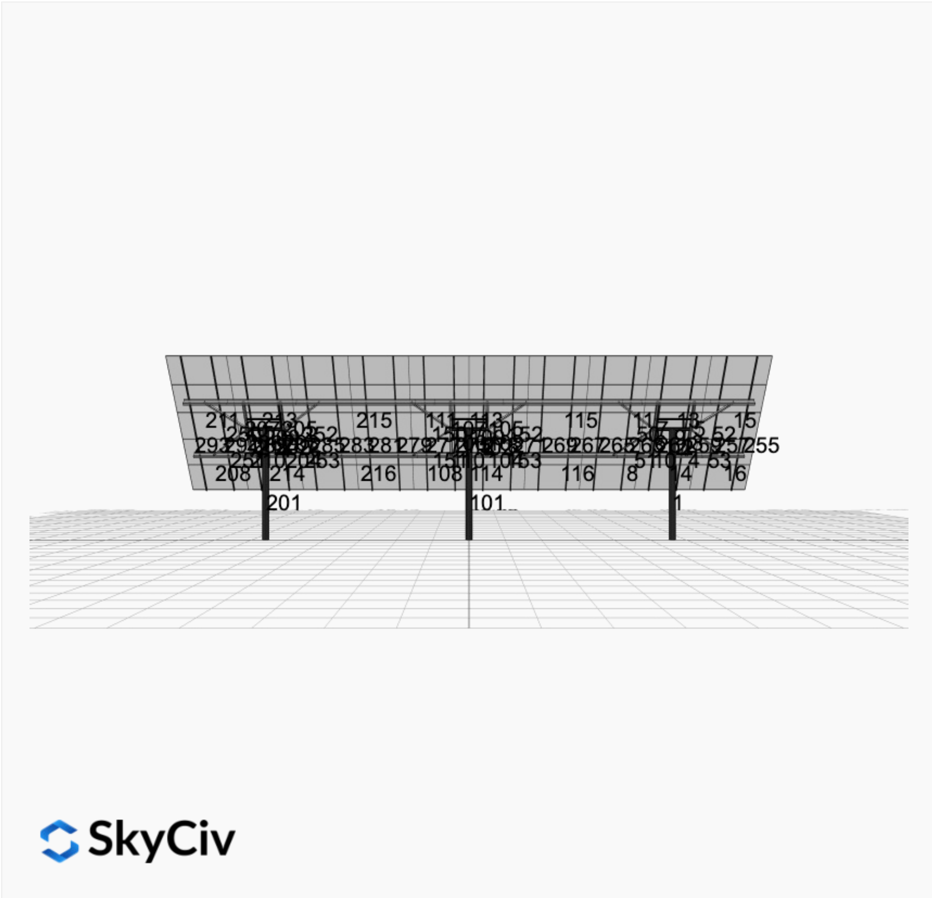
Project Details

Project Name: Table to Farm Compost - 5x10 - V5Jb
Location: 735 Co Rd 236, Durango, CO 81301, USA
Unique ID: 3P-22.5-8TOP-HD-57-L-5Hx10W-STRUTS-212B
Dealer: ______________________________

Date: Tue Jan 07 2025
Number of Modules: 50
Number of Poles: 3
Date Sold:
____



Array Dimensions N/S	18.96 ft
Array Dimensions E/W	64.17 ft
Winter Tilt Angle	50
Front Edge Clearance	5 ft

MT Solar Bill of Materials (3P-22.5-8TOP-HD-57-L-5Hx10W-STRUTS-212B)

Part	Short Description	BOM Qty
MTS-PC-8	8IN Pole Cap Assembly	3
MTS-HF-HD	H-Frame Assembly-HD	3
MTS-HD-Wing-57	57IN HD Wing	4
MTS-HD-Splice-90	90IN HD Splice	8
MTS-CLAMP-ANGLE-4PK	Angle Clamp	10

Rail Bill of Materials

Part	Qty
Rails (225in)	20
Rail Attachment	80
Module Mid Clamp	80

Part	Qty
Module End Clamp	40
Ground Lug	10

Site Details:

Site Address: 735 Co Rd 236, Durango, CO 81301, USA

Array Specification

Duty Classification:	HD
Module Width:	45.00 in
Module Length:	76.00in
Number of Rows:	5
Number of Columns:	10
Total Number of Modules:	50
Winter Tilt Angle:	50
Front Edge Clearance:	5
Total Array Height at Tilt:	19.52 ft
Total Frame Length:	62.00 ft
Frame Weight:	4216 lbs
Array Dimensions N/S:	18.96 ft
Array Dimensions E/W:	64.17 ft
Rail Length:	227.50 in
Rail Spacing:	3.21 ft

Support Specifications

Pole Size:	8in Pipe Sch 40
Pole Length above Grade:	12.26 ft
Number of Poles:	3
Pole Spacing:	22.5 ft

Foundation Specifications

Foundation Type:	Square
Foundation Dimensions:	48 x 48 in
Foundation Depth (below grade):	Pile 1: 7.25 ft Pile 2: 7.25 ft Pile 3: 7.25 ft
Foundation Volume:	12.889 y^3

Site Info

Risk Category:	I
Exposure:	C
Soil Classification:	sand
Site Location:	735 Co Rd 236, Durango, CO 81301, USA
Wind Speed:	98 mph
Snow Load:	95 psf

Design Disclaimer

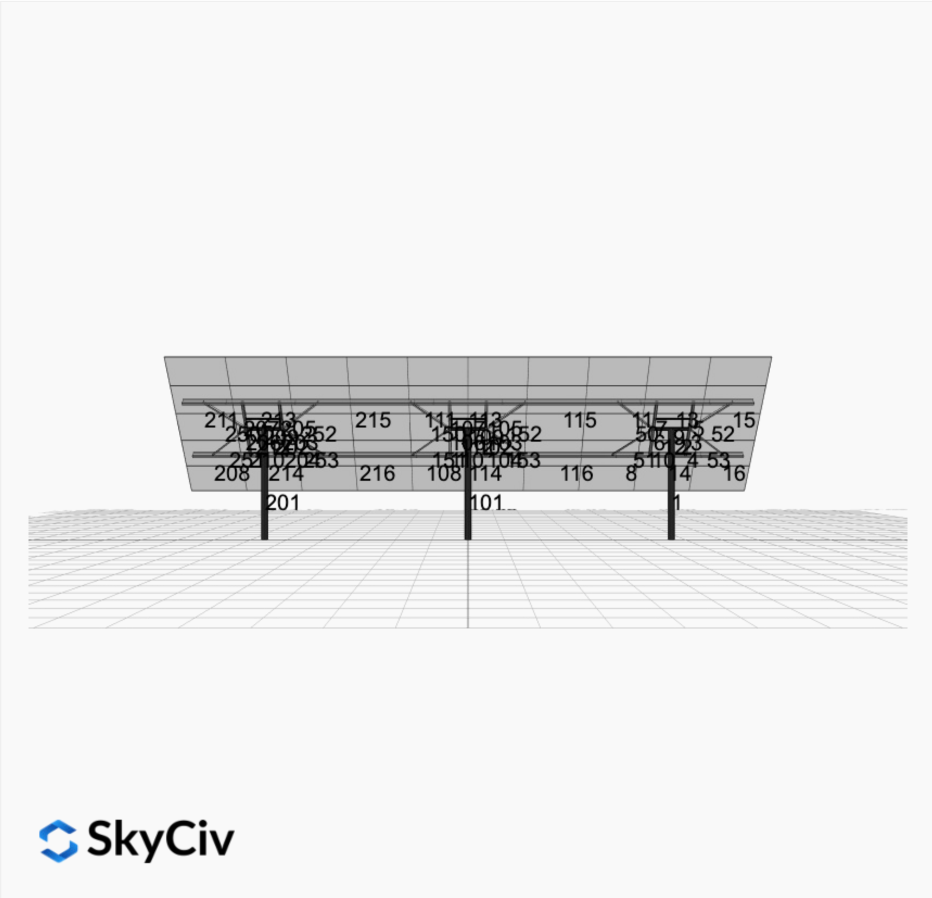
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

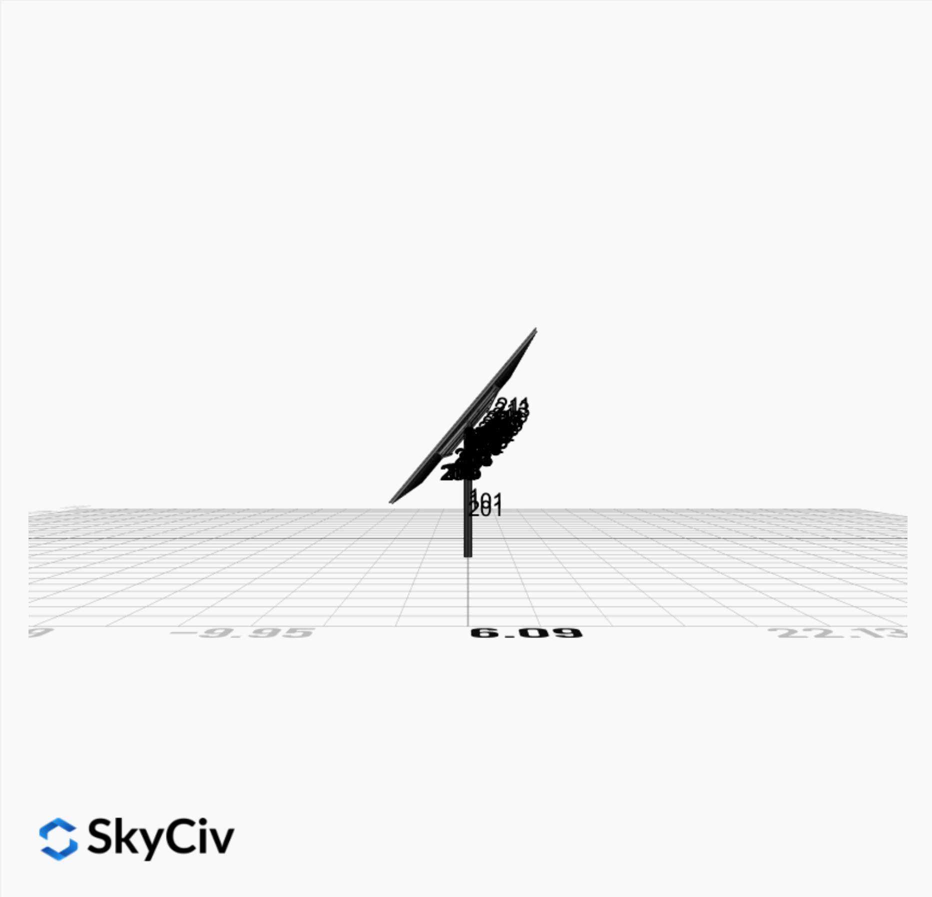
AutoDesigner Input

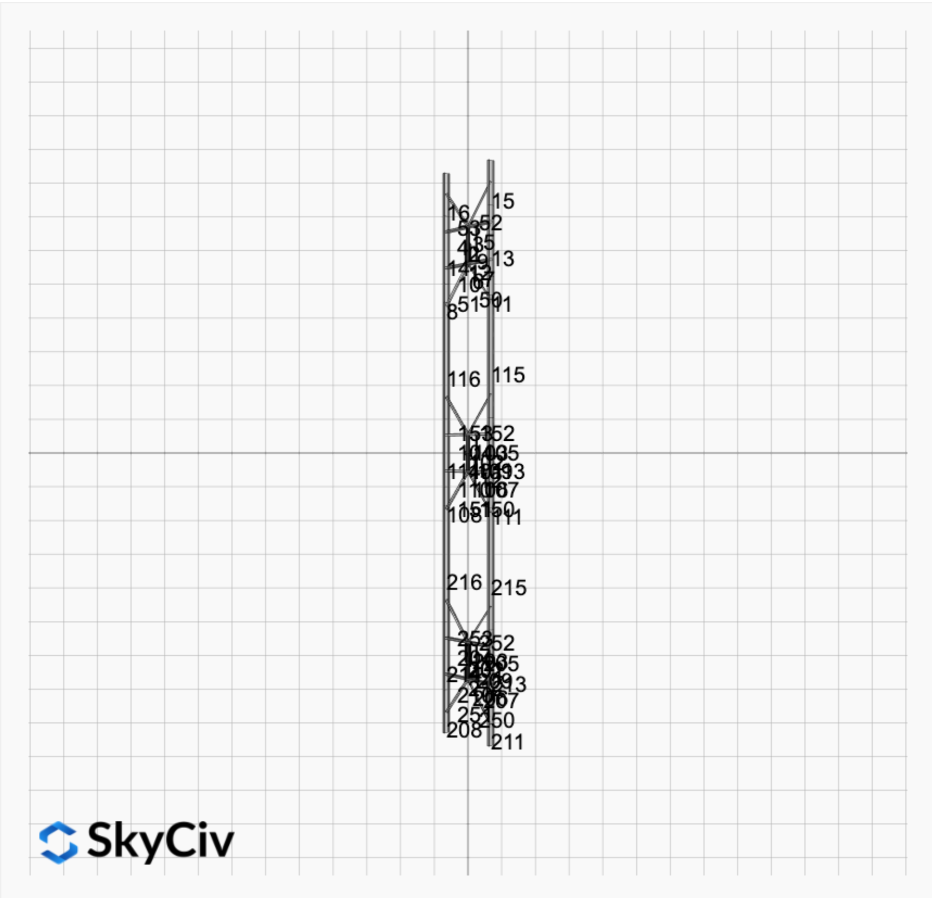
{"wind_speed_override":98,"snow_load_override":95,"direct_snow_load":false,"add_angle_brace":true,"product_type":"Beam","designer_name":"","designer_email":"","designer_phone":"","project_id":"Table to Farm Compost - 5x10 - V5Jb","site_address":"735 Co Rd 236, Durango, CO 81301, USA","module_width":45,"module_length":76,"number_rows":"5","number_columns":10,"pole_mount_section":"4_40","core_pipe_width":65,"core_pipe_section":"2_40","adjuster_section":"2_40","core_beam_height":65,"core_beam_section":"HSS3x2x1/8","main_pipe_section":"2_12GA","pole_spacing":"15","tilt_angle":50,"ground_clearance":5,"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":false}

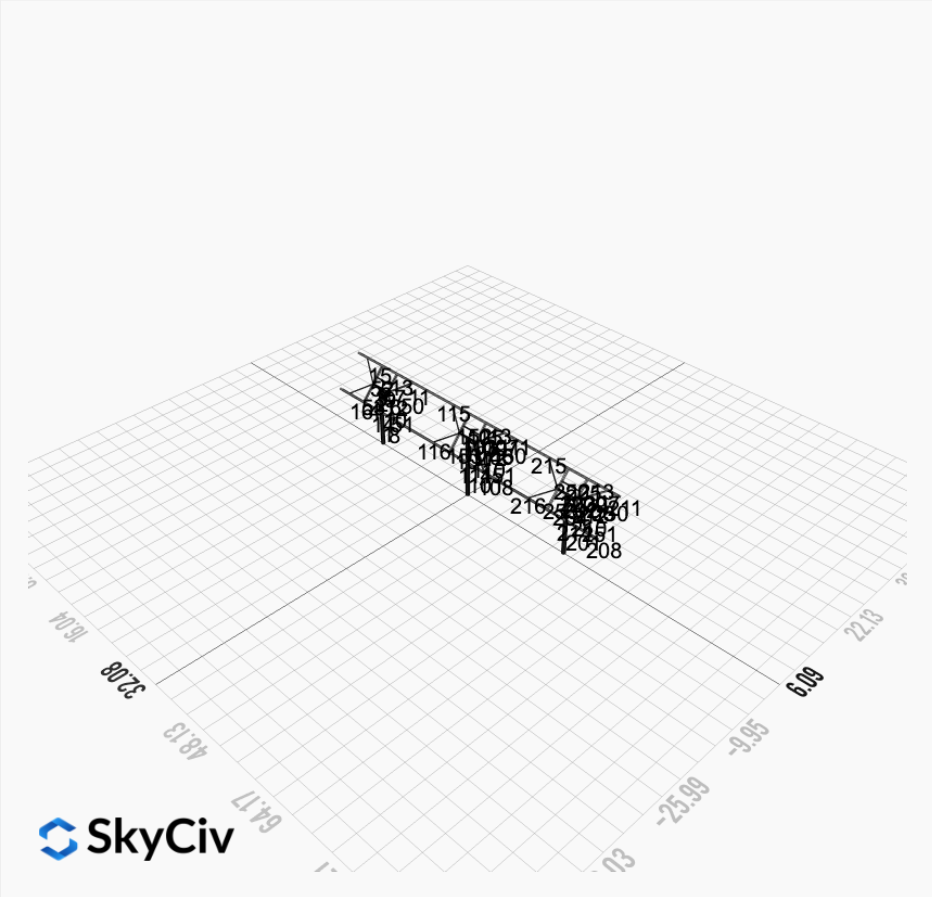
Design Notes:

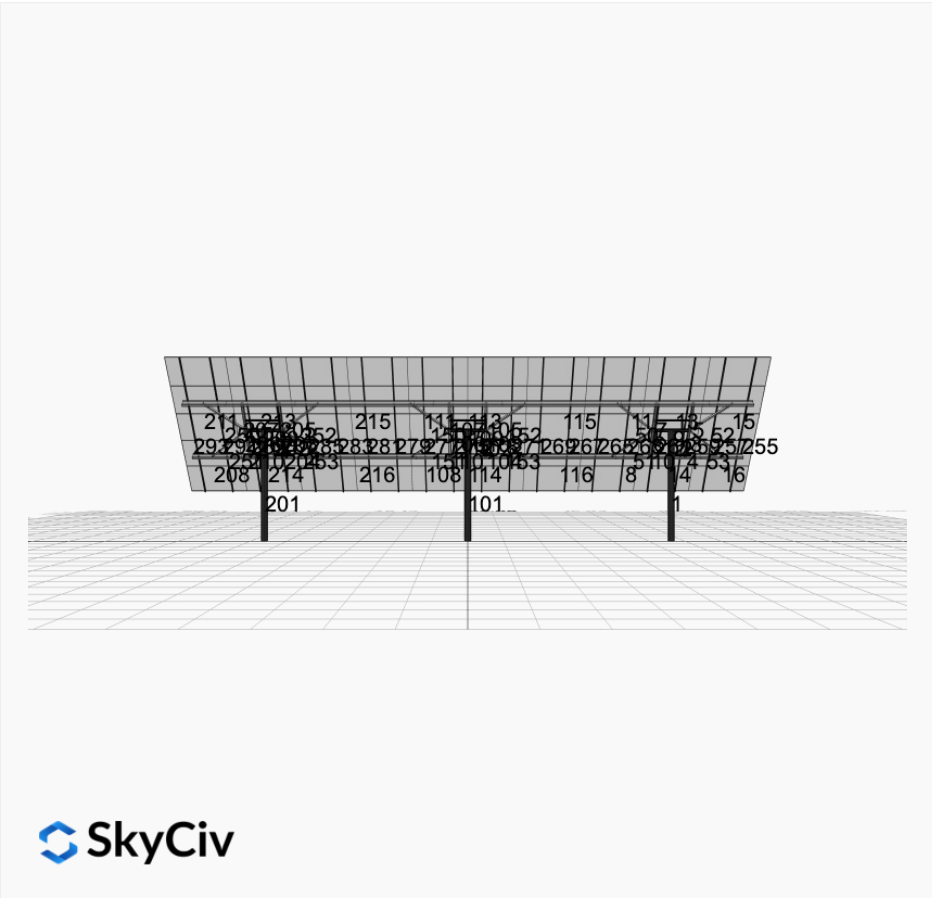
- AISC Deflection checks are set to L/1 due to structure design intent
- Foundation Soil Parameters used in this Autodesign are all estimates, proper geotechnical reports are required to confirm soil profiles
- Wind speeds, snow loads and other site specific results are based on ASCE 7 2016
- Steel frame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



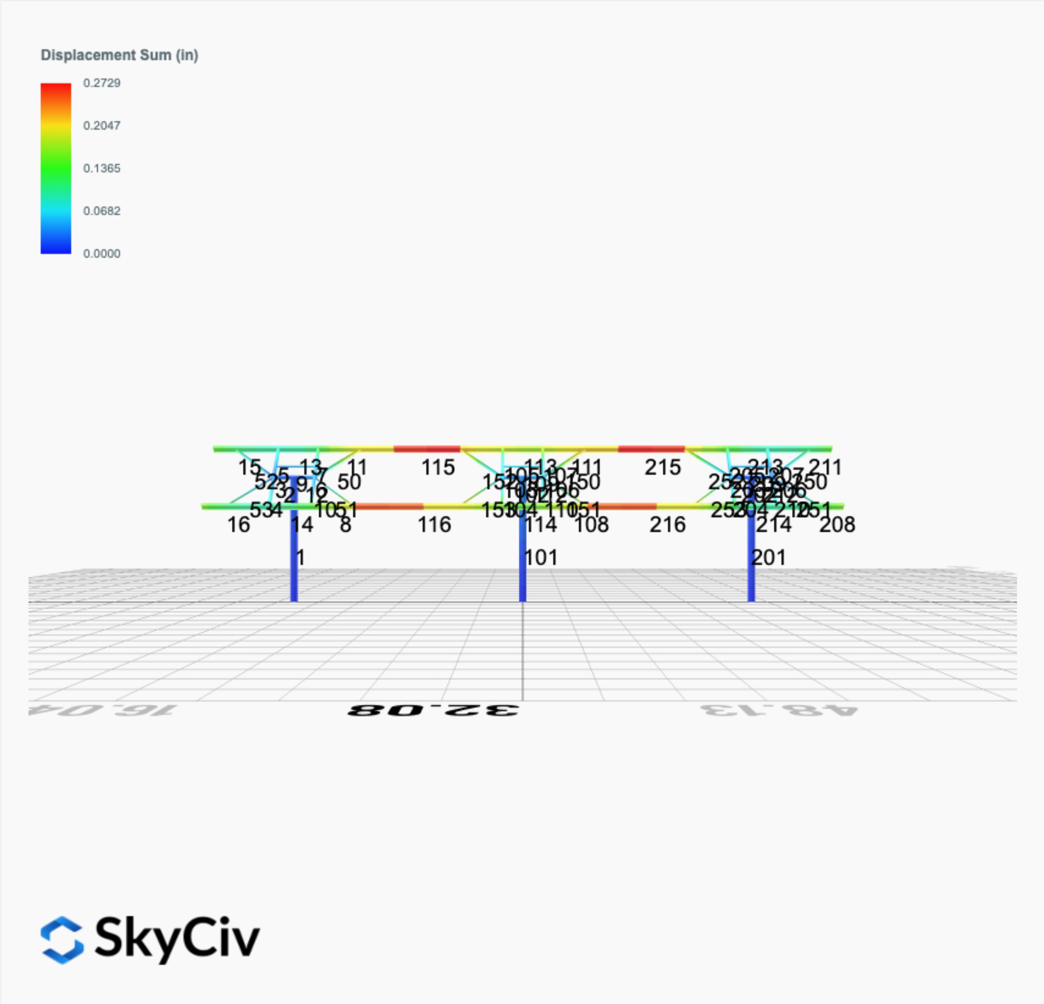

6.09
-9.95
SkyCiv

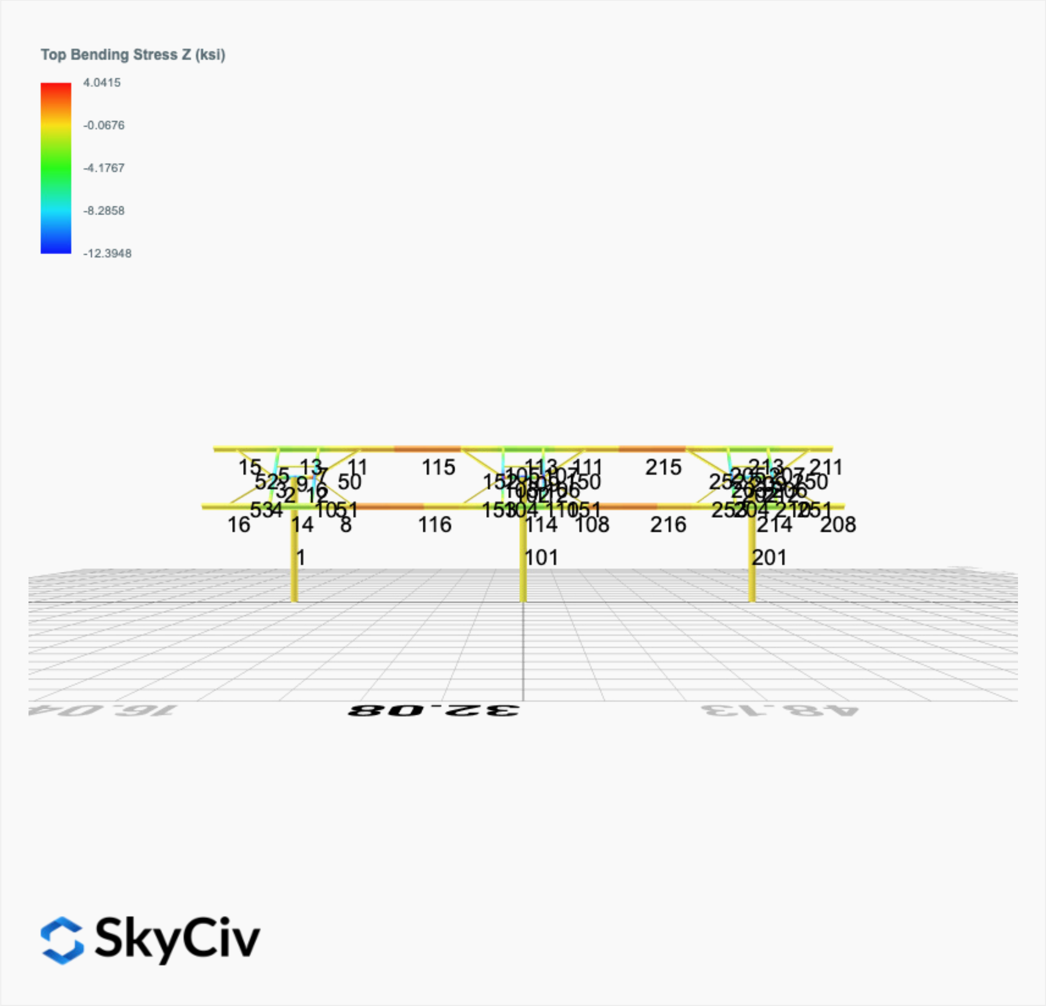

15
16
13
8
11
116
115
216
215
211
208
SkyCiv

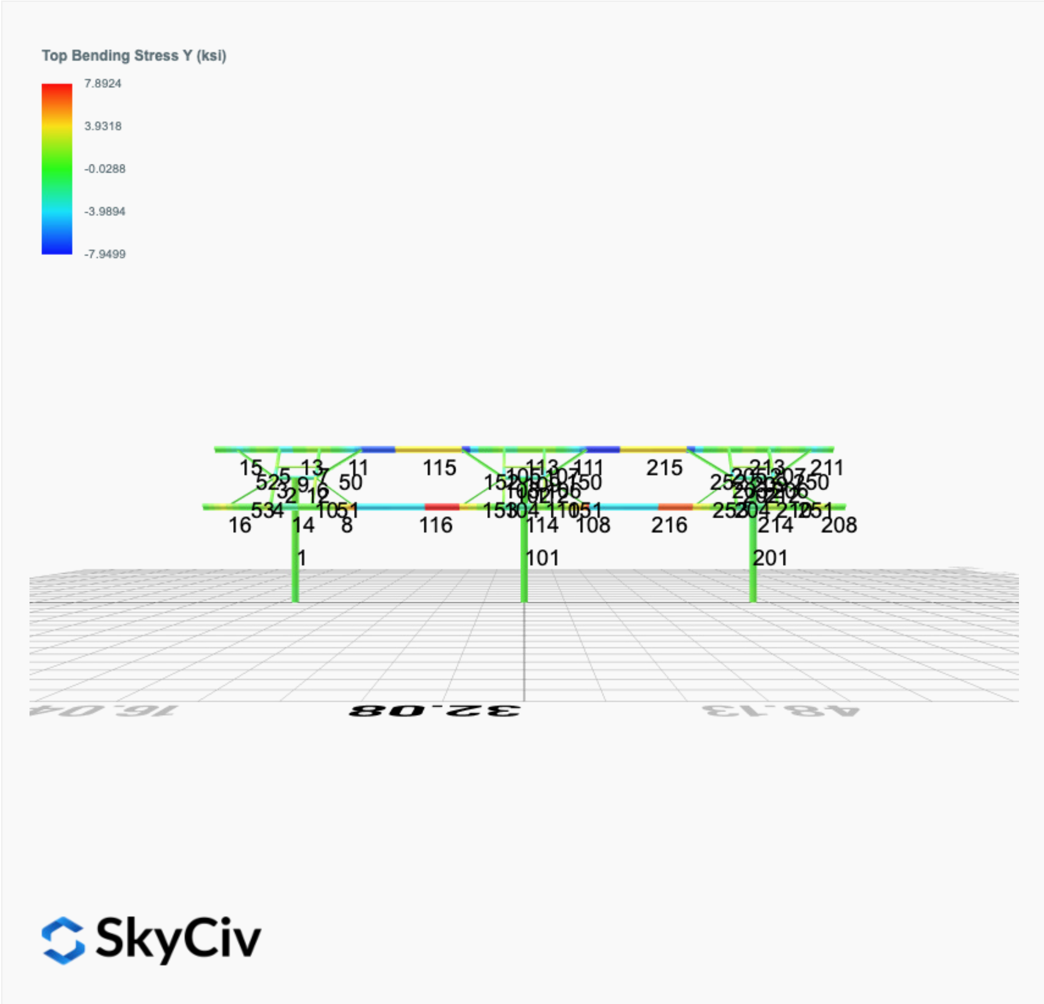


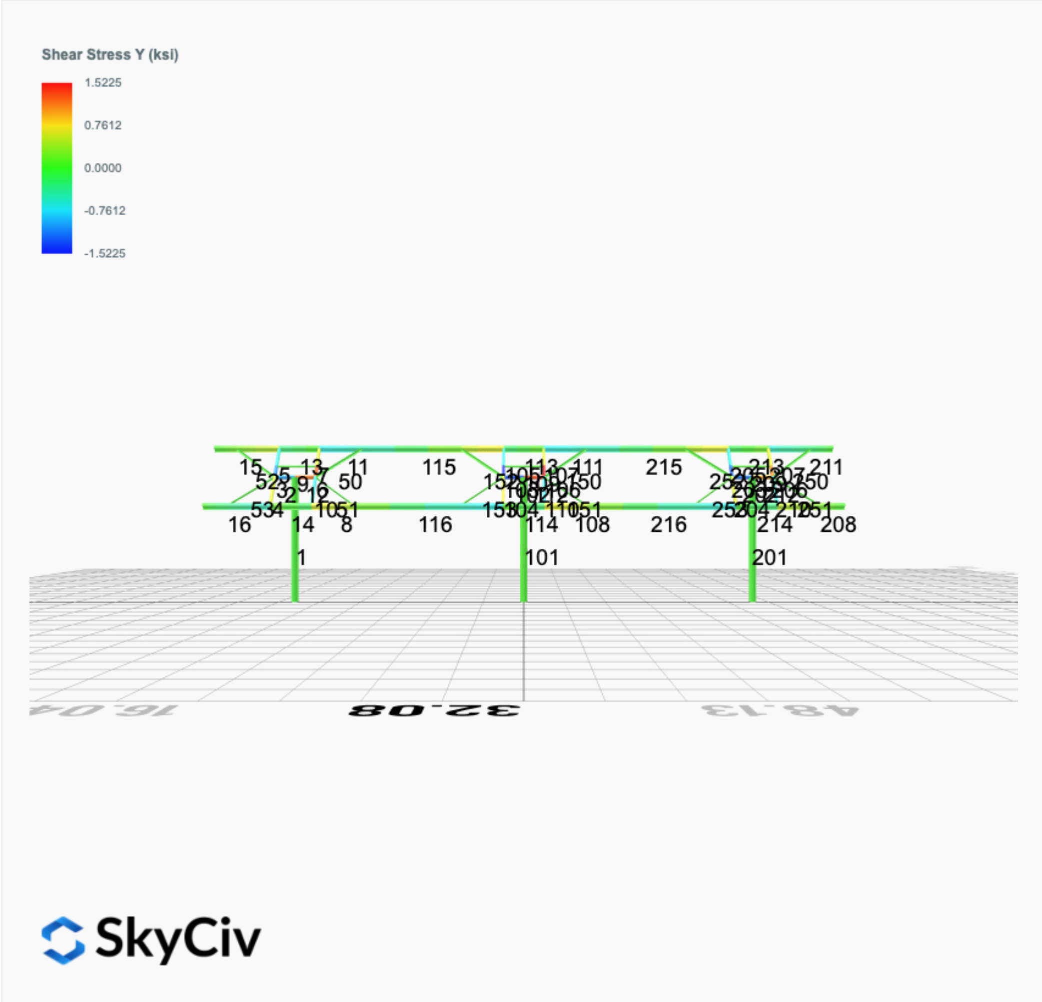


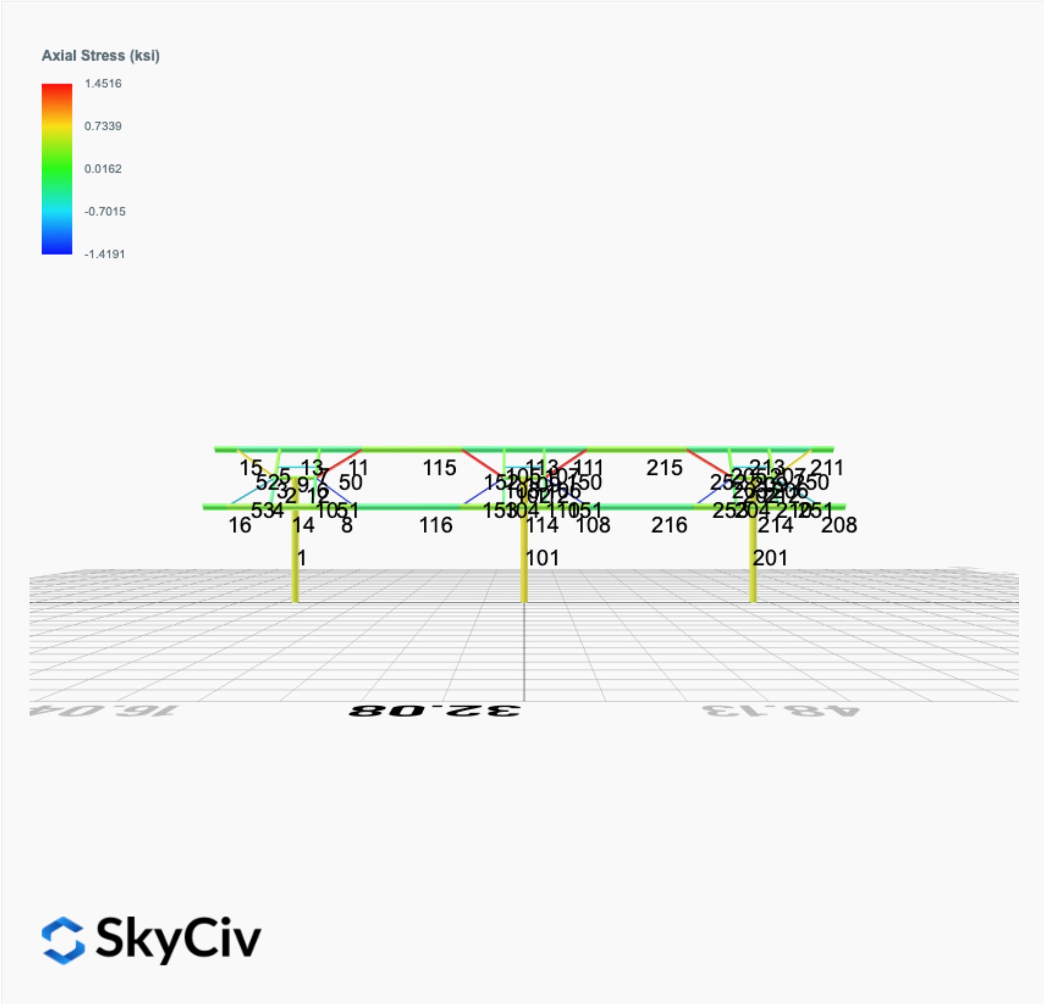
FEM Results (Envelope Worst Case for each member)




Top Bending Stress Z (ksi)
4.0415
-0.0676
-4.1767
-8.2858
-12.3948
115
215
116
216
1
101
201
32.08
SkyCiv


Top Bending Stress Y (ksi)
7.8924
3.9318
-0.0288
-3.9894
-7.9499
SkyCiv


Shear Stress Y (ksi)
1.5225
0.7612
0.0000
-0.7612
-1.5225
115
215
116
216
1
101
201
SkyCiv


Axial Stress (ksi)
1.4516
0.7339
0.0162
-0.7015
-1.4191
15
13
11
115
215
211
16
14
8
116
114
108
216
214
208
1
101
201

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	0.0093	2.7596	0.0329	0.1225	-0.0522	-0.0808
ULS: 2. D + L	0.0093	2.7596	0.0329	0.1225	-0.0522	-0.0808
ULS: 3. D + (S or Lr or R)	0.0319	7.7573	0.1123	0.4191	-0.1849	-0.2943
ULS: 3. D + (S or Lr or R)	0.0093	2.7596	0.0329	0.1225	-0.0522	-0.0808
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0262	6.5079	0.0925	0.3450	-0.1517	-0.2409
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0093	2.7596	0.0329	0.1225	-0.0522	-0.0808
ULS: 5b. D + 0.7E	0.0093	2.7596	0.0329	0.1225	-0.0522	-0.0808
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0262	6.5079	0.0925	0.3450	-0.1517	-0.2409
ULS: 8. 0.6D + 0.7E	0.0056	1.6557	0.0197	0.0735	-0.0313	-0.0485
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.0094	5.2313	0.1250	0.4546	-0.5220	37.5893
ULS: 5a. D + 0.6W_Wind downforce Case B only	0.0093	2.7596	0.0329	0.1225	-0.0522	-0.0808
ULS: 5a. D + 0.6W_Wind uplift Case A only	3.0230	0.2895	-0.0574	-0.2024	0.4082	-36.6336
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.0093	2.7596	0.0329	0.1225	-0.0522	-0.0808
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.2378	8.3616	0.1616	0.5940	-0.5041	28.0117
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0262	6.5079	0.0925	0.3450	-0.1517	-0.2409
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.2866	4.6553	0.0248	0.1013	0.1936	-27.6554
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0262	6.5079	0.0925	0.3450	-0.1517	-0.2409
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.2547	4.6133	0.1020	0.3716	-0.4046	28.1718
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0093	2.7596	0.0329	0.1225	-0.0522	-0.0808
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.2696	0.9070	-0.0348	-0.1212	0.2931	-27.4954
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0093	2.7596	0.0329	0.1225	-0.0522	-0.0808
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.0131	4.1274	0.1119	0.4056	-0.5012	37.6216
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	0.0056	1.6557	0.0197	0.0735	-0.0313	-0.0485
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	3.0193	-0.8143	-0.0706	-0.2514	0.4291	-36.6012
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.0056	1.6557	0.0197	0.0735	-0.0313	-0.0485

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	13.3666
Shear X	-5.0491
Shear Z	0.2481
Moment X	0.9193
Moment Y (Twist)	0.9297
Moment Z	64.0679

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	8.3616
Shear X	-3.0230
Shear Z	0.1616
Moment X	0.5940
Moment Y (Twist)	0.5220
Moment Z	37.6216

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	-0.0186	3.0947	-0.0000	0.0000	0.0000	0.2354
ULS: 2. D + L	-0.0186	3.0947	-0.0000	0.0000	0.0000	0.2354
ULS: 3. D + (S or Lr or R)	-0.0638	8.8848	-0.0000	0.0000	0.0000	0.8092
ULS: 3. D + (S or Lr or R)	-0.0186	3.0947	-0.0000	0.0000	0.0000	0.2354
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0525	7.4373	-0.0000	0.0000	0.0000	0.6657

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0186	3.0947	-0.0000	0.0000	0.0000	0.2354
ULS: 5b. D + 0.7E	-0.0186	3.0947	-0.0000	0.0000	0.0000	0.2354
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0525	7.4373	-0.0000	0.0000	0.0000	0.6657
ULS: 8. 0.6D + 0.7E	-0.0111	1.8568	-0.0000	0.0000	0.0000	0.1413
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.3737	6.0326	-0.0000	0.0000	0.0000	41.8296
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.0186	3.0947	-0.0000	0.0000	0.0000	0.2354
ULS: 5a. D + 0.6W_Wind uplift Case A only	3.3465	0.1536	-0.0000	0.0000	0.0000	-40.1202
ULS: 5a. D + 0.6W_Wind uplift Case B only	-0.0186	3.0947	-0.0000	0.0000	0.0000	0.2354
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.5688	9.6407	-0.0000	0.0000	0.0000	31.8614
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0525	7.4373	-0.0000	0.0000	0.0000	0.6657
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.4713	5.2315	-0.0000	0.0000	0.0000	-29.6010
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0525	7.4373	-0.0000	0.0000	0.0000	0.6657
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.5349	5.2981	-0.0000	0.0000	0.0000	31.4311
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0186	3.0947	-0.0000	0.0000	0.0000	0.2354
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.5052	0.8889	-0.0000	0.0000	0.0000	-30.0313
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0186	3.0947	-0.0000	0.0000	0.0000	0.2354
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.3663	4.7947	-0.0000	0.0000	0.0000	41.7355
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.0111	1.8568	-0.0000	0.0000	0.0000	0.1413
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	3.3539	-1.0843	-0.0000	0.0000	0.0000	-40.2144
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	-0.0111	1.8568	-0.0000	0.0000	0.0000	0.1413

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	15.4280
Shear X	-5.6276
Shear Z	-0.0000
Moment X	0.0004
Moment Y (Twist)	0.0003
Moment Z	71.5774

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	9.6407
Shear X	-3.3737
Shear Z	-0.0000
Moment X	0.0000
Moment Y (Twist)	0.0000
Moment Z	41.8296

Reaction Forces for Foundation 3 (Node ID#201), (kip, kip-ft)

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	0.0093	2.7596	-0.0329	-0.1225	0.0522	-0.0808
ULS: 2. D + L	0.0093	2.7596	-0.0329	-0.1225	0.0522	-0.0808
ULS: 3. D + (S or Lr or R)	0.0319	7.7573	-0.1123	-0.4191	0.1849	-0.2942
ULS: 3. D + (S or Lr or R)	0.0093	2.7596	-0.0329	-0.1225	0.0522	-0.0808
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0262	6.5079	-0.0925	-0.3450	0.1517	-0.2409
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0093	2.7596	-0.0329	-0.1225	0.0522	-0.0808
ULS: 5b. D + 0.7E	0.0093	2.7596	-0.0329	-0.1225	0.0522	-0.0808
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0262	6.5079	-0.0925	-0.3450	0.1517	-0.2409
ULS: 8. 0.6D + 0.7E	0.0056	1.6557	-0.0197	-0.0735	0.0313	-0.0485
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.0094	5.2313	-0.1250	-0.4546	0.5220	37.5893
ULS: 5a. D + 0.6W_Wind downforce Case B only	0.0093	2.7596	-0.0329	-0.1225	0.0522	-0.0808
ULS: 5a. D + 0.6W_Wind uplift Case A only	3.0230	0.2895	0.0574	0.2024	-0.4082	-36.6335
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.0093	2.7596	-0.0329	-0.1225	0.0522	-0.0808

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.2378	8.3617	-0.1616	-0.5940	0.5041	28.0117
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0262	6.5079	-0.0925	-0.3450	0.1517	-0.2409
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.2865	4.6553	-0.0248	-0.1013	-0.1936	-27.6554
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0262	6.5079	-0.0925	-0.3450	0.1517	-0.2409
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.2547	4.6133	-0.1020	-0.3716	0.4046	28.1718
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0093	2.7596	-0.0329	-0.1225	0.0522	-0.0808
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.2696	0.9070	0.0348	0.1212	-0.2931	-27.4954
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0093	2.7596	-0.0329	-0.1225	0.0522	-0.0808
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.0131	4.1274	-0.1119	-0.4056	0.5012	37.6216
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	0.0056	1.6557	-0.0197	-0.0735	0.0313	-0.0485
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	3.0193	-0.8143	0.0706	0.2514	-0.4291	-36.6012
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.0056	1.6557	-0.0197	-0.0735	0.0313	-0.0485

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	13.3668
Shear X	-5.0490
Shear Z	-0.2481
Moment X	-0.9195
Moment Y (Twist)	0.9302
Moment Z	64.0686

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	8.3617
Shear X	-3.0230
Shear Z	-0.1616
Moment X	-0.5940
Moment Y (Twist)	0.5220
Moment Z	37.6216

Project Details

Design Code:	AISC 360-16 LRFD
Provision:	LRFD
Country:	United States
User Name:	sales@mtsolar.us
Project Name:	Table to Farm Compost - 5x10 - V5Jb
Unit System:	imperial

Design Input Information

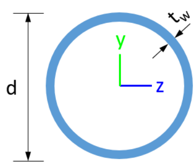
Design Factors

Φ_t	Φ_c	Φ_b	Φ_v
0.9	0.9	0.9	0.9

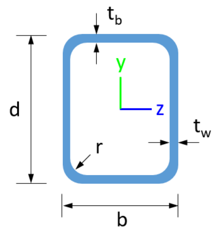
Design Materials

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

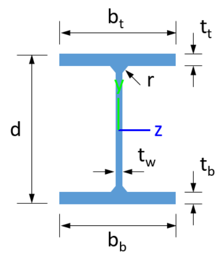
Section Dimensions



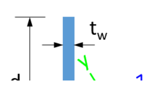
ID	Name	d (in)	t_w (in)
2	2in Pipe Sch 80	2.38	0.22
5	4in Pipe Sch 80	4.50	0.34
9	8in Pipe Sch 40	8.63	0.32

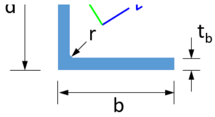


ID	Name	d (in)	b (in)	t_w (in)	t_b (in)	r (in)
16	HSS5x3x3/16	5.00	3.00	0.17	0.17	0.17



ID	Name	d (in)	t_w (in)	b_t (in)	b_b (in)	t_t (in)	t_b (in)	r (in)
19	W8x10	7.89	0.17	3.94	3.94	0.20	0.20	0.30





ID	Name	d (in)	t_w (in)	b (in)	t_b (in)	r (in)		
34	L3x2x3/16	3.00	0.19	2.00	0.19	0.31		

Section Properties								
ID	Name	A (in^2)	J (in^4)	I_{yp} (in^4)	I_{zp} (in^4)	I_w (in^6)	S_{yp} (in^3)	S_{zp} (in^3)
2	2in Pipe Sch 80	1.48	1.74	0.87	0.87	0.00	1.02	1.02
5	4in Pipe Sch 80	4.41	19.22	9.61	9.61	0.00	5.85	5.85
9	8in Pipe Sch 40	8.40	144.98	72.49	72.49	0.00	22.21	22.21
16	HSS5x3x3/16	2.58	8.64	3.85	8.53	0.73	2.96	4.21
19	W8x10	2.96	0.04	2.09	30.80	30.90	1.66	8.87
34	L3x2x3/16	0.92	0.01	0.17	0.98	0.01	0.33	0.82

Member Properties								
Member ID	Section ID	K_zL (ft)	K_yL (ft)	L_b(ft)	C_b	LST	LSC	LD
1	9	25.75	25.75	12.26	-	300	200	1
2	5	1.30	1.30	2.00	-	300	200	1
3	16	0.92	0.92	1.42	1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.16,1.18,1.18,1.18,1.17,1.18	300	200	1
4	16	2.44	2.44	3.75	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.67,1.67,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68	300	200	1
5	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.67,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68	300	200	1
6	16	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.18,1.18,1.18,1.19,1.18,1.19,1.18,1.18,1.18,1.18,1.18,1.19,1.17,1.19,1.18,1.19,1.18,1.19	300	200	1
7	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.67,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.67,1.68	300	200	1
8	19	1.33	1.33	2.05	2.10,2.10,2.10,2.10,2.10,2.10,2.10,2.09,2.10,2.10,2.10,2.09,2.10,2.10,2.10,2.10,2.10,2.10,2.10,2.09,2.10,2.10,2.10,2.10	300	200	1
9	2	2.60	2.60	4.00	-	300	200	1
10	16	2.44	2.44	3.75	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.67,1.67,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68	300	200	1
11	19	1.33	1.33	2.05	2.11,2.11,2.11,2.11,2.11,2.11,2.13,2.11,2.15,2.11,2.13,2.11,2.14,2.11,2.12,2.11,2.09,2.11,2.13,2.11,2.15,2.11,2.13,2.11,2.13,2.11	300	200	1
12	5	1.30	1.30	2.00	-	300	200	1
13	19	4.88	4.00	7.50	1.08,1.08,1.08,1.08,1.08,1.07,1.08,1.06,1.08,1.07,1.08,1.06,1.08,1.07,1.08,1.09,1.08,1.07,1.08,1.06,1.08,1.07,1.08,1.07,1.08	300	200	1
14	19	4.88	4.00	7.50	1.08,1.08,1.08,1.08,1.08,1.08,1.07,1.08,1.06,1.08,1.07,1.08,1.07,1.08,1.08,1.08,1.09,1.08,1.07,1.08,1.06,1.08,1.07,1.08,1.07,1.08	300	200	1
15	19	4.75	4.75	4.75	2.33,2.33,2.33,2.32,2.33,2.33,2.33,2.33,2.32,2.33,2.32,2.33,2.32,2.33,2.33,2.32,2.31,2.32,2.33,2.33,2.31,2.33,2.32,2.33,2.32,2.33	300	200	1
16	19	4.75	4.75	4.75	2.33,2.32,2.33,2.32,2.33,2.33,2.32,2.32,2.32,2.32,2.32,2.33,2.32,2.33,2.32,2.32,2.31,2.32,2.32,2.33,2.31,2.33,2.32,2.33,2.32,2.33	300	200	1
50	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
51	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
52	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
53	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
101	9	25.75	25.75	12.26	-	300	200	1

102	5	1.30	1.30	2.00	-	300	200	1
103	16	0.92	0.92	1.42	1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18	300	200	1
104	16	2.44	2.44	3.75	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.67,1.67,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68	300	200	1
105	16	1.52	1.52	2.33	1.67,1.67,1.67,1.67,1.67,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.67,1.67	300	200	1
106	16	0.92	0.92	1.42	1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18	300	200	1
107	16	1.52	1.52	2.33	1.67,1.67,1.67,1.67,1.67,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67	300	200	1
108	19	1.33	1.33	2.05	2.28,2.28,2.28,2.28,2.28,2.28,2.32,2.28,2.15,2.28,2.33,2.28,2.36,2.28,2.30,2.28,2.23,2.28,2.32,2.28,2.14,2.28,2.33,2.28,2.35,2.28	300	200	1
109	2	2.60	2.60	4.00	-	300	200	1
110	16	2.44	2.44	3.75	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.67,1.67,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68	300	200	1
111	19	1.33	1.33	2.05	2.32,2.32,2.32,2.32,2.32,2.32,2.11,2.32,1.64,2.32,2.10,2.32,1.96,2.32,2.15,2.32,2.04,2.32,2.11,2.32,1.61,2.32,2.10,2.32,2.04,2.32	300	200	1
112	5	1.30	1.30	2.00	-	300	200	1
113	19	4.88	4.00	7.50	1.03,1.03,1.03,1.03,1.03,1.03,1.03,1.03,1.04,1.03,1.03,1.03,1.04,1.03,1.03,1.03,1.02,1.03,1.03,1.03,1.04,1.03,1.03,1.03,1.03,1.03	300	200	1
114	19	4.88	4.00	7.50	1.03,1.03,1.03,1.03,1.03,1.03,1.03,1.03,1.03,1.03,1.03,1.03,1.03,1.03,1.03,1.03,1.02,1.03,1.03,1.03,1.03,1.03,1.03,1.03,1.03,1.03	300	200	1
115	19	12.95	12.95	12.95	1.16,1.16,1.16,1.16,1.16,1.16,1.13,1.16,1.13,1.16,1.13,1.16,1.13,1.16,1.14,1.16,1.23,1.16,1.13,1.16,1.13,1.16,1.13,1.16,1.13,1.16	300	200	1
116	19	12.95	12.95	12.95	1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.15,1.18,1.16,1.18,1.16,1.18,1.17,1.18,1.20,1.18,1.17,1.18,1.15,1.18,1.16,1.18,1.16,1.18	300	200	1
150	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
151	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
152	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
153	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
201	9	25.75	25.75	12.26	-	300	200	1
202	5	1.30	1.30	2.00	-	300	200	1
203	16	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.18,1.18,1.18,1.19,1.18,1.19,1.18,1.18,1.18,1.18,1.18,1.19,1.17,1.19,1.18,1.19,1.18,1.19	300	200	1
204	16	2.44	2.44	3.75	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.67,1.67,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68	300	200	1
205	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.67,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.67,1.68	300	200	1
206	16	0.92	0.92	1.42	1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.16,1.18,1.18,1.18,1.17,1.18	300	200	1
207	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.67,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68	300	200	1
208	19	4.75	4.75	4.75	2.33,2.32,2.33,2.32,2.33,2.33,2.32,2.32,2.32,2.32,2.32,2.33,2.32,2.33,2.32,2.32,2.31,2.32,2.32,2.33,2.31,2.33,2.32,2.33,2.32,2.33	300	200	1
209	2	2.60	2.60	4.00	-	300	200	1
210	16	2.44	2.44	3.75	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.67,1.67,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68	300	200	1
211	19	4.75	4.75	4.75	2.33,2.33,2.33,2.32,2.33,2.33,2.33,2.33,2.32,2.33,2.32,2.33,2.32,2.33,2.33,2.32,2.31,2.32,2.33,2.33,2.31,2.33,2.32,2.33,2.32,2.33	300	200	1
212	5	1.30	1.30	2.00	-	300	200	1
213	19	4.88	4.00	7.50	1.08,1.08,1.08,1.08,1.08,1.08,1.07,1.08,1.06,1.08,1.07,1.08,1.06,1.08,1.07,1.08,1.09,1.08,1.07,1.08,1.06,1.08,1.07,1.08,1.07,1.08	300	200	1
214	19	4.88	4.00	7.50	1.08,1.08,1.08,1.08,1.08,1.08,1.07,1.08,1.06,1.08,1.07,1.08,1.07,1.08,1.08,1.08,1.09,1.08,1.07,1.08,1.07,1.08,1.07,1.08,1.07,1.08	300	200	1
215	19	12.95	12.95	12.95	1.14,1.15,1.14,1.15,1.15,1.15,1.14,1.15,1.17,1.15,1.14,1.14,1.15,1.14,1.14,1.15,1.17,1.15,1.14,1.14,1.17,1.14,1.14,1.15,1.15,1.15	300	200	1

216	19	12.95	12.95	12.95	1.15,1.15,1.15,1.15,1.15,1.15,1.14,1.15,1.14,1.15,1.14,1.15,1.14,1.15,1.15,1.15,1.16,1.15,1.14,1.15,1.14,1.15,1.14,1.15,1.14,1.15	300	200	1
250	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
251	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
252	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
253	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250

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	168.33	83.29	83.29	113.39	113.39
2	198.33	196.72	21.95	21.95	59.50	59.50
3	116.10	115.41	15.79	11.10	42.08	23.28
4	116.10	111.33	15.79	11.10	42.08	23.28
5	116.10	114.23	15.79	11.10	42.08	23.28
6	116.10	115.41	15.79	11.10	42.08	23.28
7	116.10	114.23	15.79	11.10	42.08	23.28
8	133.20	123.95	32.87	6.12	40.24	43.62
9	66.48	58.89	3.82	3.82	19.94	19.94
10	116.10	111.33	15.79	11.10	42.08	23.28
11	133.20	123.95	32.87	6.12	40.24	43.62
12	198.33	196.72	21.95	21.95	59.50	59.50
13	133.20	85.85	24.21	6.12	40.24	43.62
14	133.20	85.85	24.36	6.12	40.24	43.62
15	133.20	95.15	32.87	6.12	40.24	43.62
16	133.20	95.15	32.87	6.12	40.24	43.62
50	41.27	8.45	1.63	0.88	15.23	10.15
51	41.27	8.45	1.63	0.88	15.23	10.15
52	41.27	8.45	1.63	0.88	15.23	10.15
53	41.27	8.45	1.63	0.88	15.23	10.15
101	377.97	168.33	83.29	83.29	113.39	113.39
102	198.33	196.72	21.95	21.95	59.50	59.50
103	116.10	115.41	15.79	11.10	42.08	23.28
104	116.10	111.33	15.79	11.10	42.08	23.28
105	116.10	114.23	15.79	11.10	42.08	23.28
106	116.10	115.41	15.79	11.10	42.08	23.28
107	116.10	114.23	15.79	11.10	42.08	23.28
108	133.20	123.95	32.87	6.12	40.24	43.62
109	66.48	58.89	3.82	3.82	19.94	19.94
110	116.10	111.33	15.79	11.10	42.08	23.28
111	133.20	123.95	32.87	6.12	40.24	43.62
112	198.33	196.72	21.95	21.95	59.50	59.50
113	133.20	85.85	23.45	6.12	40.24	43.62
114	133.20	85.85	23.49	6.12	40.24	43.62
115	133.20	19.55	12.21	6.12	40.24	43.62
116	133.20	19.55	12.44	6.12	40.24	43.62
150	41.27	8.45	1.63	0.88	15.23	10.15
151	41.27	8.45	1.63	0.88	15.23	10.15
152	41.27	8.45	1.63	0.88	15.23	10.15

153	41.27	8.45	1.63	0.88	15.23	10.15
201	377.97	168.33	83.29	83.29	113.39	113.39
202	198.33	196.72	21.95	21.95	59.50	59.50
203	116.10	115.41	15.79	11.10	42.08	23.28
204	116.10	111.33	15.79	11.10	42.08	23.28
205	116.10	114.23	15.79	11.10	42.08	23.28
206	116.10	115.41	15.79	11.10	42.08	23.28
207	116.10	114.23	15.79	11.10	42.08	23.28
208	133.20	95.15	32.87	6.12	40.24	43.62
209	66.48	58.89	3.82	3.82	19.94	19.94
210	116.10	111.33	15.79	11.10	42.08	23.28
211	133.20	95.15	32.87	6.12	40.24	43.62
212	198.33	196.72	21.95	21.95	59.50	59.50
213	133.20	85.85	24.20	6.12	40.24	43.62
214	133.20	85.85	24.37	6.12	40.24	43.62
215	133.20	19.55	12.32	6.12	40.24	43.62
216	133.20	19.55	12.30	6.12	40.24	43.62
250	41.27	8.45	1.63	0.88	15.23	10.15
251	41.27	8.45	1.63	0.88	15.23	10.15
252	41.27	8.45	1.63	0.88	15.23	10.15
253	41.27	8.45	1.63	0.88	15.23	10.15

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	0.079	0.769	0.025	0.045	0.002	0.809	#13	0.526	Not Required	Pass
2	0.008	0.407	0.213	0.100	0.039	0.557	#21	0.053	Not Required	Pass
3	0.008	0.568	0.178	0.056	0.075	0.746	#21	0.045	Not Required	Pass
4	0.008	0.560	0.075	0.056	0.011	0.639	#21	0.080	Not Required	Pass
5	0.008	0.352	0.048	0.056	0.015	0.402	#21	0.074	Not Required	Pass
6	0.004	0.658	0.210	0.067	0.081	0.869	#21	0.045	Not Required	Pass
7	0.004	0.409	0.024	0.066	0.008	0.433	#21	0.074	Not Required	Pass
8	0.009	0.062	0.186	0.046	0.016	0.221	#21	0.095	Not Required	Pass
9	0.031	0.050	0.078	0.002	0.002	0.133	#21	0.136	Not Required	Pass
10	0.005	0.637	0.085	0.064	0.011	0.710	#21	0.120	Not Required	Pass
11	0.007	0.060	0.188	0.048	0.017	0.225	#21	0.063	Not Required	Pass
12	0.009	0.503	0.256	0.118	0.046	0.685	#21	0.053	Not Required	Pass
13	0.008	0.246	0.083	0.060	0.012	0.325	#21	0.190	Not Required	Pass
14	0.016	0.242	0.063	0.057	0.012	0.287	#21	0.286	Not Required	Pass
15	0.008	0.090	0.085	0.031	0.012	0.111	#21	0.226	Not Required	Pass
16	0.011	0.089	0.085	0.030	0.011	0.110	#21	0.226	Not Required	Pass
50	0.337	0.009	0.005	0.003	0.002	0.349	#23	0.783	Not Required	Pass
51	0.067	0.004	0.014	0.002	0.002	0.080	#23	0.522	Not Required	Pass
52	0.176	0.009	0.005	0.002	0.001	0.188	#21	0.783	Not Required	Pass
53	0.035	0.004	0.015	0.001	0.001	0.049	#21	0.522	Not Required	Pass
101	0.092	0.859	0.000	0.050	0.000	0.894	#13	0.526	Not Required	Pass
102	0.010	0.528	0.264	0.126	0.047	0.720	#21	0.053	Not Required	Pass
103	0.005	0.706	0.226	0.071	0.092	0.935	#21	0.045	Not Required	Pass
104	0.005	0.703	0.079	0.071	0.010	0.784	#21	0.080	Not Required	Pass
105	0.005	0.438	0.045	0.070	0.017	0.486	#21	0.074	Not Required	Pass
106	0.005	0.706	0.226	0.071	0.092	0.935	#21	0.045	Not Required	Pass

107	0.004	0.438	0.045	0.070	0.017	0.486	#21	0.074	Not Required	Pass
108	0.011	0.066	0.202	0.049	0.016	0.250	#21	0.095	Not Required	Pass
109	0.038	0.046	0.064	0.001	0.000	0.129	#21	0.136	Not Required	Pass
110	0.005	0.703	0.079	0.071	0.010	0.784	#21	0.080	Not Required	Pass
111	0.008	0.061	0.200	0.049	0.017	0.258	#21	0.095	Not Required	Pass
112	0.010	0.528	0.264	0.126	0.047	0.720	#21	0.053	Not Required	Pass
113	0.008	0.257	0.039	0.061	0.009	0.297	#21	0.286	Not Required	Pass
114	0.018	0.280	0.045	0.061	0.009	0.314	#21	0.286	Not Required	Pass
115	0.060	0.434	0.259	0.049	0.024	0.609	#21	0.925	Not Required	Pass
116	0.068	0.413	0.258	0.049	0.024	0.565	#21	0.925	Not Required	Pass
150	0.344	0.009	0.005	0.004	0.002	0.357	#21	0.783	Not Required	Pass
151	0.069	0.004	0.014	0.002	0.002	0.081	#21	0.522	Not Required	Pass
152	0.344	0.009	0.005	0.004	0.002	0.357	#21	0.783	Not Required	Pass
153	0.069	0.004	0.014	0.002	0.002	0.081	#21	0.522	Not Required	Pass
201	0.079	0.769	0.025	0.045	0.002	0.809	#13	0.526	Not Required	Pass
202	0.009	0.503	0.256	0.118	0.046	0.685	#21	0.053	Not Required	Pass
203	0.004	0.658	0.210	0.067	0.081	0.869	#21	0.045	Not Required	Pass
204	0.005	0.637	0.085	0.064	0.011	0.710	#21	0.120	Not Required	Pass
205	0.004	0.409	0.024	0.066	0.008	0.433	#21	0.074	Not Required	Pass
206	0.008	0.568	0.178	0.056	0.075	0.746	#21	0.045	Not Required	Pass
207	0.008	0.352	0.048	0.056	0.015	0.403	#21	0.074	Not Required	Pass
208	0.011	0.089	0.085	0.030	0.011	0.110	#21	0.339	Not Required	Pass
209	0.031	0.050	0.078	0.002	0.002	0.133	#21	0.136	Not Required	Pass
210	0.008	0.560	0.075	0.056	0.011	0.639	#21	0.080	Not Required	Pass
211	0.008	0.090	0.085	0.031	0.012	0.111	#21	0.226	Not Required	Pass
212	0.008	0.407	0.213	0.100	0.039	0.557	#21	0.053	Not Required	Pass
213	0.008	0.246	0.083	0.060	0.012	0.325	#21	0.190	Not Required	Pass
214	0.016	0.242	0.063	0.057	0.012	0.287	#21	0.286	Not Required	Pass
215	0.060	0.437	0.259	0.048	0.024	0.612	#21	0.616	Not Required	Pass
216	0.068	0.422	0.258	0.046	0.024	0.574	#21	0.925	Not Required	Pass
250	0.176	0.009	0.005	0.002	0.001	0.188	#21	0.783	Not Required	Pass
251	0.035	0.004	0.015	0.001	0.001	0.049	#21	0.522	Not Required	Pass
252	0.337	0.009	0.005	0.003	0.002	0.349	#23	0.783	Not Required	Pass
253	0.067	0.004	0.014	0.002	0.002	0.080	#23	0.522	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

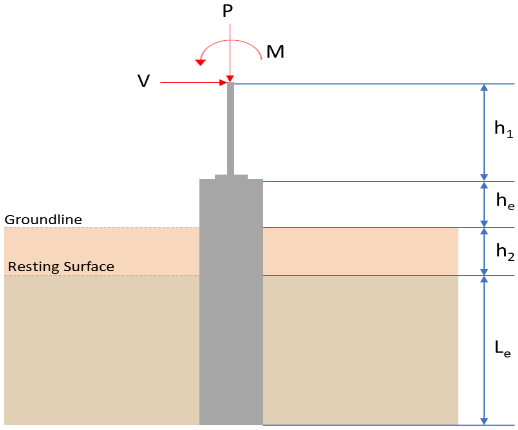
SkyCiv Foundation Design

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
$L = 7.25\ \mathrm{ft}$ - 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)	8.362	13.367
V_x (kip)	-3.023	-5.049
V_z (kip)	0.162	0.248
M_x (kipft)	0.594	0.919
M_z (kipft)	37.622	64.068

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,

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

$$H_o = \frac{(-3.023\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.48137\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(37.622 \text{ kipft}) + ((-3.023 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 5.9908 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:
$L_{e,x} = 6.6072 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.162 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.025796 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.594 \text{ kipft}) + ((0.162 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.094586 \text{ kipft/ft}$$

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:
$L_{e,z} = 2.2247 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(6.6072 \text{ ft}), (2.2247 \text{ ft})]$$

$$L_{e,req} = 6.607 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

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

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

$Ratio$ - Embedded depth

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

$$Ratio = \frac{(6.607 \text{ ft})}{(7.25 \text{ ft})}$$

$$Ratio = 0.91131$$

Status: **PASS**
Ratio: **0.910**

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

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

$$q = \frac{(8.362\ \mathrm{kip})}{(16\ \mathrm{ft}^2)}$$

$$q = 0.52262\ \mathrm{kip/ft}^2$$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{\left(0.52262\ \mathrm{kip/ft}^2\right)}{(2000\ \mathrm{psf})}$$

$$Ratio = 0.26131$$

Status: **PASS**
Ratio: **0.260**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

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

$$L/D = 1.8125$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.48137\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 5.9908\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.9908\ \mathrm{kipft/ft}) \times (7.25\ \mathrm{ft})) + \left(3 \times (-0.48137\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft})^2\right)}{(6 \times (5.9908\ \mathrm{kipft/ft})) + (4 \times (-0.48137\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft}))}$$

$$a = 5.0023\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (5.9908\ \mathrm{kipft/ft})) + (3 \times (-0.48137\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft}))]^2}{(7.25\ \mathrm{ft})^2 \times [(3 \times (5.9908\ \mathrm{kipft/ft})) + (2 \times (-0.48137\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft}))]}$$

$$p = 0.23633\ \mathrm{kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (5.9908\ \mathrm{kipft/ft})) + ((-0.48137\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft}))]}{(7.25\ \mathrm{ft})^2}$$

$$s = 0.96931\ \mathrm{kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \mathrm{psf/ft}) \times \frac{(5.0023\ \mathrm{ft})}{2}$$

$$p_a = 0.37518\ \mathrm{kip/ft}^2$$

$Ratio$ - Lateral soil capacity

	$$Ratio = \frac{p}{p_a}$$ $$Ratio = \frac{\left(0.23633\ \mathrm{kip/ft^2}\right)}{\left(0.37518\ \mathrm{kip/ft^2}\right)}$$ $$Ratio = 0.62993$$	Status: **PASS** Ratio: **0.630**
	p_s - Allowable lateral soil pressure at depth L_e, $$p_s = R\, L_e$$ $$p_s = (150\ \mathrm{psf/ft}) \times (7.25\ \mathrm{ft})$$ $$p_s = 1.0875\ \mathrm{kip/ft^2}$$ $Ratio$ - Lateral soil capacity $$Ratio = \frac{s}{p_s}$$ $$Ratio = \frac{\left(0.96931\ \mathrm{kip/ft^2}\right)}{\left(1.0875\ \mathrm{kip/ft^2}\right)}$$ $$Ratio = 0.89132$$	Status: **PASS** Ratio: **0.890**
	Considering z-direction: $H_o = 0.025796\ \mathrm{kip/ft}$ - Lateral force per length of pile, $M_o = 0.094586\ \mathrm{kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point, $$a = \frac{(4\, M_o\, L_e) + \left(3\, H_o\, L_e^2\right)}{(6\, M_o) + (4\, H_o\, L_e)}$$ $$a = \frac{(4 \times (0.094586\ \mathrm{kipft/ft}) \times (7.25\ \mathrm{ft})) + \left(3 \times (0.025796\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft})^2\right)}{(6 \times (0.094586\ \mathrm{kipft/ft})) + (4 \times (0.025796\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft}))}$$ $$a = 5.1769\ \mathrm{ft}$$ p - Earth pressure against the pile at distance a/2 from resting surface, $$p = \frac{0.75\,[(4\, M_o) + (3\, H_o\, L_e)]^2}{L_e^2\,[(3\, M_o) + (2\, H_o\, L_e)]}$$ $$p = \frac{0.75 \times [(4 \times (0.094586\ \mathrm{kipft/ft})) + (3 \times (0.025796\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft}))]^{\ 2}}{(7.25\ \mathrm{ft})^2 \times [(3 \times (0.094586\ \mathrm{kipft/ft})) + (2 \times (0.025796\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft}))]}$$ $$p = 0.019143\ \mathrm{kip/ft^2}$$ s - Earth pressure against the pile at distance L_e, $$s = \frac{6\,[(2\, M_o) + (H_o\, L_e)]}{L_e^2}$$ $$s = \frac{6 \times [(2 \times (0.094586\ \mathrm{kipft/ft})) + ((0.025796\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft}))]}{(7.25\ \mathrm{ft})^2}$$ $$s = 0.042943\ \mathrm{kip/ft^2}$$ **Check lateral soil pressure capacity:** p_a - Allowable lateral soil pressure at depth a/2, $$p_a = R\,\frac{a}{2}$$ $$p_a = (150\ \mathrm{psf/ft}) \times \frac{(5.1769\ \mathrm{ft})}{2}$$ $$p_a = 0.38827\ \mathrm{kip/ft^2}$$ $Ratio$ - Lateral soil capacity $$Ratio = \frac{p}{p_a}$$ $$Ratio = \frac{\left(0.019143\ \mathrm{kip/ft^2}\right)}{\left(0.38827\ \mathrm{kip/ft^2}\right)}$$	

$$Ratio = 0.049303$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (7.25\ \mathrm{ft})$$

$$p_s = 1.0875\ \mathrm{kip/ft^2}$$

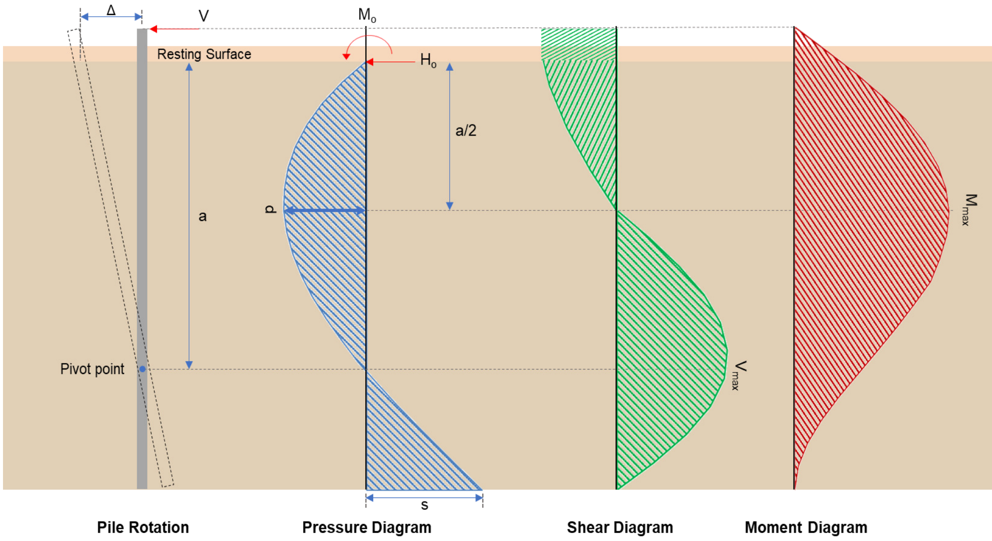
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.042943\ \mathrm{kip/ft^2})}{(1.0875\ \mathrm{kip/ft^2})}$$

$$Ratio = 0.039487$$

Status: **PASS**
Ratio: **0.040**



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-5.049\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.80398\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(64.068\ \mathrm{kipft}) + ((-5.049\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 10.202\ \mathrm{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(10.202\ \mathrm{kipft/ft})}{(-0.80398\ \mathrm{kip/ft})}$$

$$E = 12.689\ \mathrm{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (10.202\ \mathrm{kipft/ft}) \times (7.25\ \mathrm{ft})) + \left(3 \times (-0.80398\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft})^2\right)}{}$$

$$a = \frac{}{(6 \times (10.202\ \text{kipft/ft})) + (4 \times (-0.80398\ \text{kip/ft}) \times (7.25\ \text{ft}))}$$

$$a = 5\ \text{ft}$$

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

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

$$V_{max} = ((-0.80398\ \text{kip/ft}) \times (48\ \text{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (12.689\ \text{ft})}{(7.25\ \text{ft})} + 3\right) \times \left(\frac{(5\ \text{ft})}{(7.25\ \text{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (12.689\ \text{ft})}{(7.25\ \text{ft})} + 2\right) \times \left(\frac{(5\ \text{ft})}{(7.25\ \text{ft})}\right)^3\right]\right]$$

$$V_{max} = 12.081\ \text{kip}$$

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

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

$$M_{max} = ((-0.80398\ \text{kip/ft}) \times (48\ \text{in}) \times (7.25\ \text{ft})) \times \left[\left(\frac{(12.689\ \text{ft})}{(7.25\ \text{ft})} + \frac{(5\ \text{ft})}{2 \times (7.25\ \text{ft})}\right) - \left[\left(\frac{4 \times (12.689\ \text{ft})}{(7.25\ \text{ft})} + 3\right) \times \left(\frac{(5\ \text{ft})}{2 \times (7.25\ \text{ft})}\right)^3\right] + \left[\left(\frac{3 \times (12.689\ \text{ft})}{(7.25\ \text{ft})} + 2\right) \times \left(\frac{(5\ \text{ft})}{2 \times (7.25\ \text{ft})}\right)^4\right]\right]$$

$$M_{max} = 41.677\ \text{kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.248\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = 0.03949\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.919\ \text{kipft}) + ((0.248\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 0.14634\ \text{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.14634\ \text{kipft/ft})}{(0.03949\ \text{kip/ft})}$$

$$E = 3.7056\ \text{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.14634\ \text{kipft/ft}) \times (7.25\ \text{ft})) + \left(3 \times (0.03949\ \text{kip/ft}) \times (7.25\ \text{ft})^2\right)}{(6 \times (0.14634\ \text{kipft/ft})) + (4 \times (0.03949\ \text{kip/ft}) \times (7.25\ \text{ft}))}$$

$$a = 5.1753\ \text{ft}$$

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

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

$$V_{max} = ((0.03949\ \mathrm{kip/ft}) \times (48\ \mathrm{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (3.7056\ \mathrm{ft})}{(7.25\ \mathrm{ft})} + 3\right) \times \left(\frac{(5.1753\ \mathrm{ft})}{(7.25\ \mathrm{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (3.7056\ \mathrm{ft})}{(7.25\ \mathrm{ft})} + 2\right) \times \left(\frac{(5.1753\ \mathrm{ft})}{(7.25\ \mathrm{ft})}\right)^3\right]\right]$$

$$V_{max} = 0.24808\ \mathrm{kip}$$

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

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

$$M_{max} = ((0.03949\ \mathrm{kip/ft}) \times (48\ \mathrm{in}) \times (7.25\ \mathrm{ft})) \times \left[\left(\frac{(3.7056\ \mathrm{ft})}{(7.25\ \mathrm{ft})} + \frac{(5.1753\ \mathrm{ft})}{2 \times (7.25\ \mathrm{ft})}\right) - \left[\left(\frac{4 \times (3.7056\ \mathrm{ft})}{(7.25\ \mathrm{ft})} + 3\right) \times \left(\frac{(5.1753\ \mathrm{ft})}{2 \times (7.25\ \mathrm{ft})}\right)^3\right] + \left[\left(\frac{3 \times (3.7056\ \mathrm{ft})}{(7.25\ \mathrm{ft})} + 2\right) \times \left(\frac{(5.1753\ \mathrm{ft})}{2 \times (7.25\ \mathrm{ft})}\right)^4\right]\right]$$

$$M_{max} = 0.7971\ \mathrm{kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

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

Longitudinal reinforcement:

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

22.4.2.2, 10.6.1.1 $A_{st,required}$

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

$$A_{st,required} = Min\left[\frac{\frac{(13.367\ \mathrm{kip})}{(0.65)\times(0.8)} - (0.85 \times (2.5\ \mathrm{ksi}) \times (2304\ \mathrm{in}^2))}{(60\ \mathrm{ksi}) - (0.85 \times (2.5\ \mathrm{ksi}))}, (0.08 \times (2304\ \mathrm{in}^2))\right]$$

$$A_{st,required} = -84.152\ \mathrm{in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[(-84.152\ \mathrm{in}^2), (0.0018 \times (2304\ \mathrm{in}^2))\right]$$

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

n_{rebar} - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

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

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

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

$Ratio$ - Capacity

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

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

$$Ratio = 0.96556$$

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

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

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

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

$Ratio$ - Capacity

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

$$Ratio = \frac{(13.367\ \text{kip})}{(2675.2\ \text{kip})}$$

$$Ratio = 0.0049967$$

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 $f'_{ck} = 2.5\ \text{ksi} \rightarrow 2500\ \text{psi}$,

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 $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 13.367 \text{ kip} \rightarrow 13367 \text{ lbf}$,

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

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(13367 \text{ lbf})}{6 \times (2304 \text{ in}^2)}\right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 120.27 \text{ kip}$$

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

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

$$V_c = Min\left[(296.21 \text{ kip}), (120.27 \text{ kip}), (348.89 \text{ kip})\right]$$

$$V_c = 120.27 \text{ kip}$$

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

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

$$\phi V_n = (0.65) \times ((120.27 \text{ kip}) + (50.894 \text{ kip}))$$

$$\phi V_n = 111.25 \text{ kip}$$

Considering x-direction:

$V_{max} = 12.081 \text{ kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(12.081 \text{ kip})}{(111.25 \text{ kip})}$$

$$Ratio = 0.10859$$

Status: **PASS**
Ratio: **0.110**

Considering z-direction:

$V_{max} = 0.24808 \text{ kip}$ - Maximum shear force in the z-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(0.24808 \text{ kip})}{(111.25 \text{ kip})}$$

$$Ratio = 0.0022298$$

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:
$\phi M_{n,1}$

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

$$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5ksi)} \times 18432.001in^3$$

$$\phi M_{n,1} = 249.600kipft$$

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

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

$$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times \left(18432 \text{ in}^3\right)$$

$$\phi M_{n,2} = 2121.6 \text{ kipft}$$

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:

$M_{max} = 41.677 \text{ kipft}$ - Maximum moment in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(41.677 \text{ kipft})}{(249.6 \text{ kipft})}$$

$$Ratio = 0.16697$$

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

Considering z-direction:

$M_{max} = 0.7971 \text{ kipft}$ - Maximum moment in the z-direction,
$Ratio$ - Capacity

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

		$$Ratio = \frac{(0.7971\ \text{kipft})}{(249.6\ \text{kipft})}$$ $$Ratio = 0.0031935$$	Status: **PASS** Ratio: **0.000**

REFERENCES	CALCULATIONS	RESULTS

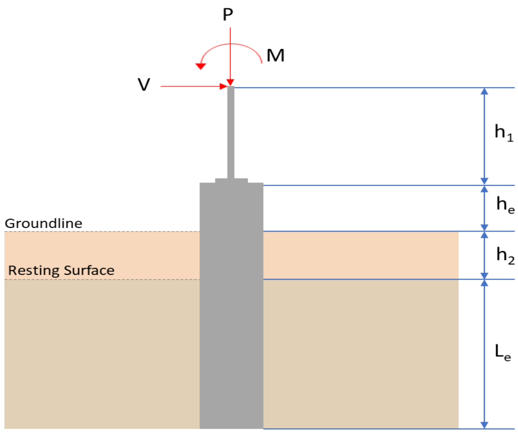
SkyCiv Foundation Design

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

$L = 7.25\ \mathrm{ft}$ - 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)	9.641	15.428
V_x (kip)	-3.374	-5.628
V_z (kip)	0.000	0.000
M_x (kipft)	0.000	0.000
M_z (kipft)	41.830	71.577

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,

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

$$H_o = \frac{(-3.374\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.53726\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(41.83\ \mathrm{kipft}) + ((-3.374\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 6.6608\ \mathrm{kipft/ft}$$

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:
$L_{e,x} = 6.7955\ \mathrm{ft}$ - Required depth in x-direction,

Considering z-direction:

$L_{e,z} = 0\ \mathrm{ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(6.7955\ \mathrm{ft}), (0\ \mathrm{ft})]$$

$$L_{e,req} = 6.796\ \mathrm{ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

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

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

$Ratio$ - Embedded depth

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

$$Ratio = \frac{(6.796\ \mathrm{ft})}{(7.25\ \mathrm{ft})}$$

$$Ratio = 0.93738$$

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

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

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

$$q = \frac{(9.641\ \mathrm{kip})}{(16\ \mathrm{ft}^2)}$$

$$q = 0.60256\ \mathrm{kip/ft}^2$$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{(0.60256\ \mathrm{kip/ft}^2)}{(2000\ \mathrm{psf})}$$

$$Ratio = 0.30128$$

Status: **PASS**
Ratio: **0.300**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

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

$$L/D = 1.8125$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.53726\ \text{kip/ft}$ - Lateral force per length of pile,
$M_o = 6.6608\ \text{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (6.6608\ \text{kipft/ft}) \times (7.25\ \text{ft})) + \left(3 \times (-0.53726\ \text{kip/ft}) \times (7.25\ \text{ft})^2\right)}{(6 \times (6.6608\ \text{kipft/ft})) + (4 \times (-0.53726\ \text{kip/ft}) \times (7.25\ \text{ft}))}$$

$$a = 5.0028\ \text{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (6.6608\ \text{kipft/ft})) + (3 \times (-0.53726\ \text{kip/ft}) \times (7.25\ \text{ft}))]^2}{(7.25\ \text{ft})^2 \times [(3 \times (6.6608\ \text{kipft/ft})) + (2 \times (-0.53726\ \text{kip/ft}) \times (7.25\ \text{ft}))]}$$

$$p = 0.26184\ \text{kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (6.6608\ \text{kipft/ft})) + ((-0.53726\ \text{kip/ft}) \times (7.25\ \text{ft}))]}{(7.25\ \text{ft})^2}$$

$$s = 1.076\ \text{kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \text{psf/ft}) \times \frac{(5.0028\ \text{ft})}{2}$$

$$p_a = 0.37521\ \text{kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.26184\ \text{kip/ft}^2\right)}{\left(0.37521\ \text{kip/ft}^2\right)}$$

$$Ratio = 0.69786$$

Status: **PASS**
Ratio: **0.700**

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\, L_e$$

$$p_s = (150\ \text{psf/ft}) \times (7.25\ \text{ft})$$

$$p_s = 1.0875\ \text{kip/ft}^2$$

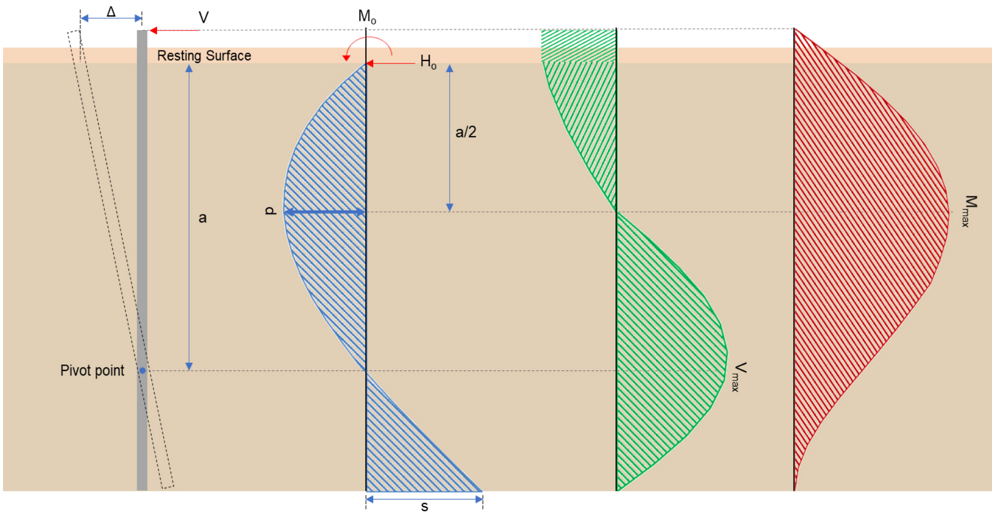
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(1.076\ \text{kip/ft}^2\right)}{\left(1.0875\ \text{kip/ft}^2\right)}$$

$$Ratio = 0.98946$$

Status: PASS
Ratio: 0.990



Pile Rotation Pressure Diagram Shear Diagram Moment Diagram

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-5.628\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = -0.89618\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(71.577\ \text{kipft}) + ((-5.628\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 11.398\ \text{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(11.398\ \text{kipft/ft})}{(-0.89618\ \text{kip/ft})}$$

$$E = 12.718\ \text{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (11.398\ \text{kipft/ft}) \times (7.25\ \text{ft})) + \left(3 \times (-0.89618\ \text{kip/ft}) \times (7.25\ \text{ft})^2\right)}{(6 \times (11.398\ \text{kipft/ft})) + (4 \times (-0.89618\ \text{kip/ft}) \times (7.25\ \text{ft}))}$$

$$a = 4.9997\ \text{ft}$$

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

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

$$V_{max} = ((-0.89618\ \text{kip/ft}) \times (48\ \text{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (12.718\ \text{ft})}{(7.25\ \text{ft})} + 3\right) \times \left(\frac{(4.9997\ \text{ft})}{(7.25\ \text{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (12.718\ \text{ft})}{(7.25\ \text{ft})} + 2\right) \times \left(\frac{(4.9997\ \text{ft})}{(7.25\ \text{ft})}\right)^3\right]\right]$$

$$V_{max} = 13.402\ \text{kip}$$

$$V_{max} = 13.492\ \text{kip}$$

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

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

$$M_{max} = ((-0.89618\ \text{kip/ft}) \times (48\ \text{in}) \times (7.25\ \text{ft})) \times \left[\left(\frac{(12.718\ \text{ft})}{(7.25\ \text{ft})} + \frac{(4.9997\ \text{ft})}{2 \times (7.25\ \text{ft})}\right) - \left[\left(\frac{4 \times (12.718\ \text{ft})}{(7.25\ \text{ft})} + 3\right) \times \left(\frac{(4.9997\ \text{ft})}{2 \times (7.25\ \text{ft})}\right)^3\right] + \left[\left(\frac{3 \times (12.718\ \text{ft})}{(7.25\ \text{ft})} + 2\right) \times \left(\frac{(4.9997\ \text{ft})}{2 \times (7.25\ \text{ft})}\right)^4\right]\right]$$

$$M_{max} = 46.548\ \text{kipft}$$

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 $A_{st,required}$

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

$$A_{st,required} = Min\left[\frac{\frac{(15.428\ \text{kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5\ \text{ksi}) \times (2304\ \text{in}^2))}{(60\ \text{ksi}) - (0.85 \times (2.5\ \text{ksi}))}, (0.08 \times (2304\ \text{in}^2))\right]$$

$$A_{st,required} = -84.083\ \text{in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[(-84.083\ \text{in}^2), (0.0018 \times (2304\ \text{in}^2))\right]$$

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

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

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

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

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

$Ratio$ - Capacity

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

$$Ratio = \frac{(15.428\ \text{kip})}{(2675.2\ \text{kip})}$$

$$Ratio = 0.0057671$$

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 $f'_{ck} = 2.5\ \text{ksi} \rightarrow 2500\ \text{psi}$, $P = 15.428\ \text{kip} \rightarrow 15428\ \text{lbf}$,

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

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500\ \text{psi})} + \frac{(15428\ \text{lbf})}{6 \times (2304\ \text{in}^2)}\right] \times (48\ \text{in}) \times (38.4\ \text{in})$$

$$V_{c,a} = 120.54\ \text{kip}$$

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

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

$$V_c = Min\left[(296.21\ \text{kip}), (120.54\ \text{kip}), (348.89\ \text{kip})\right]$$

$$V_c = 120.54\ \text{kip}$$

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

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

$$\phi V_n = (0.65) \times ((120.54\ \text{kip}) + (50.894\ \text{kip}))$$

$$\phi V_n = 111.43\ \text{kip}$$

Considering x-direction:

$V_{max} = 13.492\ \text{kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(13.492\ \text{kip})}{(111.43\ \text{kip})}$$

$$Ratio = 0.12107$$

Status: **PASS**
Ratio: **0.120**

	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:
$\phi M_{n,1}$

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

$$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5ksi)} \times 18432.001in^3$$

$$\phi M_{n,1} = 249.600kipft$$

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

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

$$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5\text{ ksi}) \times \left(18432\text{ in}^3\right)$$

$$\phi M_{n,2} = 2121.6\text{ kipft}$$

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:

$M_{max} = 46.548\text{ kipft}$ - Maximum moment in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(46.548\text{ kipft})}{(249.6\text{ kipft})}$$

$$Ratio = 0.18649$$

Status: **PASS**
Ratio: **0.190**

REFERENCES	CALCULATIONS	RESULTS

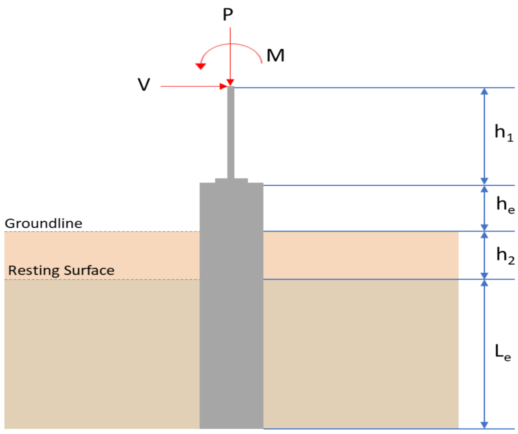
SkyCiv Foundation Design

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
$L = 7.25\ \mathrm{ft}$ - 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)	8.362	13.367
V_x (kip)	-3.023	-5.049
V_z (kip)	-0.162	-0.248
M_x (kipft)	-0.594	-0.919
M_z (kipft)	37.622	64.069

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,

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

$$H_o = \frac{(-3.023\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.48137\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(37.622\ \text{kipft}) + ((-3.023\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 5.9908\ \text{kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:
$L_{e,x} = 6.6072\ \text{ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.162\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = -0.025796\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.594\ \text{kipft}) + ((-0.162\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 0.094586\ \text{kipft/ft}$$

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:
$L_{e,z} = 1.7022\ \text{ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(6.6072\ \text{ft}), (1.7022\ \text{ft})]$$

$$L_{e,req} = 6.607\ \text{ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

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

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

$Ratio$ - Embedded depth

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

$$Ratio = \frac{(6.607\ \text{ft})}{(7.25\ \text{ft})}$$

$$Ratio = 0.91131$$

Status: **PASS**
Ratio: **0.910**

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

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

$$q = \frac{(8.362 \text{ kip})}{(16 \text{ ft}^2)}$$

$$q = 0.52262 \text{ kip/ft}^2$$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{\left(0.52262 \text{ kip/ft}^2\right)}{(2000 \text{ psf})}$$

$$Ratio = 0.26131$$

Status: **PASS**
Ratio: **0.260**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

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

$$L/D = 1.8125$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.48137 \text{ kip/ft}$ - Lateral force per length of pile,
$M_o = 5.9908 \text{ kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.9908 \text{ kipft/ft}) \times (7.25 \text{ ft})) + \left(3 \times (-0.48137 \text{ kip/ft}) \times (7.25 \text{ ft})^2\right)}{(6 \times (5.9908 \text{ kipft/ft})) + (4 \times (-0.48137 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 5.0023 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (5.9908 \text{ kipft/ft})) + (3 \times (-0.48137 \text{ kip/ft}) \times (7.25 \text{ ft}))]^2}{(7.25 \text{ ft})^2 \times [(3 \times (5.9908 \text{ kipft/ft})) + (2 \times (-0.48137 \text{ kip/ft}) \times (7.25 \text{ ft}))]}$$

$$p = 0.23633 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (5.9908 \text{ kipft/ft})) + ((-0.48137 \text{ kip/ft}) \times (7.25 \text{ ft}))]}{(7.25 \text{ ft})^2}$$

$$s = 0.96931 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(5.0023 \text{ ft})}{2}$$

$$p_a = 0.37518 \text{ kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.23633\ \mathrm{kip/ft^2}\right)}{\left(0.37518\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.62993$$

Status: **PASS**
Ratio: **0.630**

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (7.25\ \mathrm{ft})$$

$$p_s = 1.0875\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.96931\ \mathrm{kip/ft^2}\right)}{\left(1.0875\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.89132$$

Status: **PASS**
Ratio: **0.890**

Considering z-direction:

$H_o = -0.025796\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 0.094586\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.094586\ \mathrm{kipft/ft}) \times (7.25\ \mathrm{ft})) + \left(3 \times (-0.025796\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft})^2\right)}{(6 \times (0.094586\ \mathrm{kipft/ft})) + (4 \times (-0.025796\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft}))}$$

$$a = 5.1769\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.094586\ \mathrm{kipft/ft})) + (3 \times (-0.025796\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft}))]^{\ 2}}{(7.25\ \mathrm{ft})^2 \times [(3 \times (0.094586\ \mathrm{kipft/ft})) + (2 \times (-0.025796\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft}))]}$$

$$p = -0.0052765\ \mathrm{kip/ft^2}$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (0.094586\ \mathrm{kipft/ft})) + ((-0.025796\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft}))]}{(7.25\ \mathrm{ft})^2}$$

$$s = 0.00024539\ \mathrm{kip/ft^2}$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \mathrm{psf/ft}) \times \frac{(5.1769\ \mathrm{ft})}{2}$$

$$p_a = 0.38827\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(-0.0052765\ \mathrm{kip/ft^2}\right)}{\left(0.38827\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = -0.01359$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \text{psf/ft}) \times (7.25\ \text{ft})$$

$$p_s = 1.0875\ \text{kip/ft}^2$$

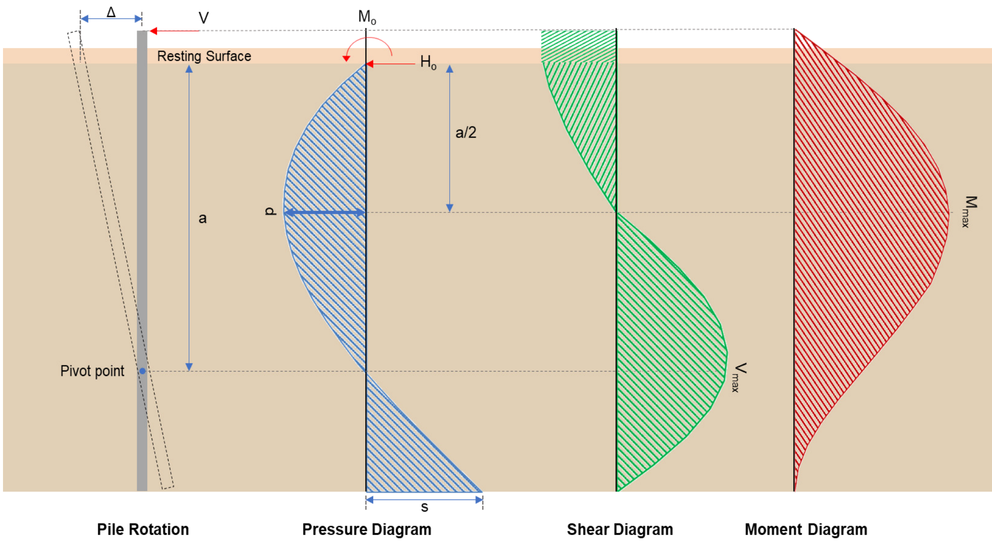
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.00024539\ \text{kip/ft}^2)}{(1.0875\ \text{kip/ft}^2)}$$

$$Ratio = 0.00022564$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-5.049\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = -0.80398\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(64.069\ \text{kipft}) + ((-5.049\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 10.202\ \text{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(10.202\ \text{kipft/ft})}{(-0.80398\ \text{kip/ft})}$$

$$E = 12.689\ \text{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (10.202\ \text{kipft/ft}) \times (7.25\ \text{ft})) + \left(3 \times (-0.80398\ \text{kip/ft}) \times (7.25\ \text{ft})^2\right)}{\ldots}$$

$$a = \frac{\quad}{(6 \times (10.202\ \mathrm{kipft/ft})) + (4 \times (-0.80398\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft}))}$$

$$a = 5\ \mathrm{ft}$$

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

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

$$V_{max} = ((-0.80398\ \mathrm{kip/ft}) \times (48\ \mathrm{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (12.689\ \mathrm{ft})}{(7.25\ \mathrm{ft})} + 3\right) \times \left(\frac{(5\ \mathrm{ft})}{(7.25\ \mathrm{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (12.689\ \mathrm{ft})}{(7.25\ \mathrm{ft})} + 2\right) \times \left(\frac{(5\ \mathrm{ft})}{(7.25\ \mathrm{ft})}\right)^3\right]\right]$$

$$V_{max} = 12.081\ \mathrm{kip}$$

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

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

$$M_{max} = ((-0.80398\ \mathrm{kip/ft}) \times (48\ \mathrm{in}) \times (7.25\ \mathrm{ft})) \times \left[\left(\frac{(12.689\ \mathrm{ft})}{(7.25\ \mathrm{ft})} + \frac{(5\ \mathrm{ft})}{2 \times (7.25\ \mathrm{ft})}\right) - \left[\left(\frac{4 \times (12.689\ \mathrm{ft})}{(7.25\ \mathrm{ft})} + 3\right) \times \left(\frac{(5\ \mathrm{ft})}{2 \times (7.25\ \mathrm{ft})}\right)^3\right] + \left[\left(\frac{3 \times (12.689\ \mathrm{ft})}{(7.25\ \mathrm{ft})} + 2\right) \times \left(\frac{(5\ \mathrm{ft})}{2 \times (7.25\ \mathrm{ft})}\right)^4\right]\right]$$

$$M_{max} = 41.678\ \mathrm{kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.248\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.03949\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.919\ \mathrm{kipft}) + ((-0.248\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 0.14634\ \mathrm{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.14634\ \mathrm{kipft/ft})}{(-0.03949\ \mathrm{kip/ft})}$$

$$E = 3.7056\ \mathrm{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.14634\ \mathrm{kipft/ft}) \times (7.25\ \mathrm{ft})) + \left(3 \times (-0.03949\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft})^2\right)}{(6 \times (0.14634\ \mathrm{kipft/ft})) + (4 \times (-0.03949\ \mathrm{kip/ft}) \times (7.25\ \mathrm{ft}))}$$

$$a = 5.1753\ \mathrm{ft}$$

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

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

$$V_{max} = ((-0.03949 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (3.7056 \text{ ft})}{(7.25 \text{ ft})} + 3\right) \times \left(\frac{(5.1753 \text{ ft})}{(7.25 \text{ ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (3.7056 \text{ ft})}{(7.25 \text{ ft})} + 2\right) \times \left(\frac{(5.1753 \text{ ft})}{(7.25 \text{ ft})}\right)^3\right]\right]$$

$$V_{max} = 0.24808 \text{ kip}$$

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

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

$$M_{max} = ((-0.03949 \text{ kip/ft}) \times (48 \text{ in}) \times (7.25 \text{ ft})) \times \left[\left(\frac{(3.7056 \text{ ft})}{(7.25 \text{ ft})} + \frac{(5.1753 \text{ ft})}{2 \times (7.25 \text{ ft})}\right) - \left[\left(\frac{4 \times (3.7056 \text{ ft})}{(7.25 \text{ ft})} + 3\right) \times \left(\frac{(5.1753 \text{ ft})}{2 \times (7.25 \text{ ft})}\right)^3\right] + \left[\left(\frac{3 \times (3.7056 \text{ ft})}{(7.25 \text{ ft})} + 2\right) \times \left(\frac{(5.1753 \text{ ft})}{2 \times (7.25 \text{ ft})}\right)^4\right]\right]$$

$$M_{max} = 0.7971 \text{ kipft}$$

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 $A_{st,required}$

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

$$A_{st,required} = Min\left[\frac{\frac{(13.367 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2))\right]$$

$$A_{st,required} = -84.152 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[(-84.152 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))\right]$$

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

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

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

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

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

$Ratio$ - Capacity

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

$$Ratio = \frac{(13.367\text{ kip})}{(2675.2\text{ kip})}$$

$$Ratio = 0.0049967$$

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 $f'_{ck} = 2.5\text{ ksi} \rightarrow 2500\text{ psi}$,
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 $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$,$P = 13.367 \text{ kip} \rightarrow 13367 \text{ lbf}$,

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

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(13367 \text{ lbf})}{6 \times (2304 \text{ in}^2)}\right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 120.27 \text{ kip}$$

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

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

$$V_c = Min\left[(296.21 \text{ kip}), (120.27 \text{ kip}), (348.89 \text{ kip})\right]$$

$$V_c = 120.27 \text{ kip}$$

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

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

$$\phi V_n = (0.65) \times ((120.27 \text{ kip}) + (50.894 \text{ kip}))$$

$$\phi V_n = 111.25 \text{ kip}$$

Considering x-direction:

$V_{max} = 12.081 \text{ kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

	$$Ratio = \frac{(12.081\text{ kip})}{(111.25\text{ kip})}$$ $$Ratio = 0.10859$$	Status: **PASS** Ratio: **0.110**
	Considering z-direction: $V_{max} = 0.24808\text{ kip}$ - Maximum shear force in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{V_{max}}{\phi V_n}$$ $$Ratio = \frac{(0.24808\text{ kip})}{(111.25\text{ kip})}$$ $$Ratio = 0.0022298$$	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: $\phi M_{n,1}$ $$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f_c')} \times S_m$$ $$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5ksi)} \times 18432.001in^3$$ $$\phi M_{n,1} = 249.600kipft$$ $\phi M_{n,2}$ $$\phi M_{n,2} = \phi\, 0.85\, f_{ck}'\, S_m$$ $$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5\text{ ksi}) \times \left(18432\text{ in}^3\right)$$ $$\phi M_{n,2} = 2121.6\text{ kipft}$$ 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:** $M_{max} = 41.678\text{ kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(41.678\text{ kipft})}{(249.6\text{ kipft})}$$ $$Ratio = 0.16698$$	Status: **PASS** Ratio: **0.170**
	Considering z-direction: $M_{max} = 0.7971\text{ kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$	

	$$Ratio = \frac{(0.7971 \text{ kipft})}{(249.6 \text{ kipft})}$$ $$Ratio = 0.0031935$$	Status: **PASS** Ratio: **0.000**