

Your Project Calculations



Project Name: qcell 480W bifacial

S3D Model Link:

https://platform.skyciv.com/structural?preload_name=qcell%20480W%20bifacial&preload_path=Shared%20Enterprise%20Folder/MT_Solar_Projects/1_2024

Public Model Link:

https://platform.skyciv.com/structural-viewer?project_id=ZMugJlpyivsrnlugovPvqWZbdYltnjvEG3mO3ITKVJe1eVkh6utzK3Wleo3dXt4s

Array Specification

Product:	Beam
Unique ID:	2P-17-10TOP-HD-24-L-3Hx4W-GIGK
Duty Classification:	HD
Module Width:	42.00 in
Module Length:	88.00in
Number of Rows:	3
Number of Columns:	4
Total Number of Modules:	12
Desired Tilt Angle:	70
Front Edge Clearance:	4
Total Array Height at Tilt:	13.93 ft
Total Frame Length:	28.50 ft
Frame Weight:	1726 lbs
Array Dimensions N/S:	10.63 ft
Array Dimensions E/W:	29.67 ft
Rail Length:	127.50 in
Rail Spacing:	3.67 ft
Rail Check:	Not Checked

Support Specifications

Pole Size:	10in Pipe Sch 40
Pole Length above Grade:	8.99 ft
Number of Poles:	2
Pole Spacing:	17 ft

Foundation Specifications

Foundation Type:	Square
Foundation Dimensions:	48 x 48 in
Foundation Depth (below grade):	Pile 1: 6.75 ft Pile 2: 6.75 ft
Foundation Volume:	8.000 y ³
Foundation Result:	PASSED
Mount Twist:	1.649008 kip

Site Info

Risk Category:	I
Exposure:	C
Soil Classification:	sand
Site Location:	6204 Boldt Rd, Valders, WI 54245, USA
Wind Speed:	130 mph
Snow Load:	40 psf
Design Uplift Pressure:	0.043418 ksf
Design Downforce Pressure:	-0.043418 ksf
Design Snow Pressure:	0.000000 ksf



Design Disclaimer

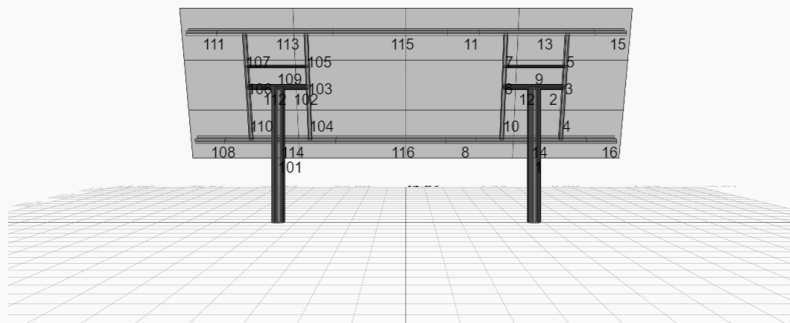
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

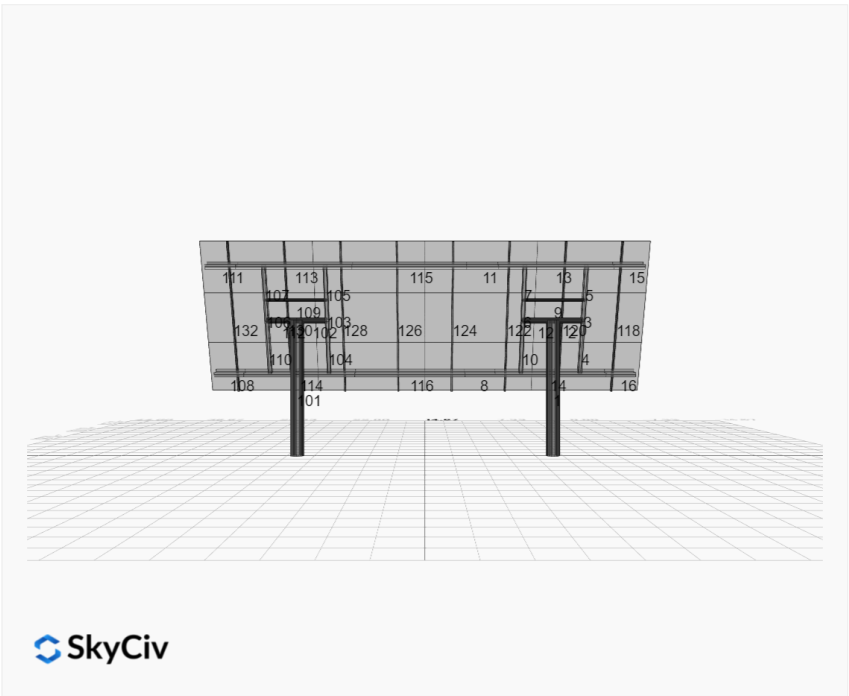
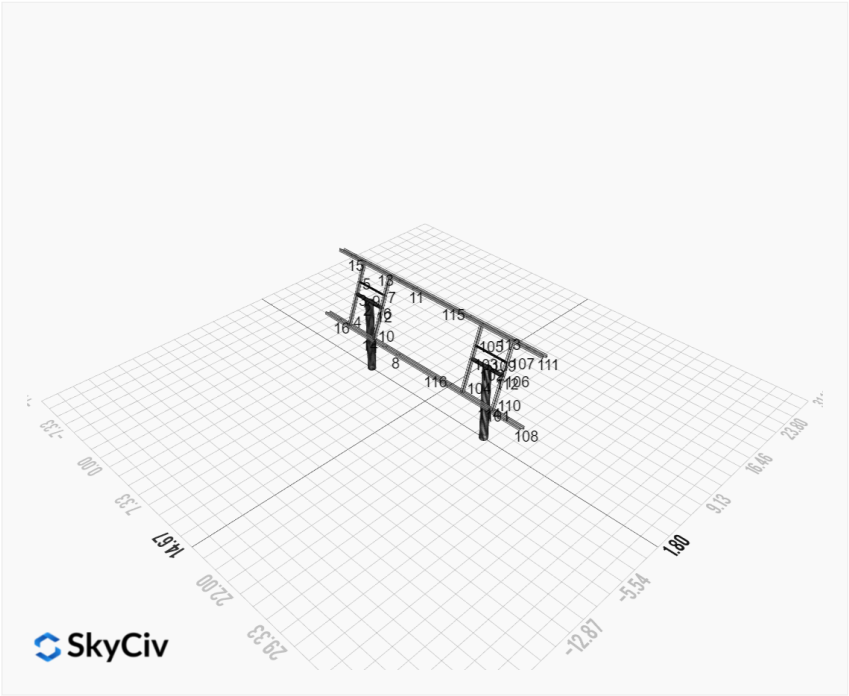
AutoDesigner Input

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  "project_id": "qcell 480W bifacial",
  "site_address": "6204 Boldt Rd, Valders, WI 54245, USA",
  "module_width": 42,
  "module_length": 88,
  "number_rows": 3,
  "number_columns": 4,
  "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": 70,
  "ground_clearance": 4,
  "risk_category": "I",
  "exposure_category": "C",
  "frame_duty_override": "HD",
  "pole_override": "10_40",
  "soil_type": "sand",
  "customer_foundation_override": "48_Square",
  "foundation_type": "Square",
  "foundation_size": 48,
  "check_rails": false,
  "wind_speed_override": 130,
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  "direct_snow_load": false,
  "add_angle_brace": false
}
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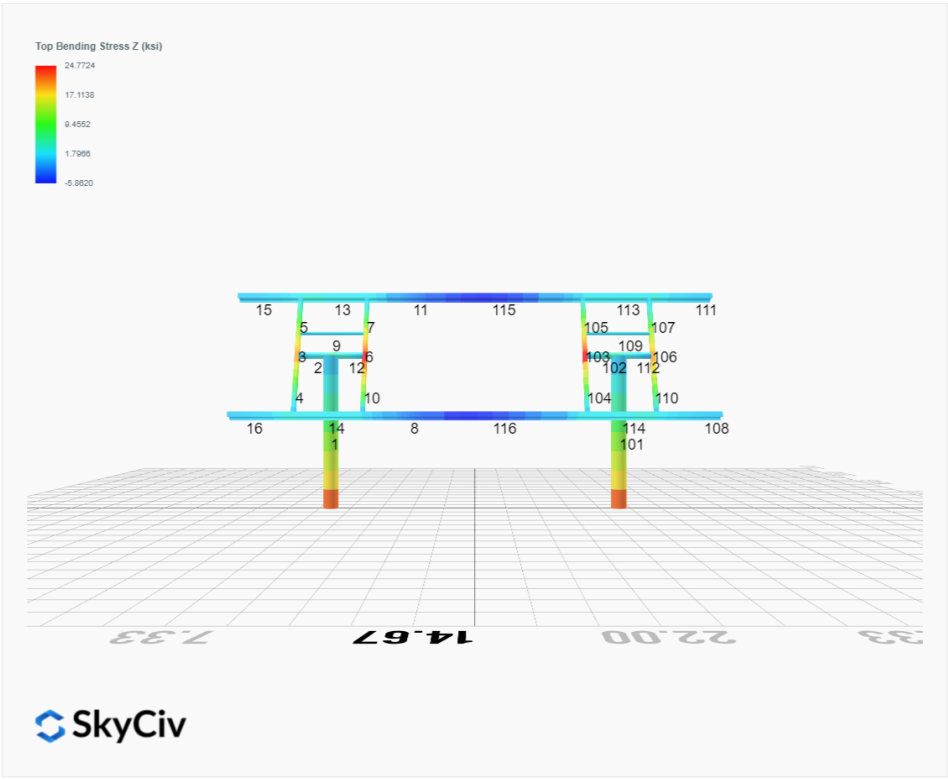
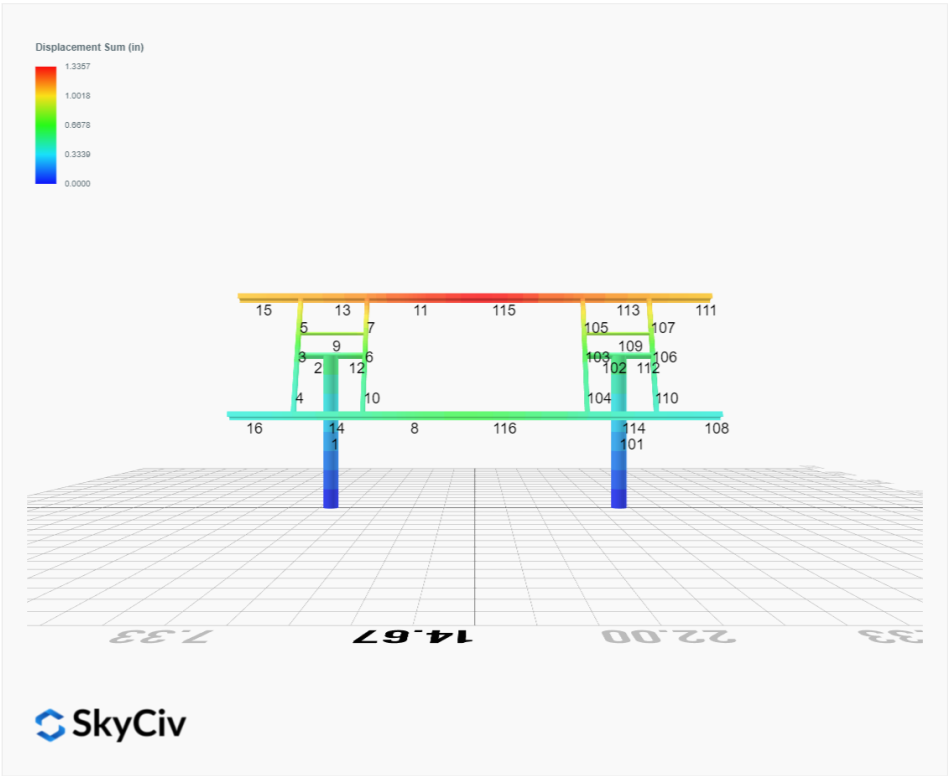
Design Notes:

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

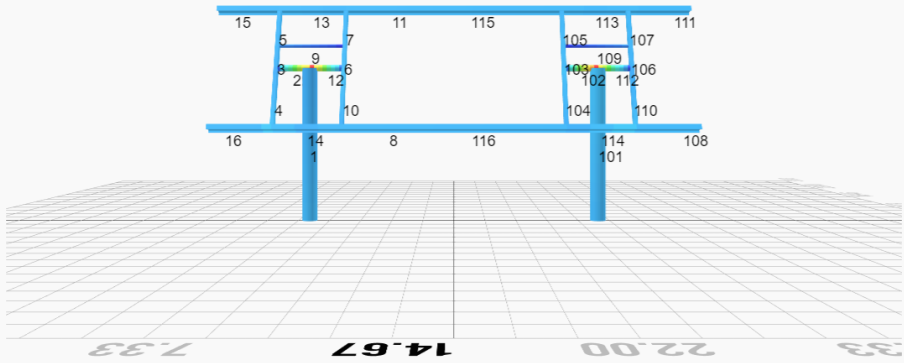




FEM Results (Envelope Worst Case for each member)

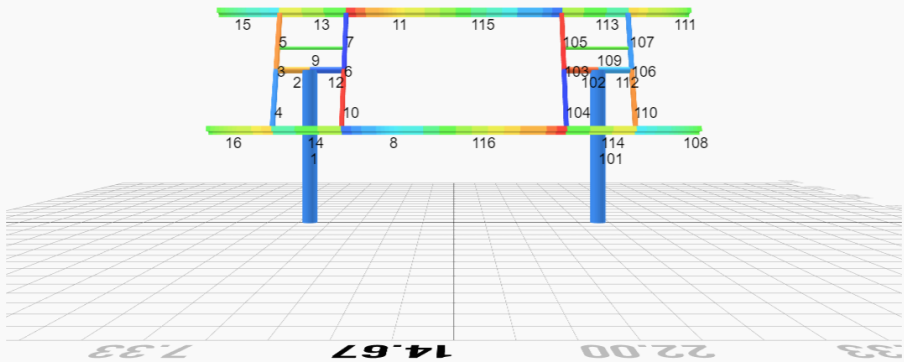


Top Bending Stress Y (ksi)



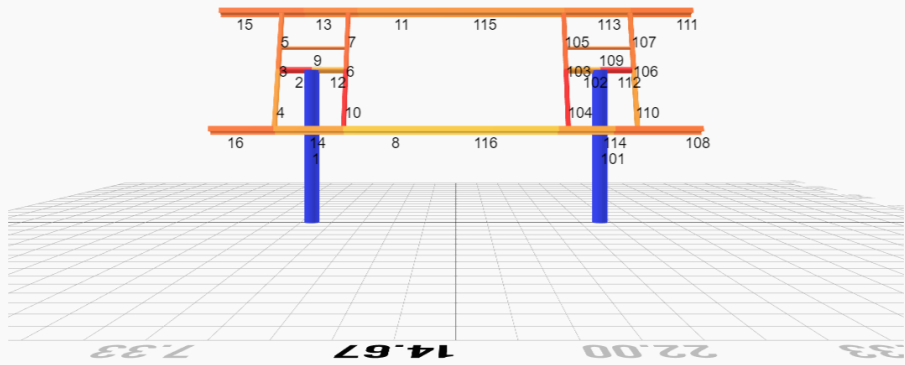
SkyCiv

Shear Stress Y (ksi)



SkyCiv

Axial Stress (ksi)



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

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	0.0000	1.6136	0.0340	0.0588	-0.0207	0.0103
ULS: 2. D + L	0.0000	1.6136	0.0340	0.0588	-0.0207	0.0103
ULS: 3. D + (S or Lr or R)	0.0000	1.6136	0.0340	0.0588	-0.0207	0.0103
ULS: 3. D + (S or Lr or R)	0.0000	1.6136	0.0340	0.0588	-0.0207	0.0103
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	1.6136	0.0340	0.0588	-0.0207	0.0103
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	1.6136	0.0340	0.0588	-0.0207	0.0103
ULS: 5b. D + 0.7E	0.0000	1.6136	0.0340	0.0588	-0.0207	0.0103
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0000	1.6136	0.0340	0.0588	-0.0207	0.0103
ULS: 8. 0.6D + 0.7E	0.0000	0.9682	0.0204	0.0353	-0.0124	0.0062
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.8581	3.0179	0.0949	0.1215	-0.9956	34.7710
ULS: 5a. D + 0.6W_Wind downforce Case B only	0.0000	1.6136	0.0340	0.0588	-0.0207	0.0103
ULS: 5a. D + 0.6W_Wind uplift Case A only	3.8581	0.2094	-0.0269	-0.0038	0.9537	-34.6151
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.0000	1.6136	0.0340	0.0588	-0.0207	0.0103
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.8936	2.6668	0.0797	0.1058	-0.7519	26.0809
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0000	1.6136	0.0340	0.0588	-0.0207	0.0103
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.8936	0.5604	-0.0117	0.0119	0.7101	-25.9587
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0000	1.6136	0.0340	0.0588	-0.0207	0.0103
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.8936	2.6668	0.0797	0.1058	-0.7519	26.0809
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0000	1.6136	0.0340	0.0588	-0.0207	0.0103
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.8936	0.5604	-0.0117	0.0119	0.7101	-25.9587
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0000	1.6136	0.0340	0.0588	-0.0207	0.0103
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.8581	2.3724	0.0814	0.0979	-0.9874	34.7669
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	0.0000	0.9682	0.0204	0.0353	-0.0124	0.0062
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	3.8581	-0.4361	-0.0405	-0.0273	0.9619	-34.6192
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.0000	0.9682	0.0204	0.0353	-0.0124	0.0062

Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	4.2768
Shear X	-6.4302
Shear Z	0.1424
Moment X	0.1751
Moment Y (Twist)	1.6487
Moment Z	58.0638

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	3.0179
Shear X	-3.8581
Shear Z	0.0949
Moment X	0.1215
Moment Y (Twist)	0.9956
Moment Z	34.7710

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

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	-0.0000	1.6136	-0.0340	-0.0588	0.0207	0.0103
ULS: 2. D + L	-0.0000	1.6136	-0.0340	-0.0588	0.0207	0.0103
ULS: 3. D + (S or Lr or R)	-0.0000	1.6136	-0.0340	-0.0588	0.0207	0.0103
ULS: 3. D + (S or Lr or R)	-0.0000	1.6136	-0.0340	-0.0588	0.0207	0.0103
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0000	1.6136	-0.0340	-0.0588	0.0207	0.0103
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0000	1.6136	-0.0340	-0.0588	0.0207	0.0103
ULS: 5b. D + 0.7E	-0.0000	1.6136	-0.0340	-0.0588	0.0207	0.0103

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0000	1.6136	-0.0340	-0.0588	0.0207	0.0103
ULS: 8. 0.6D + 0.7E	-0.0000	0.9682	-0.0204	-0.0353	0.0124	0.0062
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.8581	3.0179	-0.0949	-0.1215	0.9956	34.7710
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.0000	1.6136	-0.0340	-0.0588	0.0207	0.0103
ULS: 5a. D + 0.6W_Wind uplift Case A only	3.8581	0.2094	0.0269	0.0038	-0.9537	-34.6151
ULS: 5a. D + 0.6W_Wind uplift Case B only	-0.0000	1.6136	-0.0340	-0.0588	0.0207	0.0103
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.8936	2.6668	-0.0797	-0.1058	0.7519	26.0809
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0000	1.6136	-0.0340	-0.0588	0.0207	0.0103
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.8936	0.5604	0.0117	-0.0119	-0.7101	-25.9587
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0000	1.6136	-0.0340	-0.0588	0.0207	0.0103
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.8936	2.6668	-0.0797	-0.1058	0.7519	26.0809
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0000	1.6136	-0.0340	-0.0588	0.0207	0.0103
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.8936	0.5604	0.0117	-0.0119	-0.7101	-25.9587
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0000	1.6136	-0.0340	-0.0588	0.0207	0.0103
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.8581	2.3724	-0.0814	-0.0979	0.9874	34.7669
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.0000	0.9682	-0.0204	-0.0353	0.0124	0.0062
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	3.8581	-0.4361	0.0405	0.0273	-0.9619	-34.6192
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	-0.0000	0.9682	-0.0204	-0.0353	0.0124	0.0062

Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	4.2768
Shear X	-6.4303
Shear Z	-0.1424
Moment X	-0.1751
Moment Y (Twist)	1.6490
Moment Z	58.0646

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	3.0179
Shear X	-3.8581
Shear Z	-0.0949
Moment X	-0.1215
Moment Y (Twist)	0.9956
Moment Z	34.7710

Project Details

Design Code: AISC 360-16 LRFD
 Provision: LRFD
 Country: United States
 User Name: sales@mtsolar.us
 Unit System: imperial



Design Input Information

Design Factors			
Φ_t	Φ_c	Φ_b	Φ_v
0.9	0.9	0.9	0.9

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

Section Dimensions								

ID	Name	d (in)	t_w (in)					
2	2in Pipe Sch 80	2.38	0.22					
5	4in Pipe Sch 80	4.50	0.34					
11	10in Pipe Sch 40	10.75	0.36					

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ID	Name	d (in)	b (in)	t_w (in)	t_b (in)	r (in)		
16	HSS5x3x16	5.00	3.00	0.17	0.17	0.17		

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

Section Properties								
ID	Name	A (in ²)	J (in ⁴)	I_{yp} (in ⁴)	I_{zp} (in ⁴)	I_w (in ⁶)	S_{yp} (in ³)	S_{zp} (in ³)
2	2in Pipe Sch 80	1.48	1.74	0.87	0.87	0.00	1.02	1.02
5	4in Pipe Sch 80	4.41	19.22	9.61	9.61	0.00	5.85	5.85
11	10in Pipe Sch 40	11.91	321.47	160.73	160.73	0.00	39.38	39.38

16	HSS5x3x3/16	2.58	8.64	3.85	8.53	0.73	2.96	4.21
19	W8x10	2.96	0.04	2.09	30.80	30.90	1.66	8.87

Member Properties									
Member ID	Section ID	K _z L (ft)	K _y L (ft)	L _b (ft)	C _b	L S T	L S C	L D	
1	11	18.88	18.88	8.99	-	300	200	1	
2	5	1.30	1.30	2.00	-	300	200	1	
3	16	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.19,1.17,1.19,1.18,1.19,1.17,1.19,1.18,1.19,1.17,1.19,1.18,1.19,1.17,1.19	300	200	1	
4	16	2.44	2.44	3.75	1.70,1.70,1.70,1.70,1.70,1.70,1.67,1.70,1.66,1.70,1.67,1.70,1.66,1.70,1.67,1.70,1.66,1.70,1.67,1.70,1.66,1.70	300	200	1	
5	16	1.52	1.52	2.33	1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.69,1.66,1.69,1.67,1.69,1.66,1.69,1.67,1.69,1.66,1.69,1.67,1.69	300	200	1	
6	16	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19	300	200	1	
7	16	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.68,1.67,1.68,1.67,1.68,1.67,1.68,1.67,1.68,1.66,1.68,1.67,1.68	300	200	1	
8	19	1.33	1.33	2.05	1.29,1.29,1.29,1.29,1.29,1.29,1.28,1.29,1.28,1.29,1.28,1.29,1.28,1.29,1.28,1.29,1.28,1.29,1.28,1.29	300	200	1	
9	2	2.60	2.60	4.00	-	300	200	1	
10	16	2.44	2.44	3.75	1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.69,1.67,1.69,1.67,1.69,1.67,1.69,1.67,1.69,1.66,1.69,1.67,1.69	300	200	1	
11	19	1.33	1.33	2.05	1.30,1.30,1.30,1.30,1.30,1.30,1.29,1.30,1.28,1.30,1.29,1.30,1.28,1.30,1.29,1.30,1.28,1.30,1.29,1.30	300	200	1	
12	5	1.30	1.30	2.00	-	300	200	1	
13	19	4.88	4.00	7.50	1.22,1.22,1.22,1.22,1.22,1.22,1.24,1.22,1.24,1.22,1.24,1.22,1.24,1.22,1.24,1.22,1.25,1.22,1.24,1.22	300	200	1	
14	19	4.88	4.00	7.50	1.21,1.21,1.21,1.21,1.21,1.21,1.23,1.21,1.24,1.21,1.23,1.21,1.24,1.21,1.23,1.21,1.24,1.21,1.23,1.21	300	200	1	
15	19	4.20	4.20	2.00	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	1	
16	19	4.20	4.20	2.00	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	1	
101	11	18.88	18.88	8.99	-	300	200	1	
102	5	1.30	1.30	2.00	-	300	200	1	
103	16	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19	300	200	1	
104	16	2.44	2.44	3.75	1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.69,1.67,1.69,1.67,1.69,1.67,1.69,1.67,1.69,1.66,1.69,1.67,1.69	300	200	1	
105	16	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.68,1.67,1.68,1.67,1.68,1.67,1.68,1.67,1.68,1.66,1.68,1.67,1.68	300	200	1	
106	16	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.19,1.17,1.19,1.18,1.19,1.17,1.19,1.18,1.19,1.17,1.19,1.18,1.19	300	200	1	
107	16	1.52	1.52	2.33	1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.69,1.66,1.69,1.67,1.69,1.66,1.69,1.67,1.69,1.66,1.69,1.67,1.69	300	200	1	

115	133.20	93.89	24.99	6.12	40.24	43.62
116	133.20	93.89	24.99	6.12	40.24	43.62

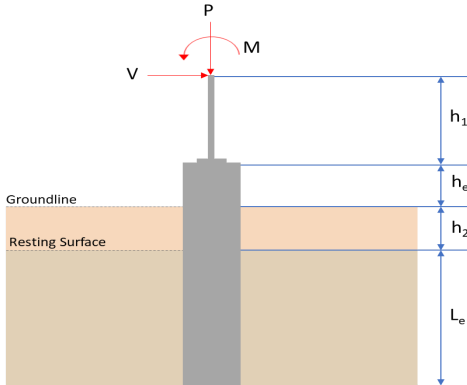
Design Ratio

Member ID	P	M _z	M _y	V _y	V _z	(P,M _z ,M _y)	Worst LC	KL/r	δ	Status
1	0.011	0.393	0.007	0.040	0.001	0.400	#13	0.308	Not Required	Pass
2	0.000	0.111	0.223	0.028	0.049	0.335	#13	0.053	Not Required	Pass
3	0.003	0.392	0.019	0.039	0.005	0.406	#13	0.045	Not Required	Pass
4	0.003	0.391	0.026	0.039	0.007	0.418	#13	0.080	Not Required	Pass
5	0.003	0.244	0.021	0.039	0.005	0.246	#13	0.074	Not Required	Pass
6	0.004	0.477	0.036	0.048	0.010	0.512	#13	0.045	Not Required	Pass
7	0.004	0.296	0.044	0.048	0.010	0.305	#13	0.074	Not Required	Pass
8	0.001	0.095	0.032	0.030	0.005	0.122	#13	0.095	Not Required	Pass
9	0.000	0.022	0.055	0.002	0.002	0.068	#13	0.204	Not Required	Pass
10	0.004	0.476	0.041	0.048	0.010	0.498	#13	0.080	Not Required	Pass
11	0.001	0.094	0.031	0.030	0.005	0.121	#13	0.095	Not Required	Pass
12	0.000	0.162	0.298	0.037	0.060	0.460	#13	0.053	Not Required	Pass
13	0.001	0.082	0.106	0.041	0.007	0.140	#13	0.286	Not Required	Pass
14	0.001	0.084	0.105	0.041	0.007	0.137	#13	0.190	Not Required	Pass
15	0.000	0.016	0.016	0.013	0.002	0.029	#13	Not Required	Not Required	Pass
16	0.000	0.016	0.016	0.013	0.002	0.029	#13	Not Required	Not Required	Pass
101	0.011	0.393	0.007	0.040	0.001	0.400	#13	0.308	Not Required	Pass
102	0.000	0.162	0.298	0.037	0.060	0.460	#13	0.053	Not Required	Pass
103	0.004	0.477	0.036	0.048	0.010	0.512	#13	0.045	Not Required	Pass
104	0.004	0.476	0.041	0.048	0.010	0.498	#13	0.080	Not Required	Pass
105	0.004	0.296	0.044	0.048	0.010	0.305	#13	0.074	Not Required	Pass
106	0.003	0.392	0.019	0.039	0.005	0.406	#13	0.045	Not Required	Pass
107	0.003	0.244	0.021	0.039	0.005	0.246	#13	0.074	Not Required	Pass
108	0.000	0.016	0.016	0.013	0.002	0.029	#13	Not Required	Not Required	Pass
109	0.000	0.022	0.055	0.002	0.002	0.068	#13	0.204	Not Required	Pass
110	0.003	0.391	0.026	0.039	0.007	0.418	#13	0.080	Not Required	Pass
111	0.000	0.016	0.016	0.013	0.002	0.029	#13	Not Required	Not Required	Pass
112	0.000	0.111	0.223	0.028	0.049	0.335	#13	0.053	Not Required	Pass
113	0.001	0.082	0.106	0.041	0.007	0.140	#13	0.190	Not Required	Pass
114	0.001	0.084	0.105	0.041	0.007	0.137	#13	0.286	Not Required	Pass
115	0.001	0.160	0.060	0.030	0.005	0.212	#13	0.346	Not Required	Pass
116	0.001	0.162	0.060	0.030	0.005	0.214	#13	0.346	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

L_u	Length between fixed points
LST	Limited slenderness for tension
LSC	Limited slenderness for compression
LD	Limited deflection
P_n	Nominal axial strength (tension/compression)
M_n	Nominal flexural strength (about Z/Y axis)
V_n	Nominal shear strength (along Z/Y axis)
P	Design ratio in case of axial force
M_z	Design ratio in case of bending about Z axis
M_y	Design ratio in case of bending about Y axis
V_y	Design ratio in case of shear along Y axis
V_z	Design ratio in case of shear along Z axis
(P, M_z , M_y)	Design ratio in case of axial force and bending action
KL/r	Design ratio in case of section slenderness
δ	Design ratio in case of member deflection
OK	Capacity is provided
NG	Capacity is not provided

REFERENCES	CALCULATIONS	RESULTS																										
	SkyCiv Foundation Design Pile Foundation Design Information : Design code : IBC 2021 (International Building Code) Unit System : Imperial																											
	Pile Input  Geometry Pile shape: rectangular b = 48 in - Pile width D = 48 in - Pile depth L = 6.75 ft - Total pile length h1 = 0 ft - Lateral load height from the top of the pile, h2 = 0 ft - Depth to resisting surface he = 0 ft - Length of pile above the ground Tabulation of Soil Parameters <table><thead><tr><th>Layer</th><th>Label</th><th>Allowable Bearing Pressure (qa) (psf)</th><th>Allowable Lateral Pressure (R) (psf/ft)</th></tr></thead><tbody><tr><td>1</td><td>Sand, silty sand, clayey sand, silty gravel & clayey gravel</td><td>2000.000</td><td>150.000</td></tr></tbody></table> Tabulation of Loads <table><thead><tr><th>Load Component</th><th>ASD</th><th>LRFD</th></tr></thead><tbody><tr><td>P (kip)</td><td>3.018</td><td>4.277</td></tr><tr><td>Vx (kip)</td><td>-3.858</td><td>-6.430</td></tr><tr><td>Vz (kip)</td><td>0.095</td><td>0.142</td></tr><tr><td>Mx (kipft)</td><td>0.121</td><td>0.175</td></tr><tr><td>Mz (kipft)</td><td>34.771</td><td>58.064</td></tr></tbody></table> Material Properties f'ck = 2.5 ksi - Concrete strength,	Layer	Label	Allowable Bearing Pressure (qa) (psf)	Allowable Lateral Pressure (R) (psf/ft)	1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000	Load Component	ASD	LRFD	P (kip)	3.018	4.277	Vx (kip)	-3.858	-6.430	Vz (kip)	0.095	0.142	Mx (kipft)	0.121	0.175	Mz (kipft)	34.771	58.064	
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Mx (kipft)	0.121	0.175																										
Mz (kipft)	34.771	58.064																										
	Required depth to resist lateral loads (ASD) H - Point of application of the lateral load $H = h_1 + h_2 + h_e$ $H = (0\text{ ft}) + (0\text{ ft}) + (0\text{ ft})$ $H = 0\text{ ft}$ Considering x-direction: Ho - Lateral force per length of pile, $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-3.858\text{ kip})}{1.57 \times (48\text{ in})}$ $H_o = -0.61433\text{ kip/ft}$ Mo - Moment per length of pile, $M_o = \frac{M_z + (V_x H)}{1.57 D}$																											

	$M_o = \frac{(34.771 \text{ kipft}) + ((-3.858 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 5.5368 \text{ kipft/ft}$ 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: $L_{e,x} = 6.0397 \text{ ft}$ - Required depth in x-direction, Considering z-direction: H_o - Lateral force per length of pile, $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(0.095 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = 0.015127 \text{ kip/ft}$ M_o - Moment per length of pile, $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(0.121 \text{ kipft}) + ((0.095 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.019268 \text{ kipft/ft}$ 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: $L_{e,z} = 1.4136 \text{ ft}$ - Required depth in z-direction, Minimum embedded depth required: $L_{e,req}$ - Depth of pile required, $L_{e,req} = MAX[L_{e,x}, L_{e,z}]$ $L_{e,req} = MAX[(6.0397 \text{ ft}), (1.4136 \text{ ft})]$ $L_{e,req} = 6.04 \text{ ft}$ L_e - Actual embedded length of pile, $L_e = L - h_e - h_2$ $L_e = (6.75 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 6.75 \text{ ft}$ <i>Ratio</i> - Embedded depth $Ratio = \frac{L_{e,req}}{L_e}$ $Ratio = \frac{(6.04 \text{ ft})}{(6.75 \text{ ft})}$ $Ratio = 0.89481$	Status: PASS Ratio: 0.890
	End-bearing Capacity (ASD) A - Pile cross-section area $A = b D$ $A = (48 \text{ in}) \times (48 \text{ in})$ $A = 16 \text{ ft}^2$ q - End-bearing pressure $q = \frac{P_o}{A}$ $q = \frac{(3.018 \text{ kip})}{(16 \text{ ft}^2)}$ $q = 0.188625 \text{ kip/ft}^2$	

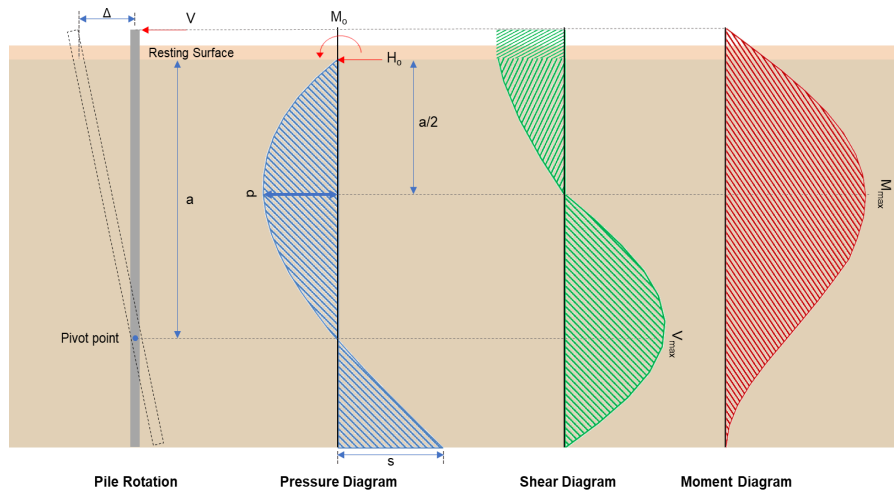
	$q = 0.10002 \text{ kip/ft}$	
	Check bearing capacity ratio: Ratio - Capacity $Ratio = \frac{q}{q_a}$ $Ratio = \frac{(0.18862 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $Ratio = 0.094312$	Status: PASS Ratio: 0.090
Czerniak	Lateral Soil Pressure (ASD): L/D - Length to least lateral dimension ratio, $L/D = \frac{L}{D}$ $L/D = \frac{(6.75 \text{ ft})}{(48 \text{ in})}$ $L/D = 1.6875$ Since $L/D \leq 10$, Pile is short. Considering x-direction: $H_o = -0.61433 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 5.5368 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point, $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (5.5368 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.61433 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (5.5368 \text{ kipft/ft})) + (4 \times (-0.61433 \text{ kip/ft}) \times (6.75 \text{ ft}))}$ $a = 4.6873 \text{ ft}$ p - Earth pressure against the pile at distance $a/2$ from resting surface, $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (5.5368 \text{ kipft/ft})) + (3 \times (-0.61433 \text{ kip/ft}) \times (6.75 \text{ ft}))]^2}{(6.75 \text{ ft})^2 \times [(3 \times (5.5368 \text{ kipft/ft})) + (2 \times (-0.61433 \text{ kip/ft}) \times (6.75 \text{ ft}))]}$ $p = 0.18649 \text{ kip/ft}^2$ s - Earth pressure against the pile at distance L_e, $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (5.5368 \text{ kipft/ft})) + ((-0.61433 \text{ kip/ft}) \times (6.75 \text{ ft}))]}{(6.75 \text{ ft})^2}$ $s = 0.91218 \text{ kip/ft}^2$ Check lateral soil pressure capacity: p_a - Allowable lateral soil pressure at depth $a/2$, $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.6873 \text{ ft})}{2}$ $p_a = 0.35155 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.18649 \text{ kip/ft}^2)}{(0.35155 \text{ kip/ft}^2)}$ $Ratio = 0.53048$ p_s - Allowable lateral soil pressure at depth L_e,	Status: PASS Ratio: 0.530

	$p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (6.75 \text{ ft})$ $p_s = 1.0125 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $Ratio = \frac{s}{p_s}$ $Ratio = \frac{(0.91218 \text{ kip/ft}^2)}{(1.0125 \text{ kip/ft}^2)}$ $Ratio = 0.90091$	Status: PASS Ratio: 0.900
	Considering z-direction: $H_o = 0.015127 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 0.019268 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point, $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.019268 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (0.015127 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (0.019268 \text{ kipft/ft})) + (4 \times (0.015127 \text{ kip/ft}) \times (6.75 \text{ ft}))}$ $a = 4.9384 \text{ ft}$ p - Earth pressure against the pile at distance $a/2$ from resting surface, $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^3 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.019268 \text{ kipft/ft})) + (3 \times (0.015127 \text{ kip/ft}) \times (6.75 \text{ ft}))]^2}{(6.75 \text{ ft})^3 \times [(3 \times (0.019268 \text{ kipft/ft})) + (2 \times (0.015127 \text{ kip/ft}) \times (6.75 \text{ ft}))]}$ $p = 0.0092346 \text{ kip/ft}^2$ s - Earth pressure against the pile at distance L_e, $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.019268 \text{ kipft/ft})) + ((0.015127 \text{ kip/ft}) \times (6.75 \text{ ft}))]}{(6.75 \text{ ft})^2}$ $s = 0.018521 \text{ kip/ft}^2$ Check lateral soil pressure capacity: p_a - Allowable lateral soil pressure at depth $a/2$, $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.9384 \text{ ft})}{2}$ $p_a = 0.37038 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.0092346 \text{ kip/ft}^2)}{(0.37038 \text{ kip/ft}^2)}$ $Ratio = 0.024933$ p_s - Allowable lateral soil pressure at depth L_e, $p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (6.75 \text{ ft})$ $p_s = 1.0125 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $Ratio = \frac{s}{p_s}$	Status: PASS Ratio: 0.020

$$Ratio = \frac{(0.018521 \text{ kip/ft}^2)}{(1.0125 \text{ kip/ft}^2)}$$

$$Ratio = 0.018292$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-6.43 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -1.0239 \text{ kip/ft}$$

M_o - Moment per length of pile,

$$M_o = \frac{M_e + (V_e H)}{1.57 D}$$

$$M_o = \frac{(58.064 \text{ kipft}) + ((-6.43 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 9.2459 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(9.2459 \text{ kipft/ft})}{(-1.0239 \text{ kip/ft})}$$

$$E = 9.0302 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (9.2459 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-1.0239 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (9.2459 \text{ kipft/ft})) + (4 \times (-1.0239 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.6871 \text{ ft}$$

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

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

$$V_{max} = ((-1.0239 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (9.0302 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.6871 \text{ ft})}{(6.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (9.0302 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.6871 \text{ ft})}{(6.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 12.396 \text{ kip}$$

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

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

$$M_{max} = ((-1.0239 \text{ kip/ft}) \times (48 \text{ in}) \times (6.75 \text{ ft})) \times \left[\left(\frac{(9.0302 \text{ ft})}{(6.75 \text{ ft})} + \frac{(4.6871 \text{ ft})}{2 \times (6.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (9.0302 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.6871 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (9.0302 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.6871 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 39.335 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.142 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.022611 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.175 \text{ kipft}) + ((0.142 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.027866 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.027866 \text{ kipft/ft})}{(0.022611 \text{ kip/ft})}$$

$$E = 1.2324 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.027866 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (0.022611 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (0.027866 \text{ kipft/ft})) + (4 \times (0.022611 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.9416 \text{ ft}$$

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

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

$$V_{max} = ((0.022611 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (1.2324 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.9416 \text{ ft})}{(6.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (1.2324 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.9416 \text{ ft})}{(6.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.090378 \text{ kip}$$

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

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

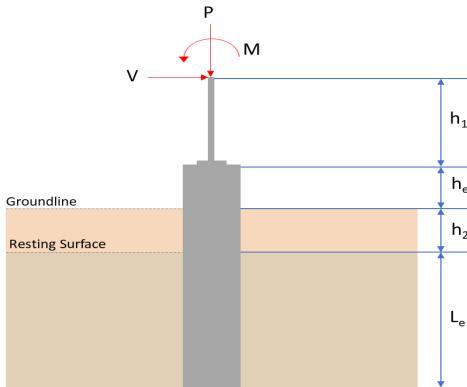
$$M_{max} = ((0.022611 \text{ kip/ft}) \times (48 \text{ in}) \times (6.75 \text{ ft})) \times \left[\left(\frac{(1.2324 \text{ ft})}{(6.75 \text{ ft})} + \frac{(4.9416 \text{ ft})}{2 \times (6.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (1.2324 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.9416 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (1.2324 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.9416 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^4 \right] \right]$$

		$M_{max} = 0.25117 \text{ kipft}$	
		</	

	Ties: #3(0.375 in) - 10 in	
22.4.2.2	Axial Compression Strength (ACI 318-19, LRFD) ϕP_N - Allowable axial compressive strength $\phi P_N = \phi 0.80 \left[(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st}) \right]$ $\phi P_N = (0.65) \times 0.80 \times \left[(0.85 \times (2.5 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2)) \right]$ $\phi P_N = 2675.2 \text{ kip}$ Ratio - Capacity $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(4.277 \text{ kip})}{(2675.2 \text{ kip})}$ $Ratio = 0.0015988$	Status: PASS Ratio: 0.000
22.5.2.2	Shear Strength (ACI 318-19, LRFD) Parameters: $b_w = 48 \text{ in}$ - Effective width, d - Effective depth $d = 0.80 D$ $d = 0.80 \times (48 \text{ in})$ $d = 38.4 \text{ in}$	
22.5.5.1.3	λ_s - size effect modification factor $\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.64282$	
22.5.5.1.1	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $V_{c,max}$ - Max shear strength of concrete $V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$ $V_{c,max} = 5 \times (0.64282) \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,max} = 296.21 \text{ kip}$	
22.5.5.1.1(a)	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 4.277 \text{ kip} \rightarrow 4277 \text{ lbf}$, $V_{c,a}$ - Shear strength of concrete (a) $V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(4277 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 119.06 \text{ kip}$	
22.5.5.1.2	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $V_{c,b}$ - Shear strength of concrete (b) $V_{c,b} = \left[2 \lambda_s \sqrt{f'_{ck}} + (0.05 f'_{ck}) \right] b_w d$ $V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + (0.05 \times (2500 \text{ psi})) \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,b} = 348.89 \text{ kip}$ V_c - Governing shear strength of concrete $V_c = Min [V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = Min [(296.21 \text{ kip}), (119.06 \text{ kip}), (348.89 \text{ kip})]$ $V_c = 119.06 \text{ kip}$	

22.5.1.2	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $V_{s,a}$ - Shear strength of steel (a) $V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$ $V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{s,a} = 737.28 \text{ kip}$ A_v - Ties rebar area, $A_v = \frac{\pi d_{tes}^2}{4}$ $A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$ $A_v = 0.11045 \text{ in}^2$ 22.5.8.5.3 $V_{s,b}$ - Shear strength of steel (b) $V_{s,b} = \frac{2 A_v f_{ysk} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$ V_s - Governing shear strength of steel $V_s = MIN[V_{s,a}, V_{s,b}]$ $V_s = MIN[(737.28 \text{ kip}), (50.894 \text{ kip})]$ $V_s = 50.894 \text{ kip}$ 22.5.1.1 ϕV_n - Allowable shear strength $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((119.06 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 110.47 \text{ kip}$ Considering x-direction: $V_{max} = 12.396 \text{ kip}$ - Maximum shear force in the x-direction, $Ratio$ - Capacity $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(12.396 \text{ kip})}{(110.47 \text{ kip})}$ $Ratio = 0.11221$ Considering z-direction: $V_{max} = 0.090378 \text{ kip}$ - Maximum shear force in the z-direction, $Ratio$ - Capacity $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.090378 \text{ kip})}{(110.47 \text{ kip})}$ $Ratio = 0.00081814$	Status: PASS Ratio: 0.110 Status: PASS Ratio: 0.000
	Flexural Strength (ACI 318-19, LRFD) S_m - Section modulus $S_m = \frac{b D^3}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$	

14.5.2.1b	$\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$ $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{2.5 \text{ ksi}} \times 18432.001 \text{ in}^3$ $\phi M_{n,1} = 249.600 \text{ kipft}$ $\phi M_{n,2}$ $\phi M_{n,2} = \phi \times 0.85 \times f'_c \times S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (18432 \text{ in}^3)$ $\phi M_{n,2} = 2121.6 \text{ kipft}$ Therefore, ϕM_n - Allowable flexural strength, $\phi M_n = \text{MIN}[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = \text{MIN}[(249.6 \text{ kipft}), (2121.6 \text{ kipft})]$ $\phi M_n = 249.6 \text{ kipft}$ Considering x-direction: $M_{max} = 39.335 \text{ kipft}$ - Maximum moment in the x-direction, Ratio - Capacity $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(39.335 \text{ kipft})}{(249.6 \text{ kipft})}$ $\text{Ratio} = 0.15759$	Status: PASS Ratio: 0.160
	Considering z-direction: $M_{max} = 0.25117 \text{ kipft}$ - Maximum moment in the z-direction, Ratio - Capacity $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(0.25117 \text{ kipft})}{(249.6 \text{ kipft})}$ $\text{Ratio} = 0.0010063$	Status: PASS Ratio: 0.000

REFERENCES	CALCULATIONS	RESULTS																										
	SkyCiv Foundation Design Pile Foundation Design Information : Design code : IBC 2021 (International Building Code) Unit System : Imperial																											
	Pile Input  Geometry Pile shape: rectangular b = 48 in - Pile width D = 48 in - Pile depth L = 6.75 ft - Total pile length h1 = 0 ft - Lateral load height from the top of the pile, h2 = 0 ft - Depth to resisting surface he = 0 ft - Length of pile above the ground Tabulation of Soil Parameters <table><thead><tr><th>Layer</th><th>Label</th><th>Allowable Bearing Pressure (qa) (psf)</th><th>Allowable Lateral Pressure (R) (psf/ft)</th></tr></thead><tbody><tr><td>1</td><td>Sand, silty sand, clayey sand, silty gravel & clayey gravel</td><td>2000.000</td><td>150.000</td></tr></tbody></table> Tabulation of Loads <table><thead><tr><th>Load Component</th><th>ASD</th><th>LRFD</th></tr></thead><tbody><tr><td>P (kip)</td><td>3.018</td><td>4.277</td></tr><tr><td>Vx (kip)</td><td>-3.858</td><td>-6.430</td></tr><tr><td>Vz (kip)</td><td>-0.095</td><td>-0.142</td></tr><tr><td>Mx (kipft)</td><td>-0.121</td><td>-0.175</td></tr><tr><td>Mz (kipft)</td><td>34.771</td><td>58.065</td></tr></tbody></table> Material Properties f'ck = 2.5 ksi - Concrete strength,	Layer	Label	Allowable Bearing Pressure (qa) (psf)	Allowable Lateral Pressure (R) (psf/ft)	1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000	Load Component	ASD	LRFD	P (kip)	3.018	4.277	Vx (kip)	-3.858	-6.430	Vz (kip)	-0.095	-0.142	Mx (kipft)	-0.121	-0.175	Mz (kipft)	34.771	58.065	
Layer	Label	Allowable Bearing Pressure (qa) (psf)	Allowable Lateral Pressure (R) (psf/ft)																									
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Mx (kipft)	-0.121	-0.175																										
Mz (kipft)	34.771	58.065																										
	Required depth to resist lateral loads (ASD) H - Point of application of the lateral load $H = h_1 + h_2 + h_e$ $H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})$ $H = 0 \text{ ft}$ Considering x-direction: Ho - Lateral force per length of pile, $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-3.858 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.61433 \text{ kip/ft}$ Mo - Moment per length of pile, $M_o = \frac{M_z + (V_x H)}{1.57 D}$																											

	$M_o = \frac{(34.771 \text{ kipft}) + ((-3.858 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 5.5368 \text{ kipft/ft}$ 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: $L_{e,x} = 6.0397 \text{ ft}$ - Required depth in x-direction, Considering z-direction: H_o - Lateral force per length of pile, $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(-0.095 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.015127 \text{ kip/ft}$ M_o - Moment per length of pile, $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(0.121 \text{ kipft}) + ((-0.095 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.019268 \text{ kipft/ft}$ 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: $L_{e,z} = 0.89867 \text{ ft}$ - Required depth in z-direction, Minimum embedded depth required: $L_{e,req}$ - Depth of pile required, $L_{e,req} = \text{MAX}[L_{e,x}, L_{e,z}]$ $L_{e,req} = \text{MAX}[(6.0397 \text{ ft}), (0.89867 \text{ ft})]$ $L_{e,req} = 6.04 \text{ ft}$ L_e - Actual embedded length of pile, $L_e = L - h_e - h_2$ $L_e = (6.75 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 6.75 \text{ ft}$ Ratio - Embedded depth $\text{Ratio} = \frac{L_{e,req}}{L_e}$ $\text{Ratio} = \frac{(6.04 \text{ ft})}{(6.75 \text{ ft})}$ $\text{Ratio} = 0.89481$	Status: PASS Ratio: 0.890
	End-bearing Capacity (ASD) A - Pile cross-section area $A = b D$ $A = (48 \text{ in}) \times (48 \text{ in})$ $A = 16 \text{ ft}^2$ q - End-bearing pressure $q = \frac{P_o}{A}$ $q = \frac{(3.018 \text{ kip})}{(16 \text{ ft}^2)}$ $q = 0.188625 \text{ kips/ft}^2$	

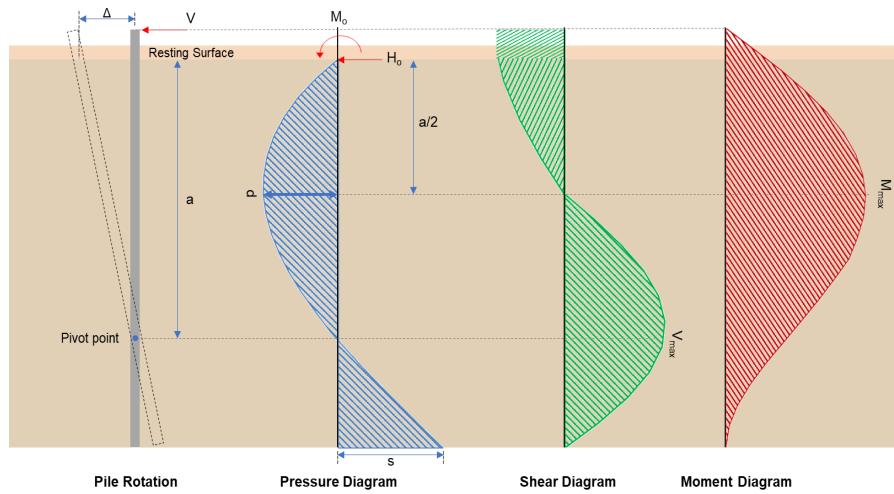
	$q = 0.10002 \text{ kip/ft}$ Check bearing capacity ratio: Ratio - Capacity $\text{Ratio} = \frac{q}{q_a}$ $\text{Ratio} = \frac{(0.18862 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $\text{Ratio} = 0.094312$	Status: PASS Ratio: 0.090
Czerniak	Lateral Soil Pressure (ASD): L/D - Length to least lateral dimension ratio, $L/D = \frac{L}{D}$ $L/D = \frac{(6.75 \text{ ft})}{(48 \text{ in})}$ $L/D = 1.6875$ Since $L/D \leq 10$, Pile is short. Considering x-direction: $H_o = -0.61433 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 5.5368 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point, $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (5.5368 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.61433 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (5.5368 \text{ kipft/ft})) + (4 \times (-0.61433 \text{ kip/ft}) \times (6.75 \text{ ft}))}$ $a = 4.6873 \text{ ft}$ p - Earth pressure against the pile at distance $a/2$ from resting surface, $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (5.5368 \text{ kipft/ft})) + (3 \times (-0.61433 \text{ kip/ft}) \times (6.75 \text{ ft}))]^2}{(6.75 \text{ ft})^2 \times [(3 \times (5.5368 \text{ kipft/ft})) + (2 \times (-0.61433 \text{ kip/ft}) \times (6.75 \text{ ft}))]}$ $p = 0.18649 \text{ kip/ft}^2$ s - Earth pressure against the pile at distance L_e, $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (5.5368 \text{ kipft/ft})) + ((-0.61433 \text{ kip/ft}) \times (6.75 \text{ ft}))]}{(6.75 \text{ ft})^2}$ $s = 0.91218 \text{ kip/ft}^2$ Check lateral soil pressure capacity: p_a - Allowable lateral soil pressure at depth $a/2$, $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.6873 \text{ ft})}{2}$ $p_a = 0.35155 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{p}{p_a}$ $\text{Ratio} = \frac{(0.18649 \text{ kip/ft}^2)}{(0.35155 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.53048$ p_s - Allowable lateral soil pressure at depth L_e,	Status: PASS Ratio: 0.530

	$p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (6.75 \text{ ft})$ $p_s = 1.0125 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{s}{p_s}$ $\text{Ratio} = \frac{(0.91218 \text{ kip/ft}^2)}{(1.0125 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.90091$	Status: PASS Ratio: 0.900
	Considering z-direction: $H_o = -0.015127 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 0.019268 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point, $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.019268 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.015127 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (0.019268 \text{ kipft/ft})) + (4 \times (-0.015127 \text{ kip/ft}) \times (6.75 \text{ ft}))}$ $a = 4.9384 \text{ ft}$ p - Earth pressure against the pile at distance $a/2$ from resting surface, $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^3 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.019268 \text{ kipft/ft})) + (3 \times (-0.015127 \text{ kip/ft}) \times (6.75 \text{ ft}))]^2}{(6.75 \text{ ft})^3 \times [(3 \times (0.019268 \text{ kipft/ft})) + (2 \times (-0.015127 \text{ kip/ft}) \times (6.75 \text{ ft}))]}$ $p = -0.005909 \text{ kip/ft}^2$ s - Earth pressure against the pile at distance L_e, $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.019268 \text{ kipft/ft})) + ((-0.015127 \text{ kip/ft}) \times (6.75 \text{ ft}))]}{(6.75 \text{ ft})^2}$ $s = -0.008372 \text{ kip/ft}^2$ Check lateral soil pressure capacity: p_a - Allowable lateral soil pressure at depth $a/2$, $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.9384 \text{ ft})}{2}$ $p_a = 0.37038 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{p}{p_a}$ $\text{Ratio} = \frac{(-0.005909 \text{ kip/ft}^2)}{(0.37038 \text{ kip/ft}^2)}$ $\text{Ratio} = -0.015954$ p_s - Allowable lateral soil pressure at depth L_e, $p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (6.75 \text{ ft})$ $p_s = 1.0125 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{s}{p_s}$	Status: PASS Ratio: -0.020

$$Ratio = \frac{(-0.008372 \text{ kip/ft}^2)}{(1.0125 \text{ kip/ft}^2)}$$

$$Ratio = -0.0082686$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-6.43 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -1.0239 \text{ kip/ft}$$

M_o - Moment per length of pile,

$$M_o = \frac{M_e + (V_e H)}{1.57 D}$$

$$M_o = \frac{(58.065 \text{ kipft}) + ((-6.43 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 9.246 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(9.246 \text{ kipft/ft})}{(-1.0239 \text{ kip/ft})}$$

$$E = 9.0303 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (9.246 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-1.0239 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (9.246 \text{ kipft/ft})) + (4 \times (-1.0239 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.6871 \text{ ft}$$

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

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

$$V_{max} = ((-1.0239 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (9.0303 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.6871 \text{ ft})}{(6.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (9.0303 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.6871 \text{ ft})}{(6.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 12.396 \text{ kip}$$

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

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

$$M_{max} = ((-1.0239 \text{ kip/ft}) \times (48 \text{ in}) \times (6.75 \text{ ft})) \times \left[\left(\frac{(9.0303 \text{ ft})}{(6.75 \text{ ft})} + \frac{(4.6871 \text{ ft})}{2 \times (6.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (9.0303 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.6871 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (9.0303 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.6871 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 39.336 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.142 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.022611 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.175 \text{ kipft}) + ((-0.142 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.027866 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.027866 \text{ kipft/ft})}{(-0.022611 \text{ kip/ft})}$$

$$E = 1.2324 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.027866 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.022611 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (0.027866 \text{ kipft/ft})) + (4 \times (-0.022611 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.9416 \text{ ft}$$

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

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

$$V_{max} = ((-0.022611 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (1.2324 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.9416 \text{ ft})}{(6.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (1.2324 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.9416 \text{ ft})}{(6.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.090378 \text{ kip}$$

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

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

$$M_{max} = ((-0.022611 \text{ kip/ft}) \times (48 \text{ in}) \times (6.75 \text{ ft})) \times \left[\left(\frac{(1.2324 \text{ ft})}{(6.75 \text{ ft})} + \frac{(4.9416 \text{ ft})}{2 \times (6.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (1.2324 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.9416 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (1.2324 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.9416 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^4 \right] \right]$$

		$M_{max} = 0.25117 \text{ kipft}$	
		Minimum Reinforcement Check (LRFD) Parameters: $f'_{ck} = 2.5 \text{ ksi}$ - Concrete strength, $f_{yk} = 60 \text{ ksi}$ - Longitudinal reinforcement strength, $\phi = 0.65$ - Reduction factor for axial strength, $\alpha = 0.8$ - Alpha factor for axial strength, $A_g = 2304 \text{ in}^2$ - Gross area of concrete, Longitudinal reinforcement: Required reinforcement due to axial load, $A_{st,required}$ $A_{st,required}$ $A_{st,required} = \text{Min} \left[\frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = \text{Min} \left[\frac{\frac{(4.277 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -84.454 \text{ in}^2$ A_{min} - Governing minimum reinforcement area, $A_{min} = \text{Max} [A_{st,required}, (0.0018 A_g)]$ $A_{min} = \text{Max} [(-84.454 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ n_{rebar} - Required number of reinforcement, $n_{rebar} = \frac{A_{min}}{A_{rebar}}$ $n_{rebar} = \frac{(4.1472 \text{ in}^2)}{(0.3068 \text{ in}^2)}$ $n_{rebar} = 14$ A_{st} - Actual total reinforcement area, $A_{st} = n_{rebar} \frac{\pi d_{bar}^2}{4}$ $A_{st} = (14) \times \frac{\pi \times (0.625 \text{ in})^2}{4}$ $A_{st} = 4.2951 \text{ in}^2$ Ratio - Capacity $\text{Ratio} = \frac{A_{min}}{A_{st}}$ $\text{Ratio} = \frac{(4.1472 \text{ in}^2)}{(4.2951 \text{ in}^2)}$ $\text{Ratio} = 0.96556$ 25.2.3 s_{rebar} - Minimum spacing of reinforcement, $s_{rebar} = \text{Max} [1.5, (1.5 d_{bar})]$ $s_{rebar} = \text{Max} [1.5, (1.5 \times (0.625 \text{ in}))]$ $s_{rebar} = 1.5 \text{ in}$ Ties: 25.7.2.2 Since longitudinal reinforcement is $\leq \text{No. } 10\phi$: Use #3(0.375 in) 25.7.2.1 s_{ties} - Maximum spacing of ties, $s_{ties} = \text{Min} [(16 d_{bar}), (48 d_{ties}), \text{Min}(D, b)]$ $s_{ties} = \text{Min} [(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), \text{Min}((48 \text{ in}), (48 \text{ in}))]$ $s_{ties} = 10 \text{ in}$ Summary: Main reinforcement: 14 - #5 (0.625 in)	Status: PASS Ratio: 0.970

		Ties: #3(0.375 in) - 10 in	
		Axial Compression Strength (ACI 318-19, LRFD)	
22.4.2.2	ϕP_N - Allowable axial compressive strength	$\phi P_N = \phi 0.80 \left[(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st}) \right]$ $\phi P_N = (0.65) \times 0.80 \times \left[(0.85 \times (2.5 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2)) \right]$ $\phi P_N = 2675.2 \text{ kip}$ Ratio - Capacity $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(4.277 \text{ kip})}{(2675.2 \text{ kip})}$ $Ratio = 0.0015988$	Status: PASS Ratio: 0.000
		Shear Strength (ACI 318-19, LRFD)	
		Parameters:	
22.5.2.2	$b_w = 48 \text{ in}$ - Effective width, d - Effective depth	$d = 0.80 D$ $d = 0.80 \times (48 \text{ in})$ $d = 38.4 \text{ in}$	
22.5.5.1.3	λ_s - size effect modification factor	$\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.64282$	
22.5.5.1.1	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $V_{c,max}$ - Max shear strength of concrete	$V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$ $V_{c,max} = 5 \times (0.64282) \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,max} = 296.21 \text{ kip}$	
22.5.5.1.1(a)	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 4.277 \text{ kip} \rightarrow 4277 \text{ lbf}$, $V_{c,a}$ - Shear strength of concrete (a)	$V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(4277 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 119.06 \text{ kip}$	
22.5.5.1.2	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $V_{c,b}$ - Shear strength of concrete (b)	$V_{c,b} = \left[2 \lambda_s \sqrt{f'_{ck}} + (0.05 f'_{ck}) \right] b_w d$ $V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + (0.05 \times (2500 \text{ psi})) \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,b} = 348.89 \text{ kip}$	
	V_c - Governing shear strength of concrete	$V_c = Min [V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = Min [(296.21 \text{ kip}), (119.06 \text{ kip}), (348.89 \text{ kip})]$ $V_c = 119.06 \text{ kip}$	

22.5.1.2 22.5.8.5.3 22.5.1.1	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $V_{s,a}$ - Shear strength of steel (a) $V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$ $V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{s,a} = 737.28 \text{ kip}$ A_v - Ties rebar area, $A_v = \frac{\pi d_{tes}^2}{4}$ $A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$ $A_v = 0.11045 \text{ in}^2$ $V_{s,b}$ - Shear strength of steel (b) $V_{s,b} = \frac{2 A_v f_{ysk} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$ V_s - Governing shear strength of steel $V_s = MIN[V_{s,a}, V_{s,b}]$ $V_s = MIN[(737.28 \text{ kip}), (50.894 \text{ kip})]$ $V_s = 50.894 \text{ kip}$ ϕV_n - Allowable shear strength $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((119.06 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 110.47 \text{ kip}$ Considering x-direction: $V_{max} = 12.396 \text{ kip}$ - Maximum shear force in the x-direction, <i>Ratio</i> - Capacity $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(12.396 \text{ kip})}{(110.47 \text{ kip})}$ $Ratio = 0.11221$ Considering z-direction: $V_{max} = 0.090378 \text{ kip}$ - Maximum shear force in the z-direction, <i>Ratio</i> - Capacity $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.090378 \text{ kip})}{(110.47 \text{ kip})}$ $Ratio = 0.00081814$	Status: PASS Ratio: 0.110 Status: PASS Ratio: 0.000
	Flexural Strength (ACI 318-19, LRFD) S_m - Section modulus $S_m = \frac{b D^3}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$	

14.5.2.1b	$\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$ $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{2.5 \text{ ksi}} \times 18432.001 \text{ in}^3$ $\phi M_{n,1} = 249.600 \text{ kipft}$ $\phi M_{n,2}$ $\phi M_{n,2} = \phi \times 0.85 \times f'_c \times S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (18432 \text{ in}^3)$ $\phi M_{n,2} = 2121.6 \text{ kipft}$ Therefore, ϕM_n - Allowable flexural strength, $\phi M_n = \text{MIN}[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = \text{MIN}[(249.6 \text{ kipft}), (2121.6 \text{ kipft})]$ $\phi M_n = 249.6 \text{ kipft}$ Considering x-direction: $M_{max} = 39.336 \text{ kipft}$ - Maximum moment in the x-direction, Ratio - Capacity $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(39.336 \text{ kipft})}{(249.6 \text{ kipft})}$ $\text{Ratio} = 0.15759$	Status: PASS Ratio: 0.160
	Considering z-direction: $M_{max} = 0.25117 \text{ kipft}$ - Maximum moment in the z-direction, Ratio - Capacity $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(0.25117 \text{ kipft})}{(249.6 \text{ kipft})}$ $\text{Ratio} = 0.0010063$	Status: PASS Ratio: 0.000