

Your Project Calculations



Project Name: Tony Halstead-RevB-JB

S3D Model Link:
https://platform.skyciv.com/structural?preload_name=Tony%20Halstead-RevB-JB&preload_path=Shared%20Enterprise%20Folder/MT_Solar_Projects/1_2024

Public Model Link:
https://platform.skyciv.com/structural-viewer?project_id=z5LSIEvKvsDRkm06kePBlpn7gyYm1hOAK1lek11pbXA021bqDW4QlrCOeVHdmX5B

Array Specification

Product:	Beam
Unique ID:	2P-15-6TOP-HD-45-L-4Hx5W-A3D2
Duty Classification:	HD
Module Width:	40.00 in
Module Length:	71.70in
Number of Rows:	4
Number of Columns:	5
Total Number of Modules:	20
Desired Tilt Angle:	30
Front Edge Clearance:	3
Total Array Height at Tilt:	9.71 ft
Total Frame Length:	30.00 ft
Frame Weight:	1270 lbs
Array Dimensions N/S:	13.50 ft
Array Dimensions E/W:	30.29 ft
Rail Length:	162.00 in
Rail Spacing:	3.03 ft
Rail Check:	

Support Specifications

Pole Size:	6in Pipe Sch 40
Pole Length above Grade:	6.38 ft
Number of Poles:	2
Pole Spacing:	15 ft

Foundation Specifications

Foundation Type:	Square
Foundation Dimensions:	48 x 48 in
Foundation Depth (below grade):	Pile 1: 5.00 ft Pile 2: 5.00 ft
Foundation Volume:	5.926 y ³
Foundation Result:	PASSED
Mount Twist:	0.535266 kip

Site Info

Risk Category:	I
Exposure:	B
Soil Classification:	sand
Site Location:	1249 Stagecoach Blvd, Evergreen, CO 80439, USA
Wind Speed:	130 mph
Snow Load:	78 psf
Design Uplift Pressure:	Multiple pressures
Design Downforce Pressure:	Multiple pressures
Design Snow Pressure:	0.034309 ksf



Design Disclaimer

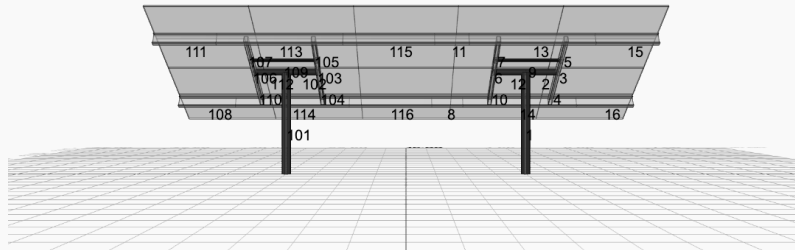
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

AutoDesigner Input

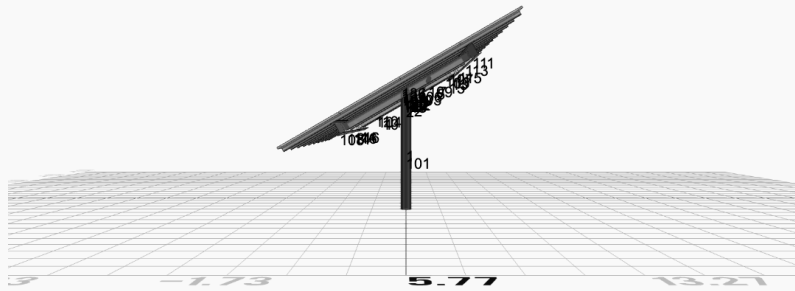
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Design Notes:

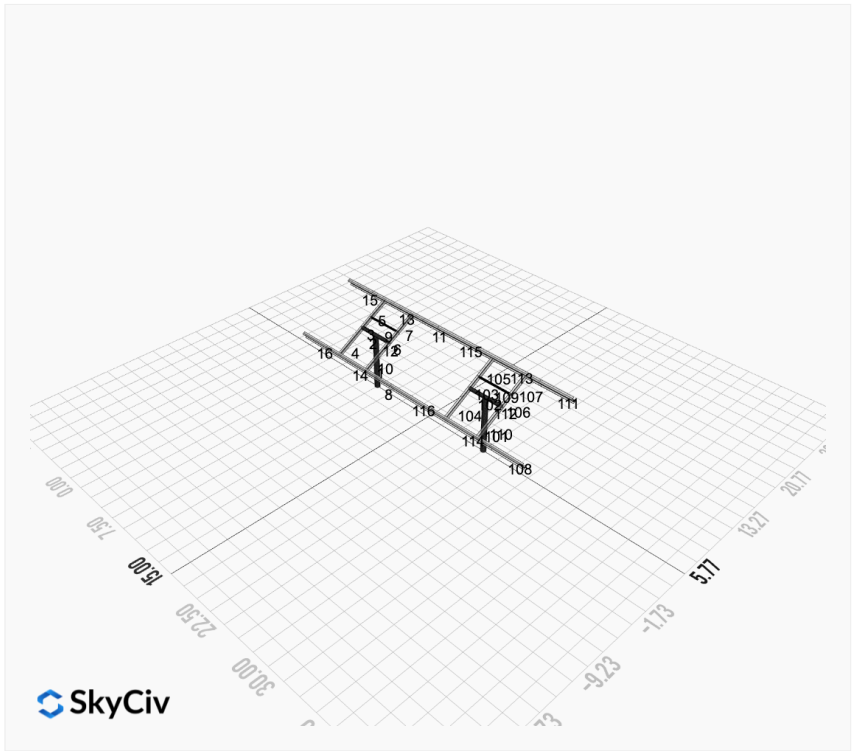
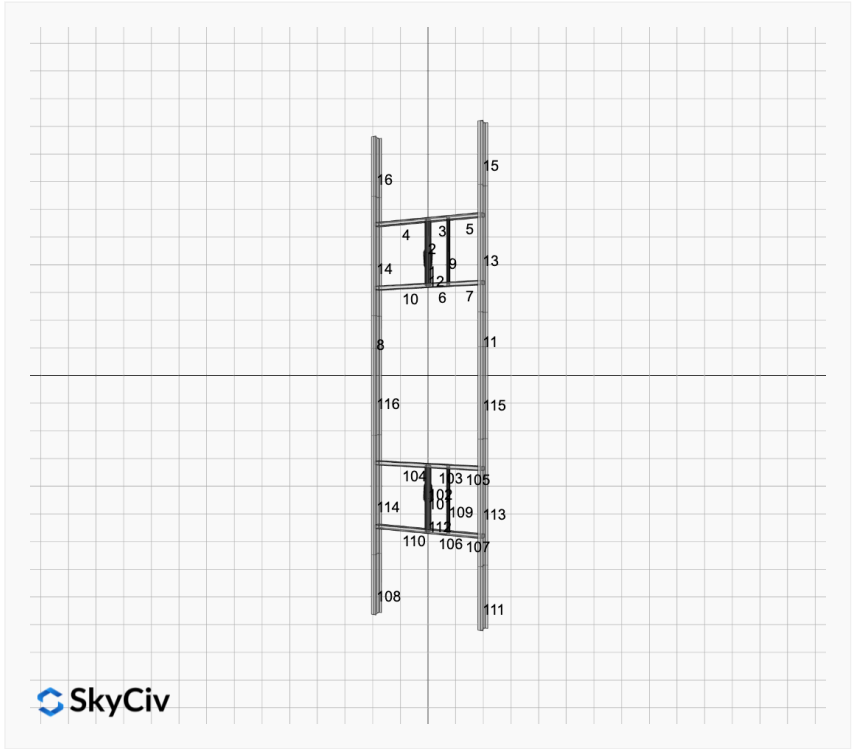
- AISC Deflection checks are set to L/1 due to structure design intent
- Foundation Soil Parameters used in this Autodesigned are all estimates, proper geotechnical reports are required to confirm soil profiles
- Wind speeds, snow loads and other site specific results are based on ASCE 7 2016
- Steel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

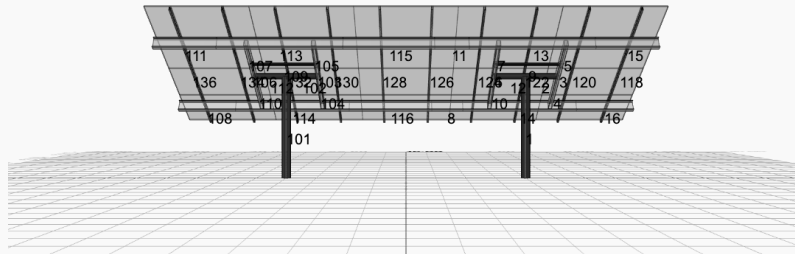


 SkyCiv



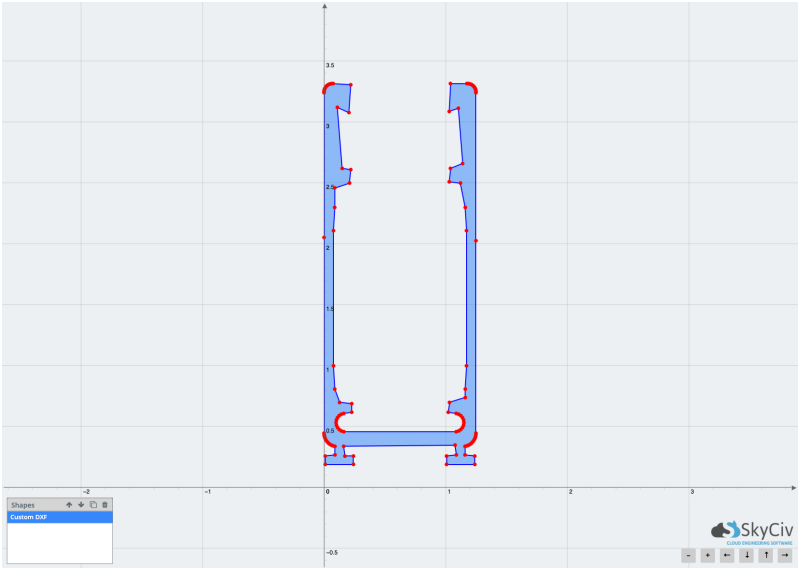
 SkyCiv



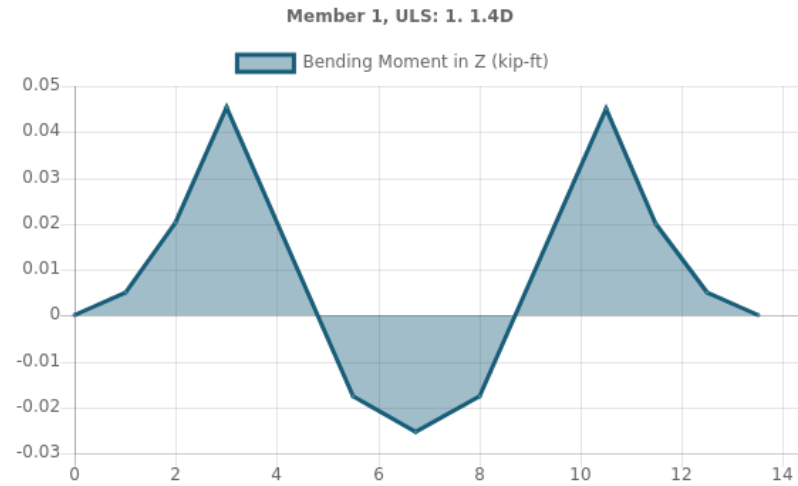


Rail Design Check

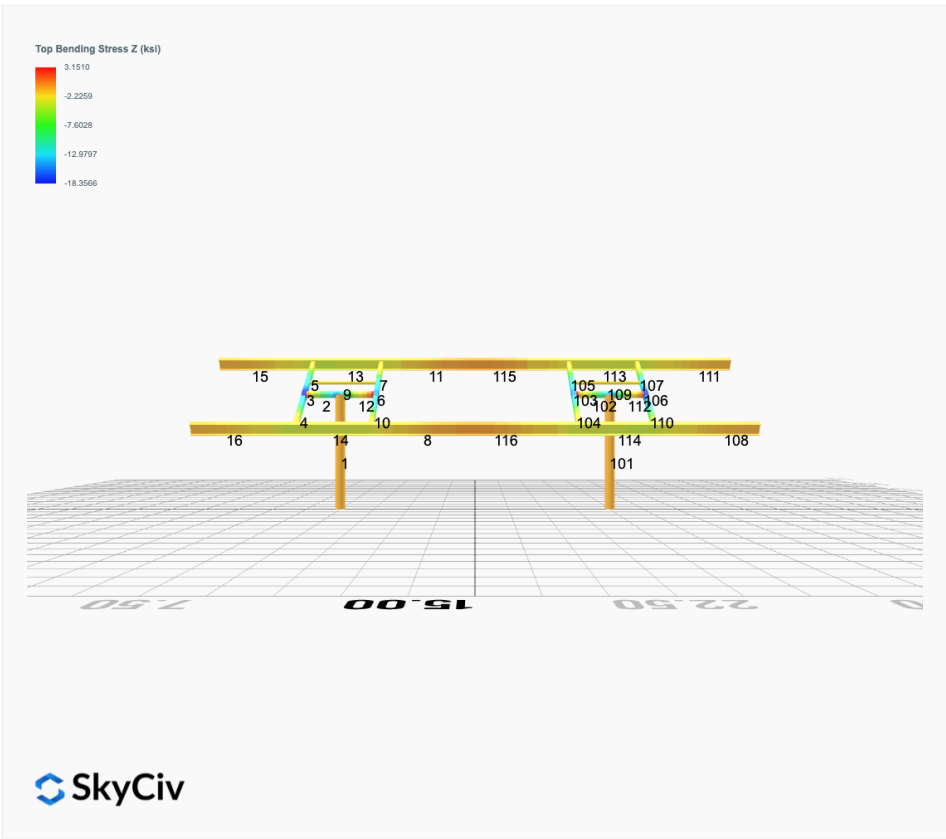
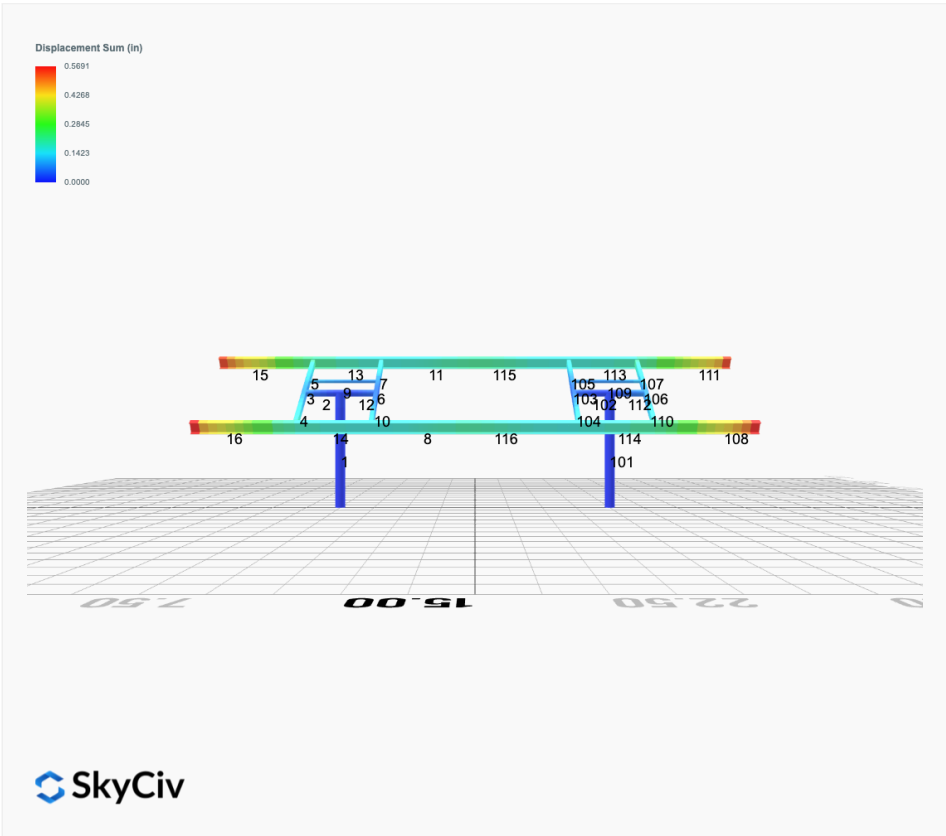
Rail Length: 13.5 ft
Additional Restraints Required: None
Tributary Width: 3.02916666666667 ft
Material: Aluminium
Density: 169 lb/ft³
Elasticity Modulus: 10000 ksi
Fy: 34.5 ksi
Fu: 37 ksi
Snow (X): 0.0900 kip/ft
Snow (Y): -0.0520 kip/ft
Wind uplift Case A: 0.0736 kip/ft
Wind uplift Case A: 0.0736 kip/ft
Wind uplift Case B (X): 0.0000 kip/ft
Wind uplift Case B (Y): 0.1023 kip/ft

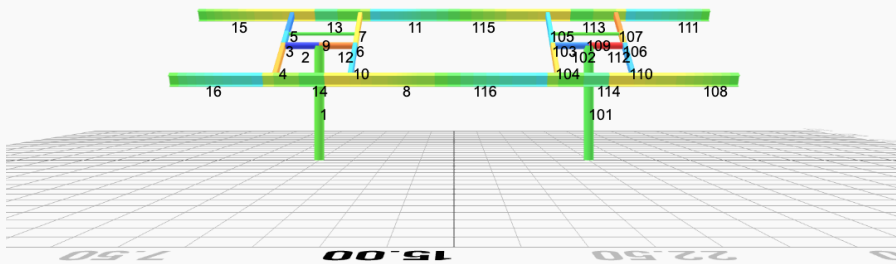
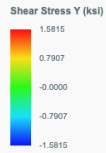
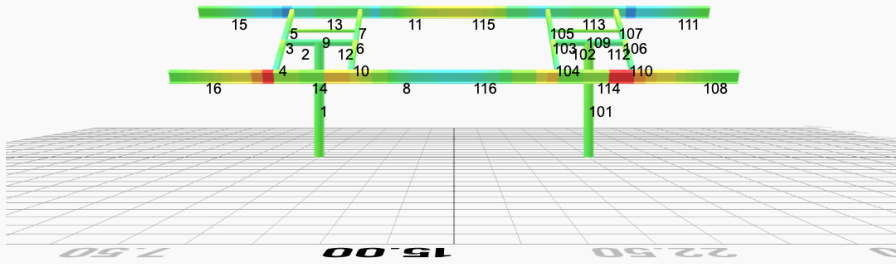
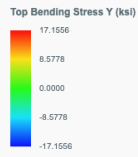


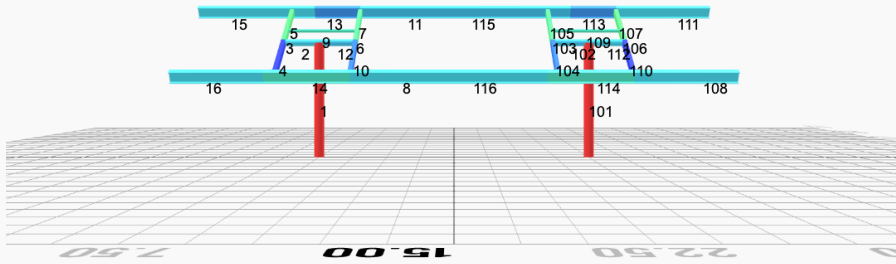
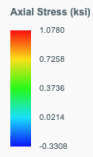
Result Check	Max Limit	Max Value	Utility	Status
Custom Stress Limit	34.5	13.79083206	0.400	PASS
Material Yield	34.5	13.79083206	0.400	PASS
Material Strength	37	13.79083206	0.373	PASS



FEM Results (Envelope Worst Case for each member)







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

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	0.0000	1.6029	-0.0429	-0.0646	0.0450	0.0259
ULS: 2. D + L	0.0000	1.6029	-0.0429	-0.0646	0.0450	0.0259
ULS: 3. D + (S or Lr or R)	-0.0000	7.6196	-0.2452	-0.3691	0.2567	0.0671
ULS: 3. D + (S or Lr or R)	0.0000	1.6029	-0.0429	-0.0646	0.0450	0.0259
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0000	6.1154	-0.1946	-0.2929	0.2038	0.0568
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	1.6029	-0.0429	-0.0646	0.0450	0.0259
ULS: 5b. D + 0.7E	0.0000	1.6029	-0.0429	-0.0646	0.0450	0.0259
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0000	6.1154	-0.1946	-0.2929	0.2038	0.0568
ULS: 8. 0.6D + 0.7E	0.0000	0.9617	-0.0257	-0.0387	0.0270	0.0156
ULS: 5a. D + 0.6W_Wind downforce Case A only	-1.7393	4.6155	-0.1703	-0.2507	0.2158	11.2492
ULS: 5a. D + 0.6W_Wind downforce Case B only	-1.7393	4.6155	-0.1703	-0.2507	0.2158	11.2492
ULS: 5a. D + 0.6W_Wind uplift Case A only	1.4909	-0.9793	0.0659	0.0942	-0.1012	-9.3817
ULS: 5a. D + 0.6W_Wind uplift Case B only	1.2424	-0.5490	0.0484	0.0687	-0.0778	-13.9599
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.3045	8.3749	-0.2902	-0.4325	0.3319	8.4743
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.3045	8.3749	-0.2902	-0.4325	0.3319	8.4743
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.1181	4.1788	-0.1130	-0.1739	0.0941	-6.9988
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.9318	4.5015	-0.1261	-0.1929	0.1117	-10.4325
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.3045	3.8624	-0.1385	-0.2042	0.1731	8.4434
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.3045	3.8624	-0.1385	-0.2042	0.1731	8.4434
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.1181	-0.3338	0.0387	0.0545	-0.0647	-7.0298
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.9318	-0.0110	0.0256	0.0354	-0.0471	-10.4635
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-1.7393	3.9743	-0.1531	-0.2249	0.1978	11.2388
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-1.7393	3.9743	-0.1531	-0.2249	0.1978	11.2388
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	1.4909	-1.6205	0.0830	0.1200	-0.1192	-9.3920
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	1.2424	-1.1901	0.0656	0.0946	-0.0958	-13.9703

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	14.0607
Shear X	-2.8989
Shear Z	-0.4831
Moment X	-0.7233
Moment Y (Twist)	0.5353
Moment Z	23.6178

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	8.3749
Shear X	-1.7393
Shear Z	-0.2902
Moment X	-0.4325
Moment Y (Twist)	0.3319
Moment Z	13.9703

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	1.6029	0.0429	0.0646	-0.0450	0.0259
ULS: 2. D + L	-0.0000	1.6029	0.0429	0.0646	-0.0450	0.0259
ULS: 3. D + (S or Lr or R)	0.0000	7.6196	0.2452	0.3691	-0.2567	0.0671
ULS: 3. D + (S or Lr or R)	-0.0000	1.6029	0.0429	0.0646	-0.0450	0.0259
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	6.1154	0.1946	0.2930	-0.2038	0.0568
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0000	1.6029	0.0429	0.0646	-0.0450	0.0259
ULS: 5b. D + 0.7E	-0.0000	1.6029	0.0429	0.0646	-0.0450	0.0259

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0000	6.1154	0.1946	0.2930	-0.2038	0.0568
ULS: 8. 0.6D + 0.7E	-0.0000	0.9617	0.0257	0.0388	-0.0270	0.0156
ULS: 5a. D + 0.6W_Wind downforce Case A only	-1.7393	4.6155	0.1703	0.2507	-0.2158	11.2492
ULS: 5a. D + 0.6W_Wind downforce Case B only	-1.7393	4.6155	0.1703	0.2507	-0.2158	11.2492
ULS: 5a. D + 0.6W_Wind uplift Case A only	1.4909	-0.9793	-0.0659	-0.0942	0.1012	-9.3817
ULS: 5a. D + 0.6W_Wind uplift Case B only	1.2424	-0.5490	-0.0484	-0.0687	0.0778	-13.9599
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.3045	8.3749	0.2902	0.4326	-0.3319	8.4743
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.3045	8.3749	0.2902	0.4326	-0.3319	8.4743
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.1181	4.1788	0.1130	0.1739	-0.0941	-6.9989
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.9318	4.5015	0.1261	0.1930	-0.1117	-10.4326
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.3045	3.8624	0.1385	0.2042	-0.1731	8.4434
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.3045	3.8624	0.1385	0.2042	-0.1731	8.4434
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.1181	-0.3338	-0.0387	-0.0545	0.0647	-7.0298
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.9318	-0.0110	-0.0256	-0.0354	0.0471	-10.4635
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-1.7393	3.9743	0.1531	0.2249	-0.1978	11.2388
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-1.7393	3.9743	0.1531	0.2249	-0.1978	11.2388
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	1.4909	-1.6205	-0.0830	-0.1200	0.1192	-9.3920
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	1.2424	-1.1901	-0.0656	-0.0946	0.0958	-13.9703

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	14.0607
Shear X	-2.8989
Shear Z	0.4831
Moment X	0.7236
Moment Y (Twist)	0.5353
Moment Z	23.6186

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	8.3749
Shear X	-1.7393
Shear Z	0.2902
Moment X	0.4326
Moment Y (Twist)	0.3319
Moment Z	13.9703

Project Details

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

User Name: sales@mtsolar.us
 Project Name: Tony Halstead-RevB-JB
 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					
7	6in Pipe Sch 40	6.63	0.28					
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		
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

7	6in Pipe Sch 40	5.58	56.28	28.14	28.14	0.00	11.28	11.28
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	7	13.39	13.39	6.38	-	300	200	1
2	5	4.20	4.20	2.00	-	300	200	1
3	16	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.18,1.16,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18	300	200	1
4	16	2.44	2.44	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.64,1.68,1.67,1.67,1.66,1.41,1.67,1.67,1.67,1.67,1.67,1.67,1.64,1.72,1.67,1.67,1.66,1.62	300	200	1
5	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66	300	200	1
6	16	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.16,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.16,1.17,1.18,1.18,1.17,1.17	300	200	1
7	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66	300	200	1
8	19	1.33	1.33	2.05	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.30,2.39,2.33,2.33,2.32,1.14,2.33,2.33,2.33,2.34,2.33,2.33,2.32,2.46,2.33,2.33,2.32,1.62	300	200	1
9	2	2.60	2.60	4.00	-	300	200	1
10	16	2.44	2.44	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.63,1.68,1.67,1.67,1.66,2.20,1.67,1.67,1.67,1.67,1.67,1.67,1.64,1.71,1.67,1.67,1.66,1.57	300	200	1
11	19	1.33	1.33	2.05	2.34,2.34,2.34,2.34,2.34,2.34,2.33,2.33,2.31,2.36,2.33,2.33,2.33,2.35,2.34,2.34,2.34,2.33,2.33,2.33,2.32,2.35,2.33,2.33,2.33,2.35	300	200	1
12	5	1.30	1.30	2.00	-	300	200	1
13	19	4.88	4.00	7.50	1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.09,1.19,1.10,1.10,1.10,1.12,1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.15,1.10,1.10,1.10,1.12	300	200	1
14	19	4.88	4.00	7.50	1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.09,1.20,1.10,1.10,1.10,1.16,1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.38,1.10,1.10,1.10,1.14	300	200	1
15	19	7.88	7.88	3.75	2.33,2.33	300	200	1
16	19	7.88	7.88	3.75	2.33,2.33	300	200	1
101	7	13.39	13.39	6.38	-	300	200	1
102	5	1.30	1.30	2.00	-	300	200	1
103	16	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.16,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.16,1.17,1.18,1.18,1.17,1.17	300	200	1
104	16	2.44	2.44	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.63,1.68,1.67,1.67,1.66,2.20,1.67,1.67,1.67,1.67,1.67,1.67,1.64,1.71,1.67,1.67,1.66,1.57	300	200	1
105	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66	300	200	1
106	16	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.18,1.16,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18	300	200	1
107	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66	300	200	1

Member Design Capacity

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115	133.20	109.71	32.87	6.12	40.24	43.62
116	133.20	109.71	32.87	6.12	40.24	43.62

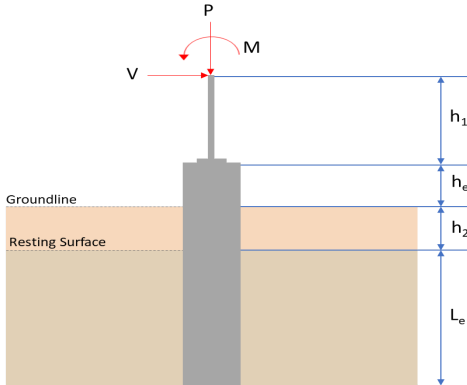
Design Ratio

Member ID	P	M _z	M _y	V _y	V _z	(P,M _z ,M _y)	Worst LC	KL/r	δ	Status
1	0.081	0.558	0.055	0.038	0.006	0.562	#16	0.358	Not Required	Pass
2	0.001	0.580	0.154	0.125	0.026	0.714	#21	0.171	Not Required	Pass
3	0.013	0.805	0.114	0.081	0.029	0.925	#21	0.045	Not Required	Pass
4	0.014	0.798	0.169	0.080	0.035	0.900	#21	0.080	Not Required	Pass
5	0.013	0.499	0.190	0.080	0.047	0.544	#21	0.074	Not Required	Pass
6	0.012	0.706	0.064	0.070	0.012	0.770	#21	0.045	Not Required	Pass
7	0.012	0.439	0.121	0.070	0.030	0.468	#21	0.074	Not Required	Pass
8	0.001	0.055	0.125	0.039	0.016	0.140	#21	0.095	Not Required	Pass
9	0.007	0.073	0.076	0.001	0.003	0.153	#21	0.204	Not Required	Pass
10	0.011	0.699	0.145	0.070	0.035	0.834	#21	0.080	Not Required	Pass
11	0.003	0.054	0.127	0.039	0.016	0.146	#21	0.095	Not Required	Pass
12	0.003	0.474	0.133	0.108	0.023	0.584	#21	0.053	Not Required	Pass
13	0.008	0.264	0.459	0.057	0.023	0.711	#21	0.286	Not Required	Pass
14	0.008	0.269	0.459	0.057	0.023	0.711	#21	0.190	Not Required	Pass
15	0.000	0.090	0.214	0.039	0.016	0.303	#21	Not Required	Not Required	Pass
16	0.000	0.090	0.214	0.039	0.016	0.303	#21	Not Required	Not Required	Pass
101	0.081	0.558	0.055	0.038	0.006	0.562	#16	0.358	Not Required	Pass
102	0.003	0.474	0.133	0.108	0.023	0.584	#21	0.053	Not Required	Pass
103	0.012	0.706	0.064	0.070	0.012	0.770	#21	0.045	Not Required	Pass
104	0.011	0.699	0.145	0.070	0.035	0.834	#21	0.080	Not Required	Pass
105	0.012	0.439	0.121	0.070	0.030	0.468	#21	0.074	Not Required	Pass
106	0.013	0.805	0.114	0.081	0.029	0.925	#21	0.045	Not Required	Pass
107	0.013	0.499	0.190	0.080	0.047	0.544	#21	0.074	Not Required	Pass
108	0.000	0.090	0.214	0.039	0.016	0.303	#21	Not Required	Not Required	Pass
109	0.007	0.073	0.076	0.001	0.003	0.153	#21	0.204	Not Required	Pass
110	0.014	0.798	0.169	0.080	0.035	0.900	#21	0.080	Not Required	Pass
111	0.000	0.090	0.214	0.039	0.016	0.303	#21	Not Required	Not Required	Pass
112	0.001	0.580	0.154	0.125	0.026	0.714	#21	0.171	Not Required	Pass
113	0.008	0.264	0.459	0.057	0.023	0.711	#21	0.190	Not Required	Pass
114	0.008	0.269	0.459	0.057	0.023	0.711	#21	0.286	Not Required	Pass
115	0.003	0.054	0.169	0.039	0.016	0.205	#21	0.253	Not Required	Pass
116	0.001	0.055	0.167	0.039	0.016	0.200	#21	0.253	Not Required	Pass

Definitions

Φ _t	Safety factor for tensile
Φ _c	Safety factor for compression
Φ _b	Safety factor for flexure
Φ _v	Safety factor for shear
E	Modulus of elasticity
F _y	Specified minimum yield stress
F _u	Specified minimum tensile strength
A	Cross-sectional area
J	Torsional constant
I _{yp}	Moment of inertia about the Y axes
I _{zp}	Moment of inertia about the Z axes
I _w	Warping constant
S _{yp}	Plastic section modulus about the Y axis
S _{zp}	Plastic section modulus about the Z axis
KL	Effective length
C _n	Buckling modification factor (from all load combinations)

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

REFERENCES	CALCULATIONS	RESULTS																										
	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 = 5 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><tr><th>Layer</th><th>Label</th><th>Allowable Bearing Pressure (qa) (psf)</th><th>Allowable Lateral Pressure (R) (psf/ft)</th></tr><tr><td>1</td><td>Sand, silty sand, clayey sand, silty gravel & clayey gravel</td><td>2000.000</td><td>150.000</td></tr></table> Tabulation of Loads <table><tr><th>Load Component</th><th>ASD</th><th>LRFD</th></tr><tr><td>P (kip)</td><td>8.375</td><td>14.061</td></tr><tr><td>Vx (kip)</td><td>-1.739</td><td>-2.899</td></tr><tr><td>Vz (kip)</td><td>-0.290</td><td>-0.483</td></tr><tr><td>Mx (kipft)</td><td>-0.433</td><td>-0.723</td></tr><tr><td>Mz (kipft)</td><td>13.970</td><td>23.618</td></tr></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)	8.375	14.061	Vx (kip)	-1.739	-2.899	Vz (kip)	-0.290	-0.483	Mx (kipft)	-0.433	-0.723	Mz (kipft)	13.970	23.618	
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Mx (kipft)	-0.433	-0.723																										
Mz (kipft)	13.970	23.618																										
	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, $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-1.739\text{ kip})}{1.57 \times (48\text{ in})}$ $H_o = -0.27691\text{ kip/ft}$ Mo - Moment per length of pile, $M_o = \frac{M_z + (V_x H)}{1.57 D}$																											

	$M_o = \frac{(13.97 \text{ kipft}) + ((-1.739 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 2.2245 \text{ kipft/ft}$ 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: $L_{e,x} = 4.652 \text{ ft}$ - Required depth in x-direction, Considering z-direction: H_o - Lateral force per length of pile, $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(-0.29 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.046178 \text{ kip/ft}$ M_o - Moment per length of pile, $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(0.433 \text{ kipft}) + ((-0.29 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.068949 \text{ kipft/ft}$ 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: $L_{e,z} = 1.2632 \text{ ft}$ - Required depth in z-direction, Minimum embedded depth required: $L_{e,req}$ - Depth of pile required, $L_{e,req} = \text{MAX}[L_{e,x}, L_{e,z}]$ $L_{e,req} = \text{MAX}[(4.652 \text{ ft}), (1.2632 \text{ ft})]$ $L_{e,req} = 4.652 \text{ ft}$ L_e - Actual embedded length of pile, $L_e = L - h_e - h_2$ $L_e = (5 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 5 \text{ ft}$ Ratio - Embedded depth $\text{Ratio} = \frac{L_{e,req}}{L_e}$ $\text{Ratio} = \frac{(4.652 \text{ ft})}{(5 \text{ ft})}$ $\text{Ratio} = 0.9304$	Status: PASS Ratio: 0.930
	End-bearing Capacity (ASD) A - Pile cross-section area $A = b D$ $A = (48 \text{ in}) \times (48 \text{ in})$ $A = 16 \text{ ft}^2$ q - End-bearing pressure $q = \frac{P_o}{A}$ $q = \frac{(8.375 \text{ kip})}{(16 \text{ ft}^2)}$ $q = 0.52344 \text{ kips/ft}^2$	

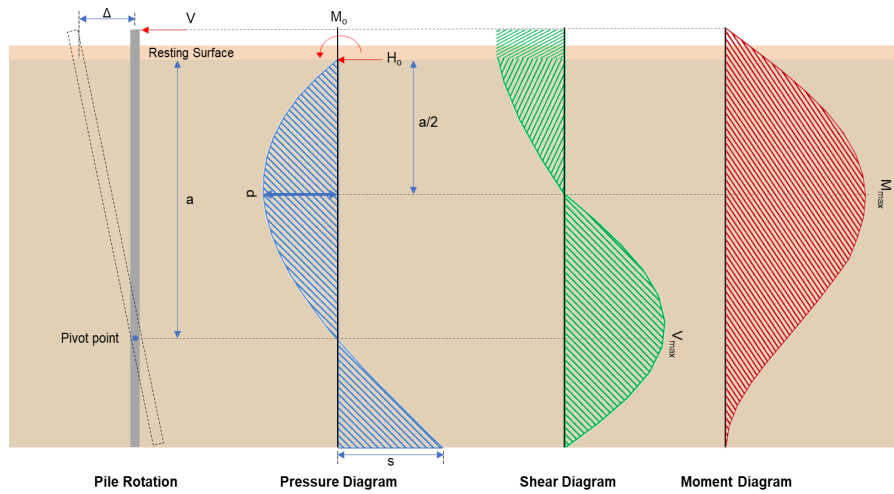
	$q = 0.52344 \text{ kip/ft}^2$	
	Check bearing capacity ratio: Ratio - Capacity $Ratio = \frac{q}{q_a}$ $Ratio = \frac{(0.52344 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $Ratio = 0.26172$	Status: PASS Ratio: 0.260
Czerniak	Lateral Soil Pressure (ASD): L/D - Length to least lateral dimension ratio, $L/D = \frac{L}{D}$ $L/D = \frac{(5 \text{ ft})}{(48 \text{ in})}$ $L/D = 1.25$ Since $L/D \leq 10$, Pile is short. Considering x-direction: $H_o = -0.27691 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 2.2245 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point, $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (2.2245 \text{ kipft/ft}) \times (5 \text{ ft})) + (3 \times (-0.27691 \text{ kip/ft}) \times (5 \text{ ft})^2)}{(6 \times (2.2245 \text{ kipft/ft})) + (4 \times (-0.27691 \text{ kip/ft}) \times (5 \text{ ft}))}$ $a = 3.4555 \text{ ft}$ p - Earth pressure against the pile at distance $a/2$ from resting surface, $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^3 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 [(4 \times (2.2245 \text{ kipft/ft})) + (3 \times (-0.27691 \text{ kip/ft}) \times (5 \text{ ft}))]^2}{(5 \text{ ft})^3 [(3 \times (2.2245 \text{ kipft/ft})) + (2 \times (-0.27691 \text{ kip/ft}) \times (5 \text{ ft}))]}$ $p = 0.17295 \text{ kip/ft}^2$ s - Earth pressure against the pile at distance L_e, $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (2.2245 \text{ kipft/ft})) + ((-0.27691 \text{ kip/ft}) \times (5 \text{ ft}))]}{(5 \text{ ft})^2}$ $s = 0.73548 \text{ kip/ft}^2$ Check lateral soil pressure capacity: p_a - Allowable lateral soil pressure at depth $a/2$, $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(3.4555 \text{ ft})}{2}$ $p_a = 0.25916 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.17295 \text{ kip/ft}^2)}{(0.25916 \text{ kip/ft}^2)}$ $Ratio = 0.66735$ p_s - Allowable lateral soil pressure at depth L_e,	Status: PASS Ratio: 0.670

	$p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (5 \text{ ft})$ $p_s = 0.75 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{s}{p_s}$ $\text{Ratio} = \frac{(0.73548 \text{ kip/ft}^2)}{(0.75 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.98064$	Status: PASS Ratio: 0.980
	Considering z-direction: $H_o = -0.046178 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 0.068949 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point, $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.068949 \text{ kipft/ft}) \times (5 \text{ ft})) + (3 \times (-0.046178 \text{ kip/ft}) \times (5 \text{ ft})^2)}{(6 \times (0.068949 \text{ kipft/ft})) + (4 \times (-0.046178 \text{ kip/ft}) \times (5 \text{ ft}))}$ $a = 3.6211 \text{ ft}$ p - Earth pressure against the pile at distance $a/2$ from resting surface, $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^3 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.068949 \text{ kipft/ft})) + (3 \times (-0.046178 \text{ kip/ft}) \times (5 \text{ ft}))]^2}{(5 \text{ ft})^3 \times [(3 \times (0.068949 \text{ kipft/ft})) + (2 \times (-0.046178 \text{ kip/ft}) \times (5 \text{ ft}))]}$ $p = -0.020451 \text{ kip/ft}^2$ s - Earth pressure against the pile at distance L_e, $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.068949 \text{ kipft/ft})) + ((-0.046178 \text{ kip/ft}) \times (5 \text{ ft}))]}{(5 \text{ ft})^2}$ $s = -0.022318 \text{ kip/ft}^2$ Check lateral soil pressure capacity: p_a - Allowable lateral soil pressure at depth $a/2$, $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(3.6211 \text{ ft})}{2}$ $p_a = 0.27158 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{p}{p_a}$ $\text{Ratio} = \frac{(-0.020451 \text{ kip/ft}^2)}{(0.27158 \text{ kip/ft}^2)}$ $\text{Ratio} = -0.075302$ p_s - Allowable lateral soil pressure at depth L_e, $p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (5 \text{ ft})$ $p_s = 0.75 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{s}{p_s}$	Status: PASS Ratio: -0.080

$$Ratio = \frac{(-0.022318 \text{ kip/ft}^2)}{(0.75 \text{ kip/ft}^2)}$$

$$Ratio = -0.029758$$

Status: **PASS**
Ratio: **-0.030**



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-2.899 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.46162 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(23.618 \text{ kipft}) + ((-2.899 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 3.7608 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(3.7608 \text{ kipft/ft})}{(-0.46162 \text{ kip/ft})}$$

$$E = 8.1469 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (3.7608 \text{ kipft/ft}) \times (5 \text{ ft})) + (3 \times (-0.46162 \text{ kip/ft}) \times (5 \text{ ft})^2)}{(6 \times (3.7608 \text{ kipft/ft})) + (4 \times (-0.46162 \text{ kip/ft}) \times (5 \text{ ft}))}$$

$$a = 3.4543 \text{ ft}$$

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

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

$$V_{max} = ((-0.46162 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (8.1469 \text{ ft})}{(5 \text{ ft})} + 3 \right) \times \left(\frac{(3.4543 \text{ ft})}{(5 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (8.1469 \text{ ft})}{(5 \text{ ft})} + 2 \right) \times \left(\frac{(3.4543 \text{ ft})}{(5 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 6.5415 \text{ kip}$$

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

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

$$M_{max} = ((-0.46162 \text{ kip/ft}) \times (48 \text{ in}) \times (5 \text{ ft})) \times \left[\left(\frac{(8.1469 \text{ ft})}{(5 \text{ ft})} + \frac{(3.4543 \text{ ft})}{2 \times (5 \text{ ft})} \right) - \left[\left(\frac{4 \times (8.1469 \text{ ft})}{(5 \text{ ft})} + 3 \right) \times \left(\frac{(3.4543 \text{ ft})}{2 \times (5 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (8.1469 \text{ ft})}{(5 \text{ ft})} + 2 \right) \times \left(\frac{(3.4543 \text{ ft})}{2 \times (5 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 15.516 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.483 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.076911 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.723 \text{ kipft}) + ((-0.483 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.11513 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.11513 \text{ kipft/ft})}{(-0.076911 \text{ kip/ft})}$$

$$E = 1.4969 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.11513 \text{ kipft/ft}) \times (5 \text{ ft})) + (3 \times (-0.076911 \text{ kip/ft}) \times (5 \text{ ft})^2)}{(6 \times (0.11513 \text{ kipft/ft})) + (4 \times (-0.076911 \text{ kip/ft}) \times (5 \text{ ft}))}$$

$$a = 3.6209 \text{ ft}$$

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

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

$$V_{max} = ((-0.076911 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (1.4969 \text{ ft})}{(5 \text{ ft})} + 3 \right) \times \left(\frac{(3.6209 \text{ ft})}{(5 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (1.4969 \text{ ft})}{(5 \text{ ft})} + 2 \right) \times \left(\frac{(3.6209 \text{ ft})}{(5 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.36957 \text{ kip}$$

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

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

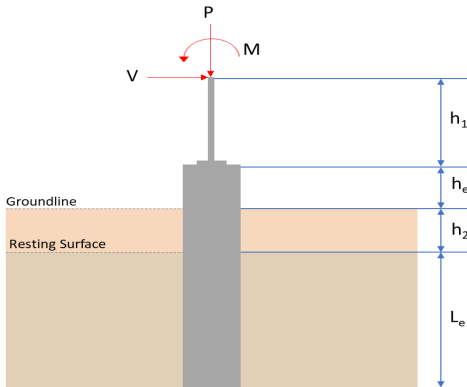
$$M_{max} = ((-0.076911 \text{ kip/ft}) \times (48 \text{ in}) \times (5 \text{ ft})) \times \left[\left(\frac{(1.4969 \text{ ft})}{(5 \text{ ft})} + \frac{(3.6209 \text{ ft})}{2 \times (5 \text{ ft})} \right) - \left[\left(\frac{4 \times (1.4969 \text{ ft})}{(5 \text{ ft})} + 3 \right) \times \left(\frac{(3.6209 \text{ ft})}{2 \times (5 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (1.4969 \text{ ft})}{(5 \text{ ft})} + 2 \right) \times \left(\frac{(3.6209 \text{ ft})}{2 \times (5 \text{ ft})} \right)^4 \right] \right]$$

		$M_{max} = 0.78759 \text{ kipft}$	
		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, $A_{st,required}$ $A_{st,required}$ $A_{st,required} = \text{Min} \left[\frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = \text{Min} \left[\frac{\frac{(14.061 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -84.129 \text{ in}^2$ A_{min} - Governing minimum reinforcement area, $A_{min} = \text{Max} [A_{st,required}, (0.0018 A_g)]$ $A_{min} = \text{Max} [(-84.129 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ 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	
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 $\text{Ratio} = \frac{P}{\phi P_N}$ $\text{Ratio} = \frac{(14.061 \text{ kip})}{(2675.2 \text{ kip})}$ $\text{Ratio} = 0.0052561$	Status: PASS Ratio: 0.010
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 $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 14.061 \text{ kip} \rightarrow 14061 \text{ lbf}$, $V_{c,a}$ - Shear strength of concrete (a) $V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(14061 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 120.36 \text{ kip}$	
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 $V_c = MIN [V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = MIN [(296.21 \text{ kip}), (120.36 \text{ kip}), (348.89 \text{ kip})]$ $V_c = 120.36 \text{ kip}$	

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 $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((120.36 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 111.32 \text{ kip}$ Considering x-direction: $V_{max} = 6.5415 \text{ kip}$ - Maximum shear force in the x-direction, $Ratio$ - Capacity $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(6.5415 \text{ kip})}{(111.32 \text{ kip})}$ $Ratio = 0.058766$ Considering z-direction: $V_{max} = 0.36957 \text{ kip}$ - Maximum shear force in the z-direction, $Ratio$ - Capacity $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.36957 \text{ kip})}{(111.32 \text{ kip})}$ $Ratio = 0.0033201$	Status: PASS Ratio: 0.060 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: $\phi M_{n,1}$ $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{2.5 \text{ ksi}} \times 18432.001 \text{ in}^3$ $\phi M_{n,1} = 249.600 \text{ kipft}$ $\phi M_{n,2}$ $\phi M_{n,2} = \phi \times 0.85 \times f'_{ck} \times S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (18432 \text{ in}^3)$ $\phi M_{n,2} = 2121.6 \text{ kipft}$ 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: $M_{max} = 15.516 \text{ kipft}$ - Maximum moment in the x-direction, Ratio - Capacity $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(15.516 \text{ kipft})}{(249.6 \text{ kipft})}$ $\text{Ratio} = 0.062164$	Status: PASS Ratio: 0.060
	Considering z-direction: $M_{max} = 0.78759 \text{ kipft}$ - Maximum moment in the z-direction, Ratio - Capacity $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(0.78759 \text{ kipft})}{(249.6 \text{ kipft})}$ $\text{Ratio} = 0.0031554$	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 = 5 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><tr><th>Layer</th><th>Label</th><th>Allowable Bearing Pressure (qa) (psf)</th><th>Allowable Lateral Pressure (R) (psf/ft)</th></tr><tr><td>1</td><td>Sand, silty sand, clayey sand, silty gravel & clayey gravel</td><td>2000.000</td><td>150.000</td></tr></table> Tabulation of Loads <table><tr><th>Load Component</th><th>ASD</th><th>LRFD</th></tr><tr><td>P (kip)</td><td>8.375</td><td>14.061</td></tr><tr><td>Vx (kip)</td><td>-1.739</td><td>-2.899</td></tr><tr><td>Vz (kip)</td><td>0.290</td><td>0.483</td></tr><tr><td>Mx (kipft)</td><td>0.433</td><td>0.724</td></tr><tr><td>Mz (kipft)</td><td>13.970</td><td>23.619</td></tr></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)	8.375	14.061	Vx (kip)	-1.739	-2.899	Vz (kip)	0.290	0.483	Mx (kipft)	0.433	0.724	Mz (kipft)	13.970	23.619	
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Mx (kipft)	0.433	0.724																										
Mz (kipft)	13.970	23.619																										
	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, $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-1.739 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.27691 \text{ kip/ft}$ Mo - Moment per length of pile, $M_o = \frac{M_z + (V_x H)}{1.57 D}$																											

	$M_o = \frac{(13.97 \text{ kipft}) + ((-1.739 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 2.2245 \text{ kipft/ft}$ 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: $L_{e,x} = 4.652 \text{ ft}$ - Required depth in x-direction, Considering z-direction: H_o - Lateral force per length of pile, $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(0.29 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = 0.046178 \text{ kip/ft}$ M_o - Moment per length of pile, $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(0.433 \text{ kipft}) + ((0.29 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.068949 \text{ kipft/ft}$ 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: $L_{e,z} = 2.2785 \text{ ft}$ - Required depth in z-direction, Minimum embedded depth required: $L_{e,req}$ - Depth of pile required, $L_{e,req} = \text{MAX}[L_{e,x}, L_{e,z}]$ $L_{e,req} = \text{MAX}[(4.652 \text{ ft}), (2.2785 \text{ ft})]$ $L_{e,req} = 4.652 \text{ ft}$ L_e - Actual embedded length of pile, $L_e = L - h_e - h_2$ $L_e = (5 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 5 \text{ ft}$ Ratio - Embedded depth $\text{Ratio} = \frac{L_{e,req}}{L_e}$ $\text{Ratio} = \frac{(4.652 \text{ ft})}{(5 \text{ ft})}$ $\text{Ratio} = 0.9304$	Status: PASS Ratio: 0.930
	End-bearing Capacity (ASD) A - Pile cross-section area $A = b D$ $A = (48 \text{ in}) \times (48 \text{ in})$ $A = 16 \text{ ft}^2$ q - End-bearing pressure $q = \frac{P_o}{A}$ $q = \frac{(8.375 \text{ kip})}{(16 \text{ ft}^2)}$ $q = 0.52344 \text{ kip/ft}^2$	

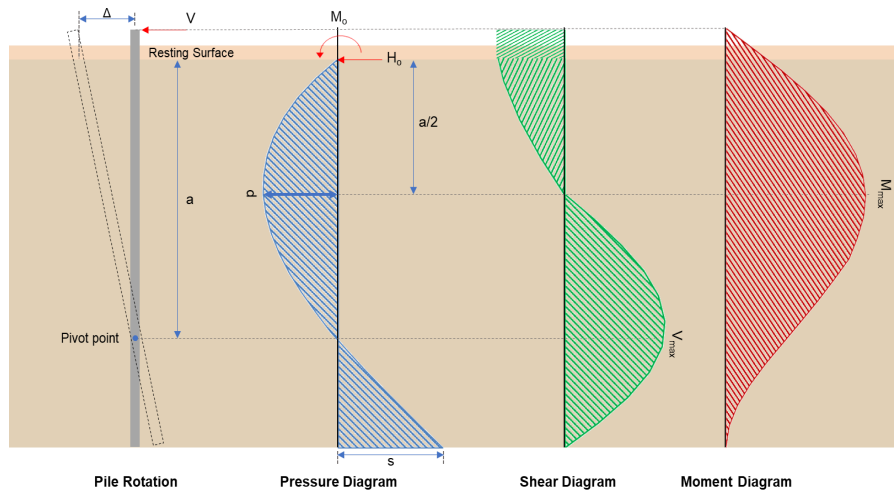
	$q = 0.52344 \text{ kip/ft}^2$	
	Check bearing capacity ratio: Ratio - Capacity $Ratio = \frac{q}{q_a}$ $Ratio = \frac{(0.52344 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $Ratio = 0.26172$	Status: PASS Ratio: 0.260
Czerniak	Lateral Soil Pressure (ASD): L/D - Length to least lateral dimension ratio, $L/D = \frac{L}{D}$ $L/D = \frac{(5 \text{ ft})}{(48 \text{ in})}$ $L/D = 1.25$ Since $L/D \leq 10$, Pile is short. Considering x-direction: $H_o = -0.27691 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 2.2245 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point, $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (2.2245 \text{ kipft/ft}) \times (5 \text{ ft})) + (3 \times (-0.27691 \text{ kip/ft}) \times (5 \text{ ft})^2)}{(6 \times (2.2245 \text{ kipft/ft})) + (4 \times (-0.27691 \text{ kip/ft}) \times (5 \text{ ft}))}$ $a = 3.4555 \text{ ft}$ p - Earth pressure against the pile at distance $a/2$ from resting surface, $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^3 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 [(4 \times (2.2245 \text{ kipft/ft})) + (3 \times (-0.27691 \text{ kip/ft}) \times (5 \text{ ft}))]^2}{(5 \text{ ft})^3 [(3 \times (2.2245 \text{ kipft/ft})) + (2 \times (-0.27691 \text{ kip/ft}) \times (5 \text{ ft}))]}$ $p = 0.17295 \text{ kip/ft}^2$ s - Earth pressure against the pile at distance L_e, $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (2.2245 \text{ kipft/ft})) + ((-0.27691 \text{ kip/ft}) \times (5 \text{ ft}))]}{(5 \text{ ft})^2}$ $s = 0.73548 \text{ kip/ft}^2$ Check lateral soil pressure capacity: p_a - Allowable lateral soil pressure at depth $a/2$, $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(3.4555 \text{ ft})}{2}$ $p_a = 0.25916 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.17295 \text{ kip/ft}^2)}{(0.25916 \text{ kip/ft}^2)}$ $Ratio = 0.66735$ p_s - Allowable lateral soil pressure at depth L_e,	Status: PASS Ratio: 0.670

	$p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (5 \text{ ft})$ $p_s = 0.75 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{s}{p_s}$ $\text{Ratio} = \frac{(0.73548 \text{ kip/ft}^2)}{(0.75 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.98064$	Status: PASS Ratio: 0.980
	Considering z-direction: $H_o = 0.046178 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 0.068949 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point, $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.068949 \text{ kipft/ft}) \times (5 \text{ ft})) + (3 \times (0.046178 \text{ kip/ft}) \times (5 \text{ ft})^2)}{(6 \times (0.068949 \text{ kipft/ft})) + (4 \times (0.046178 \text{ kip/ft}) \times (5 \text{ ft}))}$ $a = 3.6211 \text{ ft}$ p - Earth pressure against the pile at distance $a/2$ from resting surface, $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^3 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.068949 \text{ kipft/ft})) + (3 \times (0.046178 \text{ kip/ft}) \times (5 \text{ ft}))]^2}{(5 \text{ ft})^3 \times [(3 \times (0.068949 \text{ kipft/ft})) + (2 \times (0.046178 \text{ kip/ft}) \times (5 \text{ ft}))]}$ $p = 0.042083 \text{ kip/ft}^2$ s - Earth pressure against the pile at distance L_e, $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.068949 \text{ kipft/ft})) + ((0.046178 \text{ kip/ft}) \times (5 \text{ ft}))]}{(5 \text{ ft})^2}$ $s = 0.08851 \text{ kip/ft}^2$ Check lateral soil pressure capacity: p_a - Allowable lateral soil pressure at depth $a/2$, $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(3.6211 \text{ ft})}{2}$ $p_a = 0.27158 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{p}{p_a}$ $\text{Ratio} = \frac{(0.042083 \text{ kip/ft}^2)}{(0.27158 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.15496$ p_s - Allowable lateral soil pressure at depth L_e, $p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (5 \text{ ft})$ $p_s = 0.75 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{s}{p_s}$	Status: PASS Ratio: 0.150

$$Ratio = \frac{(0.08851 \text{ kip/ft}^2)}{(0.75 \text{ kip/ft}^2)}$$

$$Ratio = 0.11801$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-2.899 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.46162 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(23.619 \text{ kipft}) + ((-2.899 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 3.761 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(3.761 \text{ kipft/ft})}{(-0.46162 \text{ kip/ft})}$$

$$E = 8.1473 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (3.761 \text{ kipft/ft}) \times (5 \text{ ft})) + (3 \times (-0.46162 \text{ kip/ft}) \times (5 \text{ ft})^2)}{(6 \times (3.761 \text{ kipft/ft})) + (4 \times (-0.46162 \text{ kip/ft}) \times (5 \text{ ft}))}$$

$$a = 3.4543 \text{ ft}$$

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

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

$$V_{max} = ((-0.46162 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (8.1473 \text{ ft})}{(5 \text{ ft})} + 3 \right) \times \left(\frac{(3.4543 \text{ ft})}{(5 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (8.1473 \text{ ft})}{(5 \text{ ft})} + 2 \right) \times \left(\frac{(3.4543 \text{ ft})}{(5 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 6.5417 \text{ kip}$$

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

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

$$M_{max} = ((-0.46162 \text{ kip/ft}) \times (48 \text{ in}) \times (5 \text{ ft})) \times \left[\left(\frac{(8.1473 \text{ ft})}{(5 \text{ ft})} + \frac{(3.4543 \text{ ft})}{2 \times (5 \text{ ft})} \right) - \left[\left(\frac{4 \times (8.1473 \text{ ft})}{(5 \text{ ft})} + 3 \right) \times \left(\frac{(3.4543 \text{ ft})}{2 \times (5 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (8.1473 \text{ ft})}{(5 \text{ ft})} + 2 \right) \times \left(\frac{(3.4543 \text{ ft})}{2 \times (5 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 15.517 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.483 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.076911 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.724 \text{ kipft}) + ((0.483 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.11529 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.11529 \text{ kipft/ft})}{(0.076911 \text{ kip/ft})}$$

$$E = 1.499 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.11529 \text{ kipft/ft}) \times (5 \text{ ft})) + (3 \times (0.076911 \text{ kip/ft}) \times (5 \text{ ft})^2)}{(6 \times (0.11529 \text{ kipft/ft})) + (4 \times (0.076911 \text{ kip/ft}) \times (5 \text{ ft}))}$$

$$a = 3.6208 \text{ ft}$$

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

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

$$V_{max} = ((0.076911 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (1.499 \text{ ft})}{(5 \text{ ft})} + 3 \right) \times \left(\frac{(3.6208 \text{ ft})}{(5 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (1.499 \text{ ft})}{(5 \text{ ft})} + 2 \right) \times \left(\frac{(3.6208 \text{ ft})}{(5 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.36979 \text{ kip}$$

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

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

$$M_{max} = ((0.076911 \text{ kip/ft}) \times (48 \text{ in}) \times (5 \text{ ft})) \times \left[\left(\frac{(1.499 \text{ ft})}{(5 \text{ ft})} + \frac{(3.6208 \text{ ft})}{2 \times (5 \text{ ft})} \right) - \left[\left(\frac{4 \times (1.499 \text{ ft})}{(5 \text{ ft})} + 3 \right) \times \left(\frac{(3.6208 \text{ ft})}{2 \times (5 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (1.499 \text{ ft})}{(5 \text{ ft})} + 2 \right) \times \left(\frac{(3.6208 \text{ ft})}{2 \times (5 \text{ ft})} \right)^4 \right] \right]$$

		$M_{max} = 0.78814 \text{ kipft}$	
		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, $A_{st,required}$ $A_{st,required}$ $A_{st,required} = \text{Min} \left[\frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = \text{Min} \left[\frac{\frac{(14.061 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -84.129 \text{ in}^2$ A_{min} - Governing minimum reinforcement area, $A_{min} = \text{Max} [A_{st,required}, (0.0018 A_g)]$ $A_{min} = \text{Max} [(-84.129 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ 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 $\leq$ No. 10ø: 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	
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 $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(14.061 \text{ kip})}{(2675.2 \text{ kip})}$ $Ratio = 0.0052561$	Status: PASS Ratio: 0.010
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 $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 14.061 \text{ kip} \rightarrow 14061 \text{ lbf}$, $V_{c,a}$ - Shear strength of concrete (a) $V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(14061 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 120.36 \text{ kip}$	
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 $V_c = Min [V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = Min [(296.21 \text{ kip}), (120.36 \text{ kip}), (348.89 \text{ kip})]$ $V_c = 120.36 \text{ kip}$	

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 $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((120.36 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 111.32 \text{ kip}$ Considering x-direction: $V_{max} = 6.5417 \text{ kip}$ - Maximum shear force in the x-direction, <i>Ratio</i> - Capacity $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(6.5417 \text{ kip})}{(111.32 \text{ kip})}$ $Ratio = 0.058768$ Considering z-direction: $V_{max} = 0.36979 \text{ kip}$ - Maximum shear force in the z-direction, <i>Ratio</i> - Capacity $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.36979 \text{ kip})}{(111.32 \text{ kip})}$ $Ratio = 0.003322$	Status: PASS Ratio: 0.060 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: $M_{max} = 15.517 \text{ kipft}$ - Maximum moment in the x-direction, Ratio - Capacity $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(15.517 \text{ kipft})}{(249.6 \text{ kipft})}$ $\text{Ratio} = 0.062166$	Status: PASS Ratio: 0.060
	Considering z-direction: $M_{max} = 0.78814 \text{ kipft}$ - Maximum moment in the z-direction, Ratio - Capacity $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(0.78814 \text{ kipft})}{(249.6 \text{ kipft})}$ $\text{Ratio} = 0.0031576$	Status: PASS Ratio: 0.000