times (2304\ \text{in}^2))\right]$$

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

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,

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

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

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

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,

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

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

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

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

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

$$\phi P_N = (0.65) \times 0.80 \times \left[\left(0.85 \times (2.5\ \text{ksi}) \times \left[\left(2304\ \text{in}^2\right) - \left(4.2951\ \text{in}^2\right)\right]\right) + \left((60\ \text{ksi}) \times \left(4.2951\ \text{in}^2\right)\right)\right]$$

$$\phi P_N = 2675.2\ \text{kip}$$

$Ratio$ - Capacity

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

$$Ratio = \frac{(15.032\ \text{kip})}{(2675.2\ \text{kip})}$$

$$Ratio = 0.0056191$$

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

Shear Strength (ACI 318-19, LRFD)

Parameters:

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

22.5.2.2 d - Effective depth

$$d = 0.80\ D$$

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

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

22.5.5.1.3 λ_s - size effect modification factor

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

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

$$\lambda_s = 0.64282$$

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

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

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

$$V_{c,max} = 5 \times (0.64282) \times \sqrt{(2500\ \text{psi})} \times (48\ \text{in}) \times (38.4\ \text{in})$$

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

The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 15.032 \text{ kip} \rightarrow 15032 \text{ lbf}$,

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

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(15032 \text{ lbf})}{6 \times (2304 \text{ in}^2)}\right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 120.49 \text{ kip}$$

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

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

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

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

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

V_c - Governing shear strength of concrete

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

$$V_c = Min\left[(296.21 \text{ kip}), (120.49 \text{ kip}), (348.89 \text{ kip})\right]$$

$$V_c = 120.49 \text{ kip}$$

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

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

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

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

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

A_v - Ties rebar area,

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

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

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

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

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

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

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

V_s - Governing shear strength of steel

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

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

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

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((120.49 \text{ kip}) + (50.894 \text{ kip}))$$

$$\phi V_n = 111.4 \text{ kip}$$

Considering x-direction:

$V_{max} = 25.031 \text{ kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

	$$Ratio = \frac{(25.031 \text{ kip})}{(111.4 \text{ kip})}$$ $$Ratio = 0.2247$$	Status: **PASS** Ratio: **0.220**
	Considering z-direction: $V_{max} = 0.044076 \text{ kip}$ - Maximum shear force in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{V_{max}}{\phi V_n}$$ $$Ratio = \frac{(0.044076 \text{ kip})}{(111.4 \text{ kip})}$$ $$Ratio = 0.00039566$$	Status: **PASS** Ratio: **0.000**
14.5.2.1b	**Flexural Strength (ACI 318-19, LRFD)** S_m - Section modulus $$S_m = \frac{b\,D^2}{6}$$ $$S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$$ $$S_m = 18432 \text{ in}^3$$ $\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$ $$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f_c')} \times S_m$$ $$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 ksi)} \times 18432.001 in^3$$ $$\phi M_{n,1} = 249.600 kipft$$ $\phi M_{n,2}$ $$\phi M_{n,2} = \phi\, 0.85\, f_{ck}'\, S_m$$ $$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times \left(18432 \text{ in}^3\right)$$ $$\phi M_{n,2} = 2121.6 \text{ kipft}$$ Therefore, ϕM_n - Allowable flexural strength, $$\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$$ $$\phi M_n = MIN[(249.6 \text{ kipft}), (2121.6 \text{ kipft})]$$ $$\phi M_n = 249.6 \text{ kipft}$$ **Considering x-direction:** $M_{max} = 122.48 \text{ kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(122.48 \text{ kipft})}{(249.6 \text{ kipft})}$$ $$Ratio = 0.4907$$	Status: **PASS** Ratio: **0.490**
	Considering z-direction: $M_{max} = 0.2014 \text{ kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$	

	$$Ratio = \frac{(0.2014\ \text{kipft})}{(249.6\ \text{kipft})}$$ $$Ratio = 0.00080687$$	Status: **PASS** Ratio: **0.000**

REFERENCES	CALCULATIONS	RESULTS

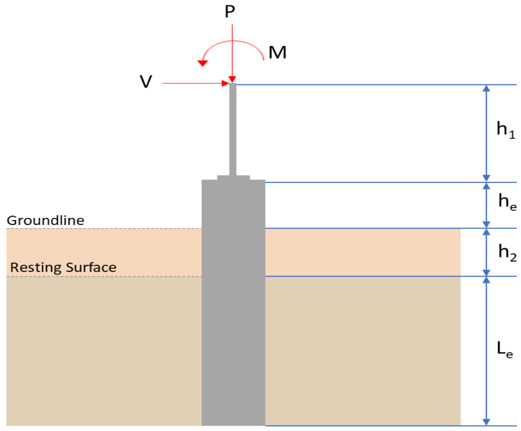
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: rectangular
$b = 48$ in - Pile width
$D = 48$ in - Pile depth
$L = 10.25$ ft - Total pile length
$h_1 = 0$ ft - Lateral load height from the top of the pile,
$h_2 = 0$ ft - Depth to resisting surface
$h_e = 0$ 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)	9.855	15.032
V_x (kip)	-5.867	-9.779
V_z (kip)	0.025	0.042
M_x (kipft)	-0.142	-0.238
M_z (kipft)	112.536	190.260

Material Properties

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

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

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

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

Considering x-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-5.867 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.93424 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(112.54\ \text{kipft}) + ((-5.867\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 17.92\ \text{kipft/ft}$$

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:
$L_{e,x} = 9.6322\ \text{ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.025\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = 0.0039809\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.142\ \text{kipft}) + ((0.025\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 0.022611\ \text{kipft/ft}$$

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:
$L_{e,z} = 1.2837\ \text{ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(9.6322\ \text{ft}), (1.2837\ \text{ft})]$$

$$L_{e,req} = 9.632\ \text{ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (10.25\ \text{ft}) - (0\ \text{ft}) - (0\ \text{ft})$$

$$L_e = 10.25\ \text{ft}$$

$Ratio$ - Embedded depth

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

$$Ratio = \frac{(9.632\ \text{ft})}{(10.25\ \text{ft})}$$

$$Ratio = 0.93971$$

Status: **PASS**
Ratio: **0.940**

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

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

$$q = \frac{(9.855\ \mathrm{kip})}{(16\ \mathrm{ft}^2)}$$

$$q = 0.61594\ \mathrm{kip/ft}^2$$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{\left(0.61594\ \mathrm{kip/ft}^2\right)}{(2000\ \mathrm{psf})}$$

$$Ratio = 0.30797$$

Status: **PASS**
Ratio: **0.310**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(10.25\ \mathrm{ft})}{(48\ \mathrm{in})}$$

$$L/D = 2.5625$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.93424\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 17.92\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (17.92\ \mathrm{kipft/ft}) \times (10.25\ \mathrm{ft})) + \left(3 \times (-0.93424\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft})^2\right)}{(6 \times (17.92\ \mathrm{kipft/ft})) + (4 \times (-0.93424\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft}))}$$

$$a = 7.0577\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times \left[(4 \times (17.92\ \mathrm{kipft/ft})) + (3 \times (-0.93424\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft}))\right]^2}{(10.25\ \mathrm{ft})^2 \times \left[(3 \times (17.92\ \mathrm{kipft/ft})) + (2 \times (-0.93424\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft}))\right]}$$

$$p = 0.38054\ \mathrm{kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times \left[(2 \times (17.92\ \mathrm{kipft/ft})) + ((-0.93424\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft}))\right]}{(10.25\ \mathrm{ft})^2}$$

$$s = 1.5\ \mathrm{kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \mathrm{psf/ft}) \times \frac{(7.0577\ \mathrm{ft})}{2}$$

$$p_a = 0.52933\ \mathrm{kip/ft}^2$$

$Ratio$ - Lateral soil capacity

	$$Ratio = \frac{p}{p_a}$$ $$Ratio = \frac{\left(0.38054\ \mathrm{kip/ft^2}\right)}{\left(0.52933\ \mathrm{kip/ft^2}\right)}$$ $$Ratio = 0.7189$$	Status: **PASS** Ratio: **0.720**
	p_s - Allowable lateral soil pressure at depth L_e, $$p_s = R\,L_e$$ $$p_s = (150\ \mathrm{psf/ft}) \times (10.25\ \mathrm{ft})$$ $$p_s = 1.5375\ \mathrm{kip/ft^2}$$ $Ratio$ - Lateral soil capacity $$Ratio = \frac{s}{p_s}$$ $$Ratio = \frac{\left(1.5\ \mathrm{kip/ft^2}\right)}{\left(1.5375\ \mathrm{kip/ft^2}\right)}$$ $$Ratio = 0.97553$$	Status: **PASS** Ratio: **0.980**
	Considering z-direction: $H_o = 0.0039809\ \mathrm{kip/ft}$ - Lateral force per length of pile, $M_o = 0.022611\ \mathrm{kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point, $$a = \frac{(4\,M_o\,L_e) + \left(3\,H_o\,L_e^2\right)}{(6\,M_o) + (4\,H_o\,L_e)}$$ $$a = \frac{(4 \times (0.022611\ \mathrm{kipft/ft}) \times (10.25\ \mathrm{ft})) + \left(3 \times (0.0039809\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft})^2\right)}{(6 \times (0.022611\ \mathrm{kipft/ft})) + (4 \times (0.0039809\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft}))}$$ $$a = 7.2998\ \mathrm{ft}$$ p - Earth pressure against the pile at distance a/2 from resting surface, $$p = \frac{0.75\,[(4\,M_o) + (3\,H_o\,L_e)]^2}{L_e^2\,[(3\,M_o) + (2\,H_o\,L_e)]}$$ $$p = \frac{0.75 \times [(4 \times (0.022611\ \mathrm{kipft/ft})) + (3 \times (0.0039809\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft}))]^2}{(10.25\ \mathrm{ft})^2 \times [(3 \times (0.022611\ \mathrm{kipft/ft})) + (2 \times (0.0039809\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft}))]}$$ $$p = 0.0021643\ \mathrm{kip/ft^2}$$ s - Earth pressure against the pile at distance L_e, $$s = \frac{6\,[(2\,M_o) + (H_o\,L_e)]}{L_e^2}$$ $$s = \frac{6 \times [(2 \times (0.022611\ \mathrm{kipft/ft})) + ((0.0039809\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft}))]}{(10.25\ \mathrm{ft})^2}$$ $$s = 0.0049129\ \mathrm{kip/ft^2}$$ **Check lateral soil pressure capacity:** p_a - Allowable lateral soil pressure at depth a/2, $$p_a = R\,\frac{a}{2}$$ $$p_a = (150\ \mathrm{psf/ft}) \times \frac{(7.2998\ \mathrm{ft})}{2}$$ $$p_a = 0.54748\ \mathrm{kip/ft^2}$$ $Ratio$ - Lateral soil capacity $$Ratio = \frac{p}{p_a}$$ $$Ratio = \frac{\left(0.0021643\ \mathrm{kip/ft^2}\right)}{\left(0.54748\ \mathrm{kip/ft^2}\right)}$$	

$$Ratio = 0.0039532$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (10.25\ \mathrm{ft})$$

$$p_s = 1.5375\ \mathrm{kip/ft^2}$$

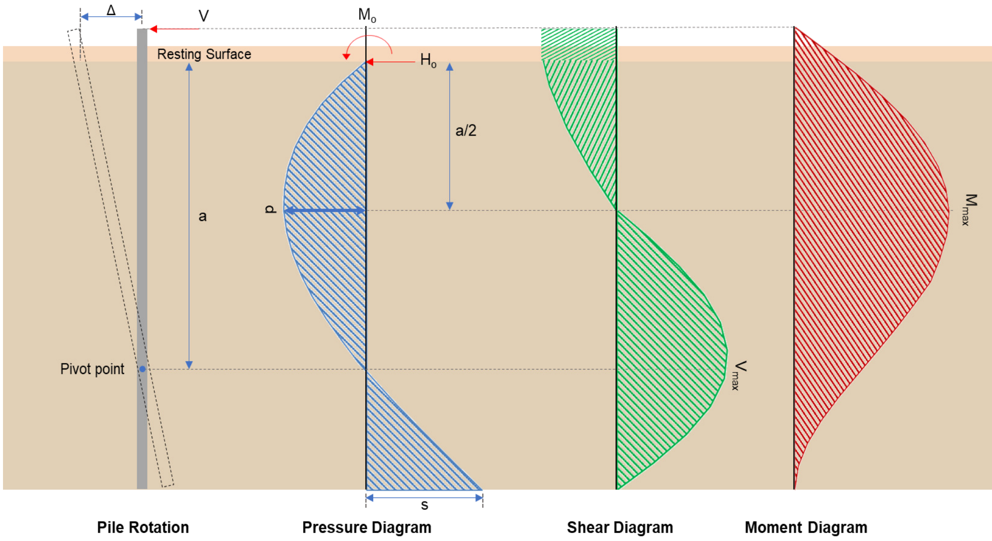
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.0049129\ \mathrm{kip/ft^2})}{(1.5375\ \mathrm{kip/ft^2})}$$

$$Ratio = 0.0031954$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-9.779\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -1.5572\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(190.26\ \mathrm{kipft}) + ((-9.779\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 30.296\ \mathrm{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(30.296\ \mathrm{kipft/ft})}{(-1.5572\ \mathrm{kip/ft})}$$

$$E = 19.456\ \mathrm{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (30.296\ \mathrm{kipft/ft}) \times (10.25\ \mathrm{ft})) + \left(3 \times (-1.5572\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft})^2\right)}{}$$

$$a = \frac{\quad}{(6 \times (30.296\ \mathrm{kipft/ft})) + (4 \times (-1.5572\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft}))}$$

$$a = 7.0554\ \mathrm{ft}$$

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

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

$$V_{max} = ((-1.5572\ \mathrm{kip/ft}) \times (48\ \mathrm{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (19.456\ \mathrm{ft})}{(10.25\ \mathrm{ft})} + 3\right) \times \left(\frac{(7.0554\ \mathrm{ft})}{(10.25\ \mathrm{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (19.456\ \mathrm{ft})}{(10.25\ \mathrm{ft})} + 2\right) \times \left(\frac{(7.0554\ \mathrm{ft})}{(10.25\ \mathrm{ft})}\right)^3\right]\right]$$

$$V_{max} = 25.031\ \mathrm{kip}$$

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

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

$$M_{max} = ((-1.5572\ \mathrm{kip/ft}) \times (48\ \mathrm{in}) \times (10.25\ \mathrm{ft})) \times \left[\left(\frac{(19.456\ \mathrm{ft})}{(10.25\ \mathrm{ft})} + \frac{(7.0554\ \mathrm{ft})}{2 \times (10.25\ \mathrm{ft})}\right) - \left[\left(\frac{4 \times (19.456\ \mathrm{ft})}{(10.25\ \mathrm{ft})} + 3\right) \times \left(\frac{(7.0554\ \mathrm{ft})}{2 \times (10.25\ \mathrm{ft})}\right)^3\right] + \left[\left(\frac{3 \times (19.456\ \mathrm{ft})}{(10.25\ \mathrm{ft})} + 2\right) \times \left(\frac{(7.0554\ \mathrm{ft})}{2 \times (10.25\ \mathrm{ft})}\right)^4\right]\right]$$

$$M_{max} = 122.48\ \mathrm{kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.042\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = 0.0066879\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.238\ \mathrm{kipft}) + ((0.042\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 0.037898\ \mathrm{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.037898\ \mathrm{kipft/ft})}{(0.0066879\ \mathrm{kip/ft})}$$

$$E = 5.6667\ \mathrm{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.037898\ \mathrm{kipft/ft}) \times (10.25\ \mathrm{ft})) + \left(3 \times (0.0066879\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft})^2\right)}{(6 \times (0.037898\ \mathrm{kipft/ft})) + (4 \times (0.0066879\ \mathrm{kip/ft}) \times (10.25\ \mathrm{ft}))}$$

$$a = 7.3003\ \mathrm{ft}$$

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

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

$$V_{max} = \left((0.0066879\ \text{kip/ft}) \times (48\ \text{in})\right) \times \left[1 - \left[3 \times \left(\frac{4 \times (5.6667\ \text{ft})}{(10.25\ \text{ft})} + 3\right) \times \left(\frac{(7.3003\ \text{ft})}{(10.25\ \text{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (5.6667\ \text{ft})}{(10.25\ \text{ft})} + 2\right) \times \left(\frac{(7.3003\ \text{ft})}{(10.25\ \text{ft})}\right)^3\right]\right]$$

$$V_{max} = 0.043967\ \text{kip}$$

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

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

$$M_{max} = \left((0.0066879\ \text{kip/ft}) \times (48\ \text{in}) \times (10.25\ \text{ft})\right) \times \left[\left(\frac{(5.6667\ \text{ft})}{(10.25\ \text{ft})} + \frac{(7.3003\ \text{ft})}{2 \times (10.25\ \text{ft})}\right) - \left[\left(\frac{4 \times (5.6667\ \text{ft})}{(10.25\ \text{ft})} + 3\right) \times \left(\frac{(7.3003\ \text{ft})}{2 \times (10.25\ \text{ft})}\right)^3\right] + \left[\left(\frac{3 \times (5.6667\ \text{ft})}{(10.25\ \text{ft})} + 2\right) \times \left(\frac{(7.3003\ \text{ft})}{2 \times (10.25\ \text{ft})}\right)^4\right]\right]$$

$$M_{max} = 0.20084\ \text{kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

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

Longitudinal reinforcement:

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

22.4.2.2, 10.6.1.1 $A_{st,required}$

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

$$A_{st,required} = Min\left[\frac{\frac{(15.032\ \text{kip})}{(0.65)\times(0.8)} - \left(0.85 \times (2.5\ \text{ksi}) \times \left(2304\ \text{in}^2\right)\right)}{(60\ \text{ksi}) - (0.85 \times (2.5\ \text{ksi}))}, \left(0.08 \times \left(2304\ \text{in}^2\right)\right)\right]$$

$$A_{st,required} = -84.097\ \text{in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[\left(-84.097\ \text{in}^2\right), \left(0.0018 \times \left(2304\ \text{in}^2\right)\right)\right]$$

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

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,

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

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

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

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,

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

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

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

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

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

$$\phi P_N = (0.65) \times 0.80 \times \left[\left(0.85 \times (2.5\text{ ksi}) \times \left[\left(2304\text{ in}^2\right) - \left(4.2951\text{ in}^2\right)\right]\right) + \left((60\text{ ksi}) \times \left(4.2951\text{ in}^2\right)\right)\right]$$

$$\phi P_N = 2675.2\text{ kip}$$

$Ratio$ - Capacity

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

$$Ratio = \frac{(15.032\text{ kip})}{(2675.2\text{ kip})}$$

$$Ratio = 0.0056191$$

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

Shear Strength (ACI 318-19, LRFD)

Parameters:

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

22.5.2.2 d - Effective depth

$$d = 0.80\, D$$

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

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

22.5.5.1.3 λ_s - size effect modification factor

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

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

$$\lambda_s = 0.64282$$

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

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

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

$$V_{c,max} = 5 \times (0.64282) \times \sqrt{(2500\text{ psi})} \times (48\text{ in}) \times (38.4\text{ in})$$

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

The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 15.032 \text{ kip} \rightarrow 15032 \text{ lbf}$,

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

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(15032 \text{ lbf})}{6 \times (2304 \text{ in}^2)}\right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 120.49 \text{ kip}$$

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

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

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

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

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

V_c - Governing shear strength of concrete

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

$$V_c = Min\left[(296.21 \text{ kip}), (120.49 \text{ kip}), (348.89 \text{ kip})\right]$$

$$V_c = 120.49 \text{ kip}$$

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

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

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

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

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

A_v - Ties rebar area,

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

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

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

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

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

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

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

V_s - Governing shear strength of steel

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

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

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

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((120.49 \text{ kip}) + (50.894 \text{ kip}))$$

$$\phi V_n = 111.4 \text{ kip}$$

Considering x-direction:

$V_{max} = 25.031 \text{ kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

	$$Ratio = \frac{(25.031\ \text{kip})}{(111.4\ \text{kip})}$$ $$Ratio = 0.2247$$	Status: **PASS** Ratio: **0.220**
	Considering z-direction: $V_{max} = 0.043967\ \text{kip}$ - Maximum shear force in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{V_{max}}{\phi V_n}$$ $$Ratio = \frac{(0.043967\ \text{kip})}{(111.4\ \text{kip})}$$ $$Ratio = 0.00039468$$	Status: **PASS** Ratio: **0.000**
14.5.2.1b	**Flexural Strength (ACI 318-19, LRFD)** S_m - Section modulus $$S_m = \frac{b\, D^2}{6}$$ $$S_m = \frac{(48\ \text{in}) \times (48\ \text{in})^2}{6}$$ $$S_m = 18432\ \text{in}^3$$ $\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$ $$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f_c')} \times S_m$$ $$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 ksi)} \times 18432.001 in^3$$ $$\phi M_{n,1} = 249.600 kipft$$ $\phi M_{n,2}$ $$\phi M_{n,2} = \phi\ 0.85\ f_{ck}'\ S_m$$ $$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5\ \text{ksi}) \times \left(18432\ \text{in}^3\right)$$ $$\phi M_{n,2} = 2121.6\ \text{kipft}$$ Therefore, ϕM_n - Allowable flexural strength, $$\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$$ $$\phi M_n = MIN[(249.6\ \text{kipft}), (2121.6\ \text{kipft})]$$ $$\phi M_n = 249.6\ \text{kipft}$$ **Considering x-direction:** $M_{max} = 122.48\ \text{kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(122.48\ \text{kipft})}{(249.6\ \text{kipft})}$$ $$Ratio = 0.49071$$	Status: **PASS** Ratio: **0.490**
	Considering z-direction: $M_{max} = 0.20084\ \text{kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$	

	$$Ratio = \frac{(0.20084 \text{ kipft})}{(249.6 \text{ kipft})}$$ $$Ratio = 0.00080465$$	Status: **PASS** Ratio: **0.000**