

Your Project Calculations



Project Name: MTSOLAR_Pat_Nelson

S3D Model Link:

https://platform.skyciv.com/structural?preload_name=MTSOLAR_Pat_Nelson&preload_path=Shared%20Enterprise%20Folder/MT_Solar_Projects/9_2023

Public Model Link:

https://platform.skyciv.com/structural-viewer?project_id=5iRSk6aGFs0stOf1dShDr6PzVpxKEF0J6adTUXXFJNYXuhdoh23uIGtBhLeckMsW

Array Specification

Product:	Beam
Unique ID:	3P-19.75-8TOP-HD-57-L-5Hx10W-B3E5
Duty Classification:	HD
Module Width:	44.66 in
Module Length:	67.80in
Number of Rows:	5
Number of Columns:	10
Total Number of Modules:	50
Desired Tilt Angle:	45
Front Edge Clearance:	5
Total Array Height at Tilt:	18.23 ft
Total Frame Length:	56.50 ft
Frame Weight:	4340 lbs
Array Dimensions N/S:	18.82 ft
Array Dimensions E/W:	57.33 ft
Rail Length:	225.80 in
Rail Spacing:	2.82 ft
Rail Check:	Not Checked

Support Specifications

Pole Size:	8in Pipe Sch 80
Pole Length above Grade:	11.65 ft
Number of Poles:	3
Pole Spacing:	19.75 ft

Foundation Specifications

Foundation Type:	Square
Foundation Dimensions:	48 x 48 in
Foundation Depth (below grade):	Pile 1: 7.50 ft Pile 2: 7.50 ft Pile 3: 7.50 ft
Foundation Volume:	13.333 y ³
Foundation Result:	PASSED
Mount Twist:	0.254537 kip

Site Info

Risk Category:	I
Exposure:	B
Soil Classification:	sand
Site Location:	Ogdensburg, NY 13669, USA
Wind Speed:	100 mph
Snow Load:	60 psf
Design Uplift Pressure:	Multiple pressures
Design Downforce Pressure:	Multiple pressures
Design Snow Pressure:	0.016495 ksf



Design Disclaimer

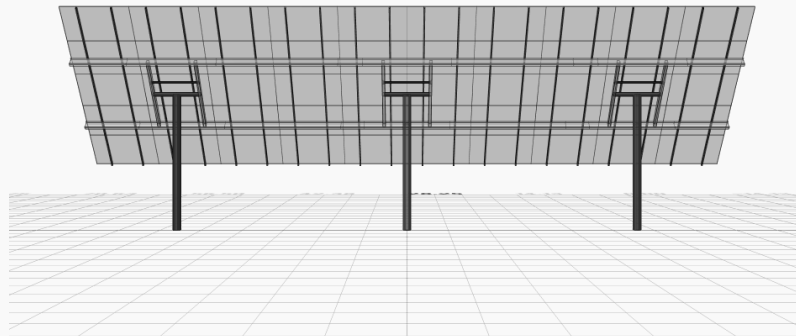
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

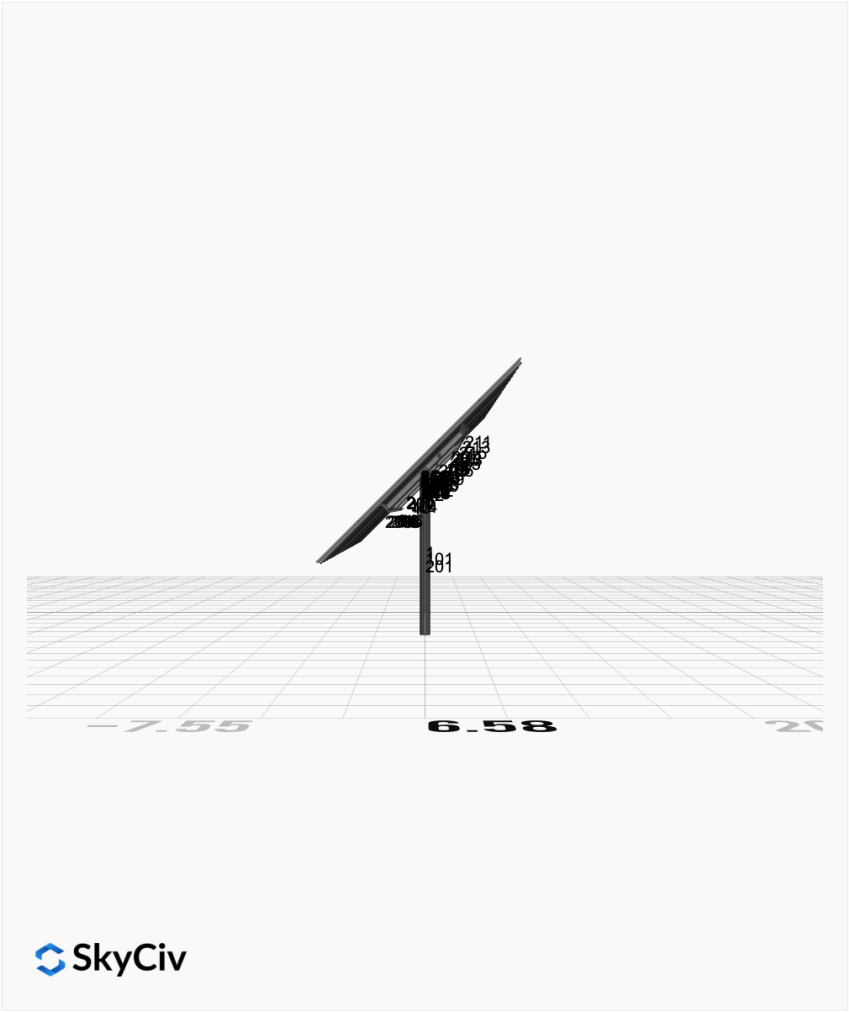
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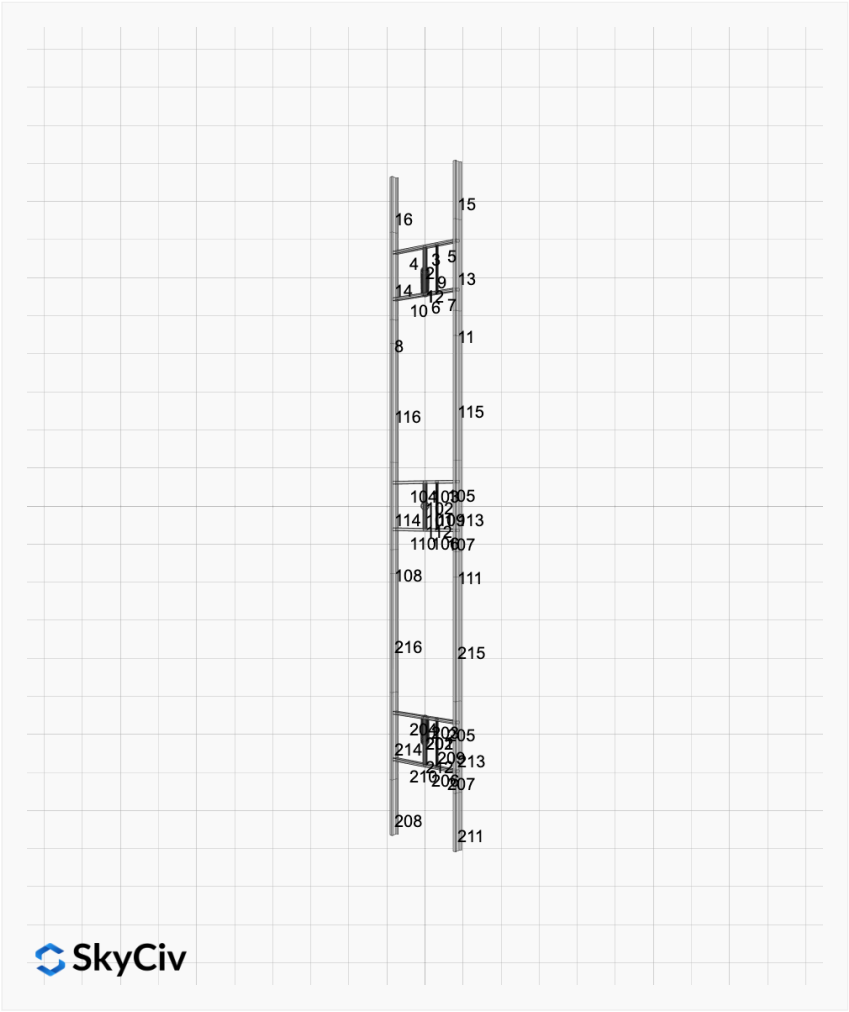
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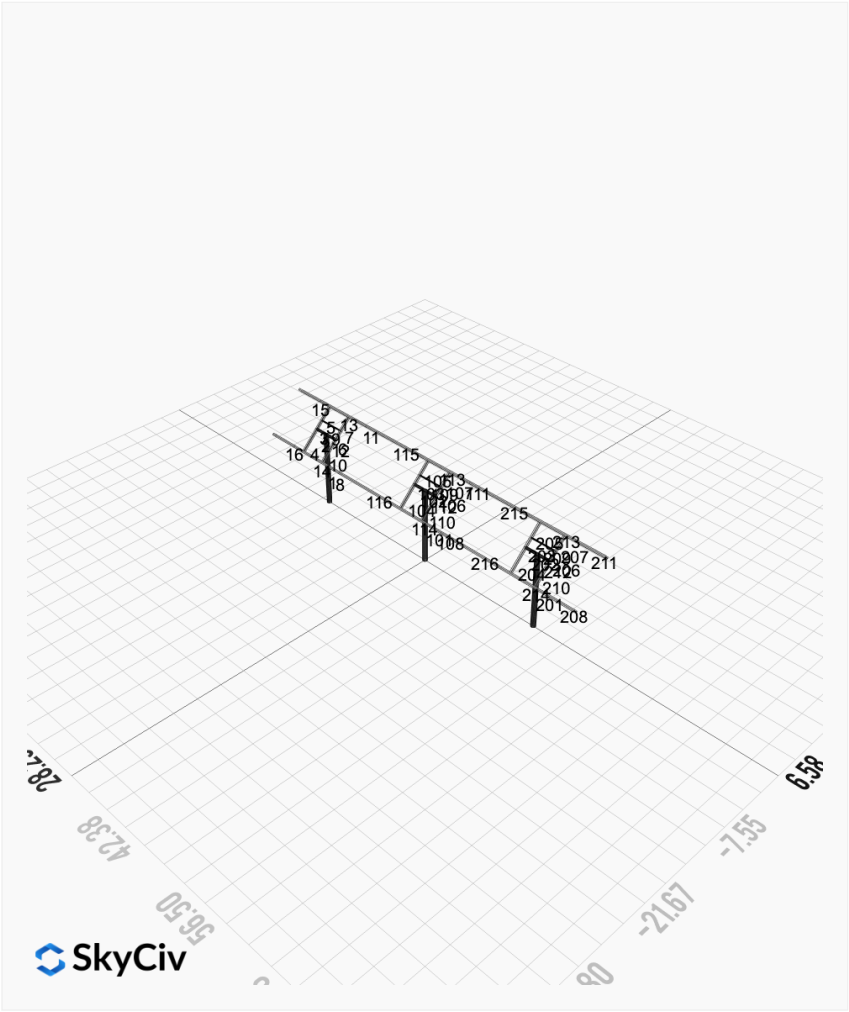
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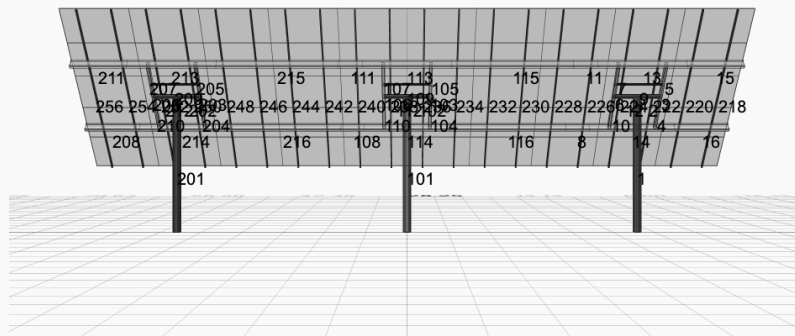
- AISC Deflection checks are set to L/1 due to structure design intent
- Foundation Design and Sizing is approximate only



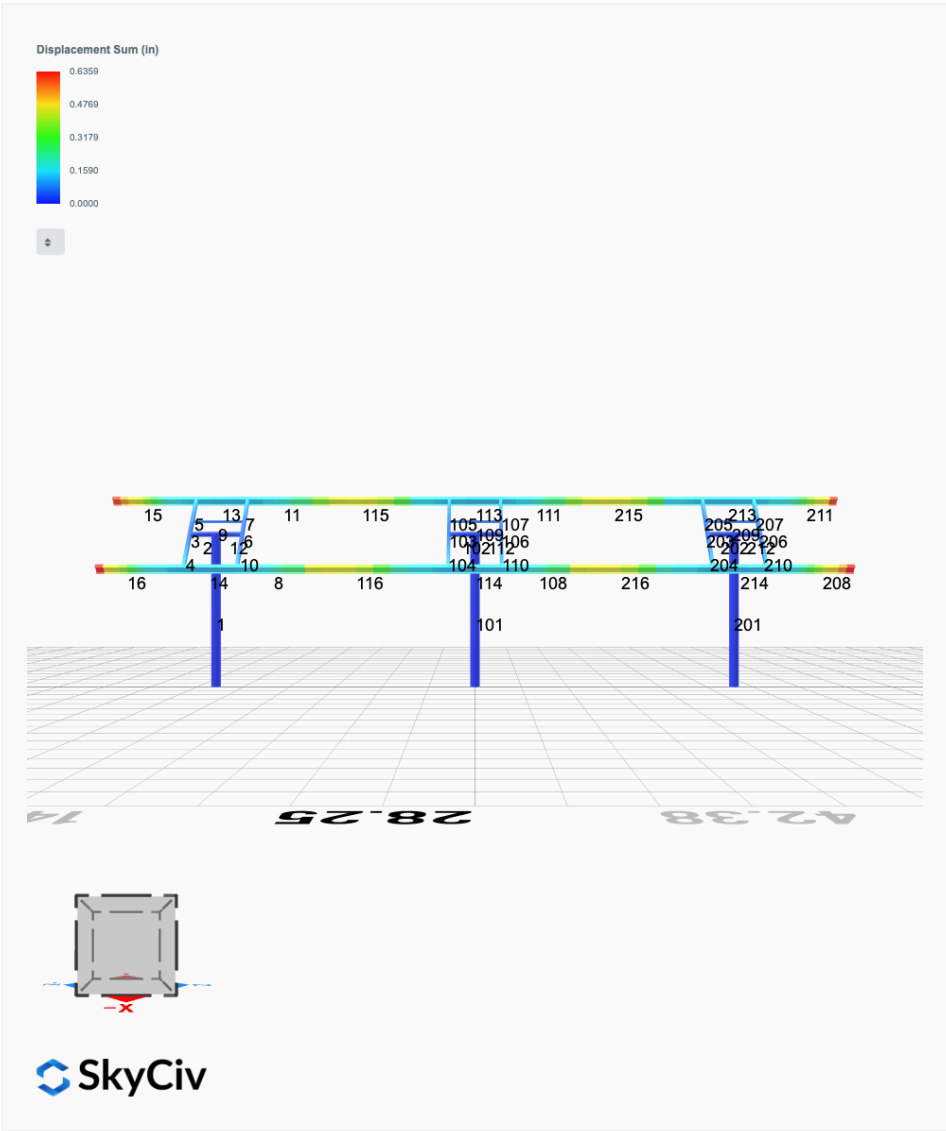




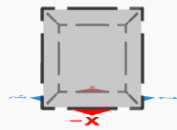
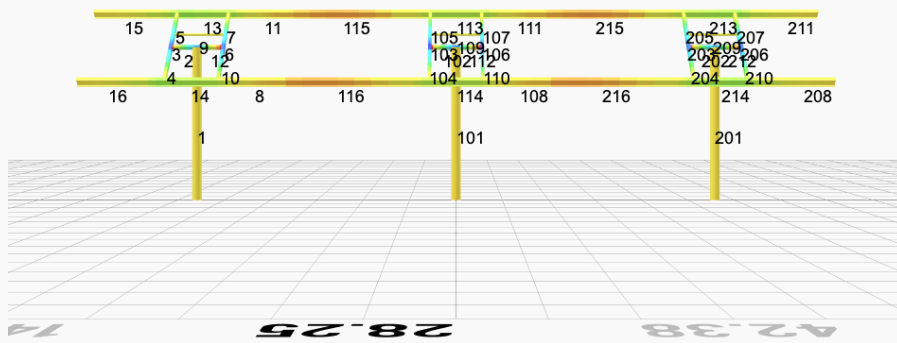




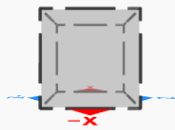
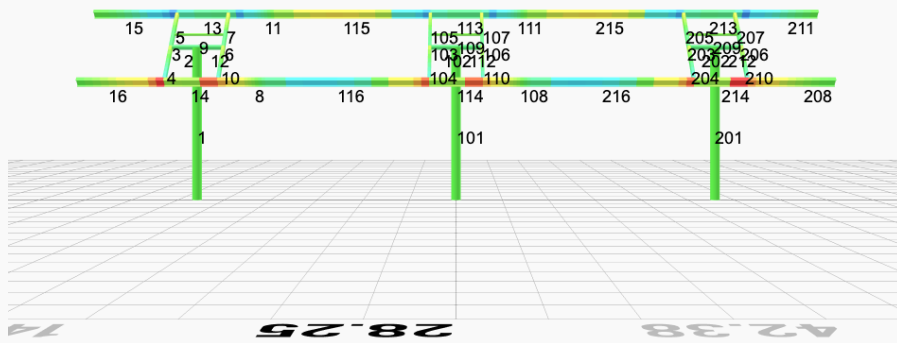
FEM Results (Envelope Worst Case for each member)



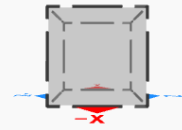
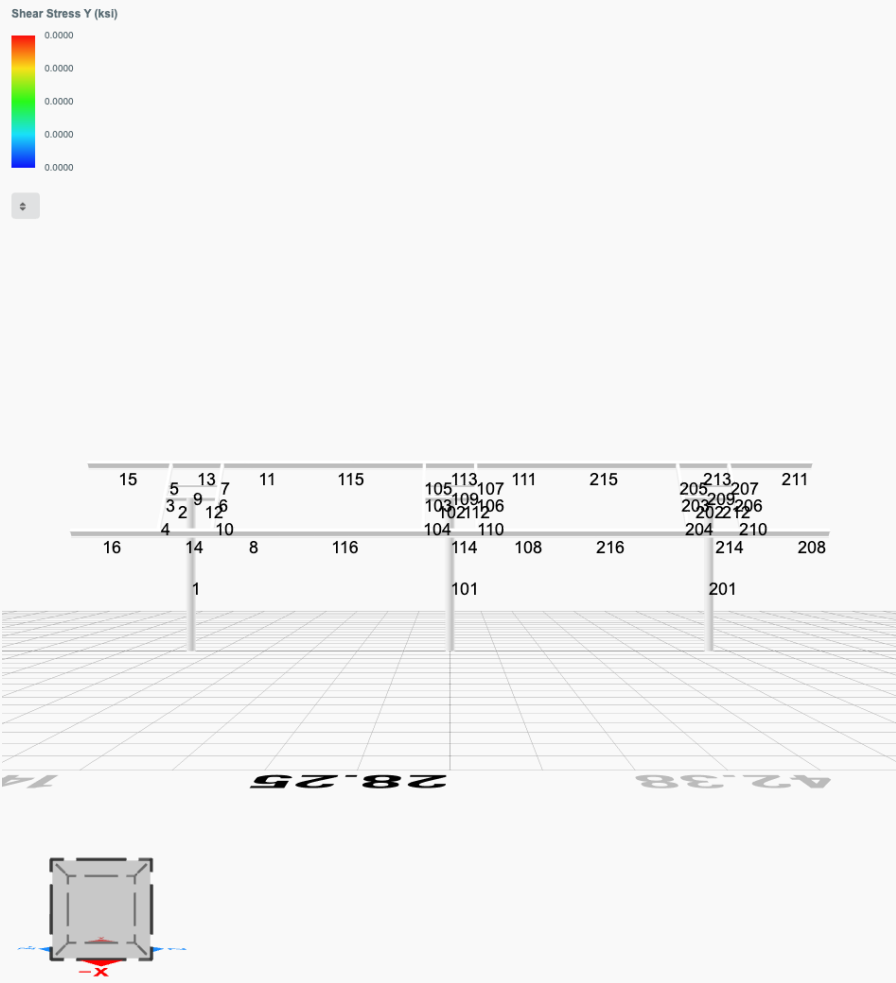
Top Bending Stress Z (ksi)

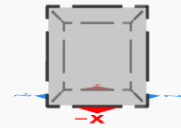
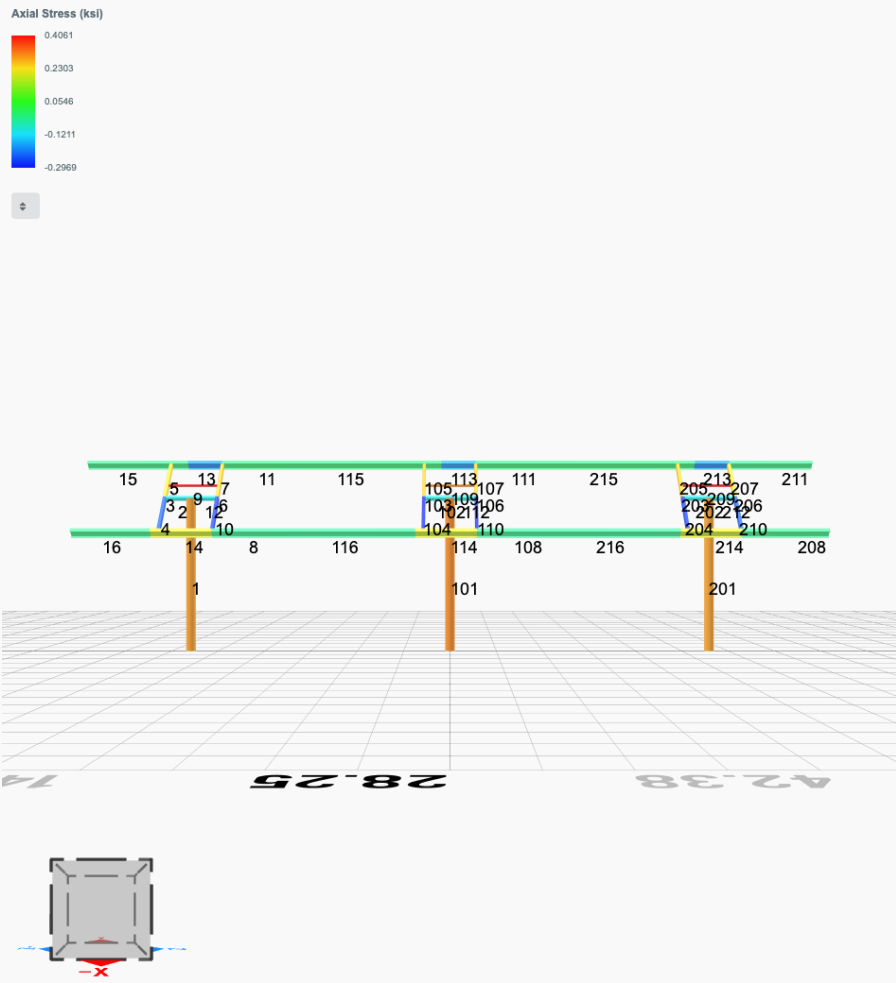


Top Bending Stress Y (ksi)



 SkyCiv





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

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	-0.0058	2.6929	0.0002	0.0046	0.0547	0.0863
ULS: 2. D + L	-0.0058	2.6929	0.0002	0.0046	0.0547	0.0863
ULS: 3. D + (S or Lr or R)	-0.0176	6.7385	0.0008	0.0152	0.1658	0.2348
ULS: 3. D + (S or Lr or R)	-0.0058	2.6929	0.0002	0.0046	0.0547	0.0863
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0146	5.7271	0.0006	0.0126	0.1380	0.1977
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0058	2.6929	0.0002	0.0046	0.0547	0.0863
ULS: 5b. D + 0.7E	-0.0058	2.6929	0.0002	0.0046	0.0547	0.0863
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0146	5.7271	0.0006	0.0126	0.1380	0.1977
ULS: 8. 0.6D + 0.7E	-0.0035	1.6158	0.0001	0.0028	0.0328	0.0518
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.7295	6.4090	-0.0010	0.0003	0.0522	45.3834
ULS: 5a. D + 0.6W_Wind downforce Case B only	-3.7295	6.4090	-0.0010	0.0003	0.0522	45.3834
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.6865	0.0056	0.0020	0.0108	0.0510	-30.1910
ULS: 5a. D + 0.6W_Wind uplift Case B only	2.3735	0.3196	-0.0008	0.0022	0.0657	-34.0639
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.8074	8.5142	-0.0003	0.0093	0.1362	34.1705
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.8074	8.5142	-0.0003	0.0093	0.1362	34.1705
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.0046	3.7116	0.0020	0.0172	0.1352	-22.5103
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.7698	3.9471	-0.0001	0.0107	0.1463	-25.4150
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.7986	5.4800	-0.0007	0.0014	0.0529	34.0591
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.7986	5.4800	-0.0007	0.0014	0.0529	34.0591
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.0134	0.6774	0.0016	0.0093	0.0519	-22.6217
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.7786	0.9129	-0.0005	0.0028	0.0630	-25.5264
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.7272	5.3318	-0.0011	-0.0016	0.0304	45.3489
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-3.7272	5.3318	-0.0011	-0.0016	0.0304	45.3489
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.6888	-1.0716	0.0020	0.0090	0.0291	-30.2255
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	2.3758	-0.7576	-0.0009	0.0003	0.0439	-34.0985

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	12.8015
Shear X	-6.2198
Shear Z	0.0034
Moment X	0.0272
Moment Y (Twist)	0.2548
Moment Z	76.6575

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	8.5142
Shear X	-3.7295
Shear Z	0.0020
Moment X	0.0172
Moment Y (Twist)	0.1658
Moment Z	45.3834

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	0.0116	2.8211	-0.0000	0.0000	0.0000	-0.1008
ULS: 2. D + L	0.0116	2.8211	-0.0000	0.0000	0.0000	-0.1008
ULS: 3. D + (S or Lr or R)	0.0351	7.1298	0.0000	0.0000	0.0000	-0.3315
ULS: 3. D + (S or Lr or R)	0.0116	2.8211	-0.0000	0.0000	0.0000	-0.1008
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0293	6.0526	0.0000	0.0000	0.0000	-0.2739
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0116	2.8211	-0.0000	0.0000	0.0000	-0.1008
ULS: 5b. D + 0.7E	0.0116	2.8211	-0.0000	0.0000	0.0000	-0.1008

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0293	6.0526	0.0000	0.0000	0.0000	-0.2739
ULS: 8. 0.6D + 0.7E	0.0070	1.6927	-0.0000	0.0000	0.0000	-0.0605
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.8519	6.6999	-0.0000	0.0000	0.0000	46.8039
ULS: 5a. D + 0.6W_Wind downforce Case B only	-3.8519	6.6999	-0.0000	0.0000	0.0000	46.8039
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.8094	0.0135	-0.0000	0.0000	0.0000	-31.4653
ULS: 5a. D + 0.6W_Wind uplift Case B only	2.4728	0.3482	-0.0000	0.0000	0.0000	-35.3809
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.8684	8.9617	0.0000	0.0000	0.0000	34.9047
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.8684	8.9617	0.0000	0.0000	0.0000	34.9047
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.1276	3.9469	0.0000	0.0000	0.0000	-23.7972
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.8751	4.1979	0.0000	0.0000	0.0000	-26.7340
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.8860	5.7302	-0.0000	0.0000	0.0000	35.0777
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.8860	5.7302	-0.0000	0.0000	0.0000	35.0777
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.1099	0.7154	-0.0000	0.0000	0.0000	-23.6241
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.8575	0.9664	-0.0000	0.0000	0.0000	-26.5609
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.8565	5.5714	-0.0000	0.0000	0.0000	46.8442
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-3.8565	5.5714	-0.0000	0.0000	0.0000	46.8442
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.8047	-1.1150	-0.0000	0.0000	0.0000	-31.4249
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	2.4681	-0.7803	-0.0000	0.0000	0.0000	-35.3406

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	13.5108
Shear X	-6.4392
Shear Z	-0.0000
Moment X	0.0002
Moment Y (Twist)	0.0002
Moment Z	78.9713

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	8.9617
Shear X	-3.8565
Shear Z	0.0000
Moment X	0.0000
Moment Y (Twist)	0.0000
Moment Z	46.8442

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

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	-0.0058	2.6929	-0.0002	-0.0046	-0.0547	0.0863
ULS: 2. D + L	-0.0058	2.6929	-0.0002	-0.0046	-0.0547	0.0863
ULS: 3. D + (S or Lr or R)	-0.0176	6.7385	-0.0008	-0.0152	-0.1658	0.2348
ULS: 3. D + (S or Lr or R)	-0.0058	2.6929	-0.0002	-0.0046	-0.0547	0.0863
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0146	5.7271	-0.0006	-0.0126	-0.1380	0.1977
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0058	2.6929	-0.0002	-0.0046	-0.0547	0.0863
ULS: 5b. D + 0.7E	-0.0058	2.6929	-0.0002	-0.0046	-0.0547	0.0863
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0146	5.7271	-0.0006	-0.0126	-0.1380	0.1977
ULS: 8. 0.6D + 0.7E	-0.0035	1.6158	-0.0001	-0.0028	-0.0328	0.0518
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.7295	6.4090	0.0010	-0.0003	-0.0522	45.3834
ULS: 5a. D + 0.6W_Wind downforce Case B only	-3.7295	6.4090	0.0010	-0.0003	-0.0522	45.3834
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.6865	0.0056	-0.0020	-0.0108	-0.0510	-30.1910
ULS: 5a. D + 0.6W_Wind uplift Case B only	2.3735	0.3196	0.0008	-0.0022	-0.0657	-34.0639
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.8074	8.5142	0.0003	-0.0093	-0.1361	34.1705
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.8074	8.5142	0.0003	-0.0093	-0.1361	34.1705
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.0046	3.7116	-0.0020	-0.0172	-0.1352	-22.5103
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.7698	3.9471	0.0001	-0.0107	-0.1463	-25.4150

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.7986	5.4800	0.0007	-0.0014	-0.0528	34.0591
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.7986	5.4800	0.0007	-0.0014	-0.0528	34.0591
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.0134	0.6774	-0.0016	-0.0093	-0.0519	-22.6217
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.7786	0.9129	0.0005	-0.0028	-0.0630	-25.5264
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.7272	5.3318	0.0011	0.0016	-0.0304	45.3489
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-3.7272	5.3318	0.0011	0.0016	-0.0304	45.3489
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.6888	-1.0716	-0.0020	-0.0090	-0.0291	-30.2255
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	2.3758	-0.7576	0.0009	-0.0003	-0.0439	-34.0984

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	12.8015
Shear X	-6.2198
Shear Z	-0.0034
Moment X	-0.0270
Moment Y (Twist)	0.2545
Moment Z	76.6584

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	8.5142
Shear X	-3.7295
Shear Z	-0.0020
Moment X	-0.0172
Moment Y (Twist)	0.1658
Moment Z	45.3834

Project Details

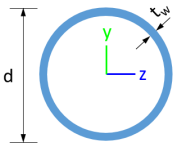
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 Provision: LRFD
 Country: United States
 User Name: sales@mtsolar.us
 Unit System: imperial



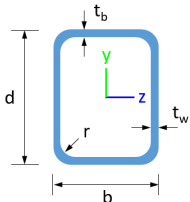
Design Input Information

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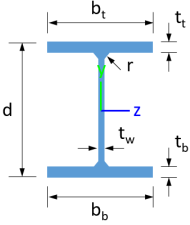
Design Materials			
ID	E (ksi)	F_y (ksi)	F_u (ksi)
1	29000	50	65

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					
10	8in Pipe Sch 80	8.63	0.50					

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

								
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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
10	8in Pipe Sch 80	12.76	211.43	105.72	105.72	0.00	33.05	33.05

16	HSS5x3x3/16	2.58	8.64	3.85	8.53	92.39	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	10	24.47	24.47	11.65	-	300	200	1	
2	5	1.30	1.30	2.00	-	300	200	1	
3	16	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.18,1.18,1.18,1.19,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18	300	200	1	
4	16	2.44	2.44	3.75	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.72,1.67,1.67,1.66,1.64,1.67,1.67,1.68,1.67,1.67,1.67,1.65,1.73,1.67,1.67,1.66,1.65	300	200	1	
5	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66	300	200	1	
6	16	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18	300	200	1	
7	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66	300	200	1	
8	19	1.33	1.33	2.05	2.11,2.12,2.11,2.12,2.12,2.11,2.11,2.11,2.12,2.28,2.11,2.11,2.12,2.08,2.11,2.11,2.12,2.12,2.11,2.11,2.12,2.33,2.11,2.11,2.12,2.09	300	200	1	
9	2	2.60	2.60	4.00	-	300	200	1	
10	16	2.44	2.44	3.75	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.73,1.67,1.67,1.66,1.64,1.67,1.67,1.68,1.67,1.67,1.67,1.65,1.74,1.67,1.67,1.66,1.65	300	200	1	
11	19	1.33	1.33	2.05	2.11,2.11,2.11,2.11,2.11,2.11,2.12,2.12,2.17,2.23,2.12,2.12,2.13,2.19,2.12,2.12,2.11,2.09,2.12,2.12,2.19,2.25,2.12,2.12,2.12,2.18	300	200	1	
12	5	1.30	1.30	2.00	-	300	200	1	
13	19	4.88	4.00	7.50	1.10,1.10,1.10,1.10,1.10,1.10,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.10,1.10,1.10,1.10,1.09,1.09,1.09,1.09,1.09,1.09	300	200	1	
14	19	4.88	4.00	7.50	1.09,1.10,1.09,1.10,1.10,1.09,1.09,1.09,1.09,2.24,1.09,1.09,1.09,1.06,1.09,1.09,1.10,1.10,1.09,1.09,1.09,1.59,1.09,1.09,1.07	300	200	1	
15	19	9.97	9.97	4.75	2.33,2.33	300	200	1	
16	19	9.97	9.97	4.75	2.33,2.33	300	200	1	
101	10	24.47	24.47	11.65	-	300	200	1	
102	5	1.30	1.30	2.00	-	300	200	1	
103	16	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18	300	200	1	
104	16	2.44	2.44	3.75	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.72,1.67,1.67,1.66,1.64,1.67,1.67,1.68,1.67,1.67,1.67,1.65,1.73,1.67,1.67,1.66,1.65	300	200	1	
105	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66	300	200	1	
106	16	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18	300	200	1	
107	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66	300	200	1	

108	19	1.33	1.33	2.0 5	2.07,2.07,2.07,2.07,2.07,2.07,2.06,2.06,2.04,2.26,2.06,2.06,2.06,1.73,2.06,2.06,2.08,2.07,2.0 6,2.06,2.03,2.35,2.06,2.06,2.06,1.85	3 0 0	2 0 0	1
109	2	2.60	2.60	4.0 0	-	3 0 0	2 0 0	1
110	16	2.44	2.44	3.7 5	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.72,1.67,1.67,1.66,1.64,1.67,1.67,1.68,1.67,1.6 7,1.67,1.65,1.73,1.67,1.67,1.66,1.65	3 0 0	2 0 0	1
111	19	1.33	1.33	2.0 5	2.08,2.08,2.08,2.08,2.08,2.08,2.04,2.04,1.66,1.80,2.00,2.00,1.82,1.89,2.06,2.06,2.17,2.30,2.0 5,2.05,1.63,1.78,1.99,1.99,1.86,1.91	3 0 0	2 0 0	1
112	5	1.30	1.30	2.0 0	-	3 0 0	2 0 0	1
113	19	4.88	4.00	7.5 0	1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.05,1.05,1.04,1.04,1.04,1.05,1.04,1.04,1.04,1.03,1.0 4,1.04,1.05,1.05,1.04,1.04,1.04,1.05	3 0 0	2 0 0	1
114	19	4.88	4.00	7.5 0	1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,2.17,1.04,1.04,1.04,1.03,1.04,1.04,1.04,1.04,1.0 4,1.04,1.04,1.57,1.04,1.04,1.04,1.03	3 0 0	2 0 0	1
115	19	6.63	6.63	10. 20	1.15,1.15,1.15,1.15,1.15,1.15,1.14,1.14,1.11,1.12,1.13,1.13,1.12,1.13,1.14,1.14,1.17,1.20,1.1 4,1.14,1.11,1.12,1.13,1.13,1.13,1.13	3 0 0	2 0 0	1
116	19	6.63	6.63	10. 20	1.15,1.15,1.15,1.15,1.15,1.15,1.14,1.14,1.14,1.21,1.14,1.14,1.14,1.12,1.14,1.14,1.15,1.15,1.1 4,1.14,1.14,1.19,1.14,1.14,1.14,1.13	3 0 0	2 0 0	1
201	10	24.4 7	24.4 7	11. 65	-	3 0 0	2 0 0	1
202	5	1.30	1.30	2.0 0	-	3 0 0	2 0 0	1
203	16	0.92	0.92	1.4 2	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.1 8,1.18,1.17,1.17,1.18,1.18,1.18,1.18	3 0 0	2 0 0	1
204	16	2.44	2.44	3.7 5	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.73,1.67,1.67,1.66,1.64,1.67,1.67,1.68,1.67,1.6 7,1.67,1.65,1.74,1.67,1.67,1.66,1.65	3 0 0	2 0 0	1
205	16	1.52	1.52	2.3 3	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.67,1.67,1.6 7,1.67,1.65,1.66,1.67,1.67,1.66,1.66	3 0 0	2 0 0	1
206	16	0.92	0.92	1.4 2	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.18,1.18,1.18,1.19,1.1 8,1.18,1.17,1.17,1.18,1.18,1.18,1.18	3 0 0	2 0 0	1
207	16	1.52	1.52	2.3 3	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.67,1.67,1.6 7,1.67,1.65,1.66,1.67,1.67,1.66,1.66	3 0 0	2 0 0	1
208	19	9.97	9.97	4.7 5	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.3 3,2.33,2.33,2.33,2.33,2.33,2.33,2.33	3 0 0	2 0 0	1
209	2	2.60	2.60	4.0 0	-	3 0 0	2 0 0	1
210	16	2.44	2.44	3.7 5	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.72,1.67,1.67,1.66,1.64,1.67,1.67,1.68,1.67,1.6 7,1.67,1.65,1.73,1.67,1.67,1.66,1.65	3 0 0	2 0 0	1
211	19	9.97	9.97	4.7 5	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.3 3,2.33,2.33,2.33,2.33,2.33,2.33,2.33	3 0 0	2 0 0	1
212	5	1.30	1.30	2.0 0	-	3 0 0	2 0 0	1
213	19	4.88	4.00	7.5 0	1.10,1.10,1.10,1.10,1.10,1.10,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.10,1.10,1.10,1.10,1.0 9,1.09,1.09,1.09,1.09,1.09,1.09,1.09	3 0 0	2 0 0	1
214	19	4.88	4.00	7.5 0	1.09,1.10,1.09,1.10,1.10,1.09,1.09,1.09,1.09,2.23,1.09,1.09,1.09,1.06,1.09,1.09,1.10,1.10,1.0 9,1.09,1.09,1.58,1.09,1.09,1.09,1.07	3 0 0	2 0 0	1
215	19	6.63	6.63	10. 20	1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.17,1.16,1.15,1.1 7,1.17,1.18,1.18,1.17,1.17,1.18,1.18	3 0 0	2 0 0	1
216	19	6.63	6.63	10. 20	1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.21,1.17,1.17,1.17,1.16,1.17,1.17,1.17,1.17,1.1 7,1.17,1.17,1.19,1.17,1.17,1.17,1.16	3 0 0	2 0 0	1

Member Design Capacity

Member ID	$\Phi_t P_n$ (kip)	$\Phi_c P_n$ (kip)	$\Phi_b M_{zn}$ (k-ft)	$\Phi_b M_{yn}$ (k-ft)	$\Phi_v V_{yn}$ (kip)	$\Phi_v V_{zn}$ (kip)
1	574.32	268.28	123.94	123.94	172.30	172.30
2	198.33	196.72	21.95	21.95	59.50	59.50
3	116.10	115.41	15.79	11.10	42.08	23.28
4	116.10	111.33	15.79	11.10	42.08	23.28
5	116.10	114.23	15.79	11.10	42.08	23.28
6	116.10	115.41	15.79	11.10	42.08	23.28
7	116.10	114.23	15.79	11.10	42.08	23.28
8	133.20	126.01	32.87	6.12	40.24	43.62
9	66.48	58.89	3.82	3.82	19.94	19.94
10	116.10	111.33	15.79	11.10	42.08	23.28
11	133.20	126.01	32.87	6.12	40.24	43.62
12	198.33	196.72	21.95	21.95	59.50	59.50
13	133.20	104.94	24.98	6.12	40.24	43.62
14	133.20	104.94	24.29	6.12	40.24	43.62
15	133.20	32.95	32.87	6.12	40.24	43.62
16	133.20	32.95	32.87	6.12	40.24	43.62
101	574.32	268.28	123.94	123.94	172.30	172.30
102	198.33	196.72	21.95	21.95	59.50	59.50
103	116.10	115.41	15.79	11.10	42.08	23.28
104	116.10	111.33	15.79	11.10	42.08	23.28
105	116.10	114.23	15.79	11.10	42.08	23.28
106	116.10	115.41	15.79	11.10	42.08	23.28
107	116.10	114.23	15.79	11.10	42.08	23.28
108	133.20	126.01	32.87	6.12	40.24	43.62
109	66.48	58.89	3.82	3.82	19.94	19.94
110	116.10	111.33	15.79	11.10	42.08	23.28
111	133.20	126.01	32.87	6.12	40.24	43.62
112	198.33	196.72	21.95	21.95	59.50	59.50
113	133.20	104.94	23.60	6.12	40.24	43.62
114	133.20	104.94	23.60	6.12	40.24	43.62
115	133.20	69.16	17.18	6.12	40.24	43.62
116	133.20	69.16	17.33	6.12	40.24	43.62
201	574.32	268.28	123.94	123.94	172.30	172.30
202	198.33	196.72	21.95	21.95	59.50	59.50
203	116.10	115.41	15.79	11.10	42.08	23.28
204	116.10	111.33	15.79	11.10	42.08	23.28
205	116.10	114.23	15.79	11.10	42.08	23.28
206	116.10	115.41	15.79	11.10	42.08	23.28
207	116.10	114.23	15.79	11.10	42.08	23.28
208	133.20	32.95	32.87	6.12	40.24	43.62
209	66.48	58.89	3.82	3.82	19.94	19.94
210	116.10	111.33	15.79	11.10	42.08	23.28
211	133.20	32.95	32.87	6.12	40.24	43.62
212	198.33	196.72	21.95	21.95	59.50	59.50
213	133.20	104.94	24.98	6.12	40.24	43.62
214	133.20	104.94	24.29	6.12	40.24	43.62
215	133.20	69.16	17.80	6.12	40.24	43.62
216	133.20	69.16	17.95	6.12	40.24	43.62

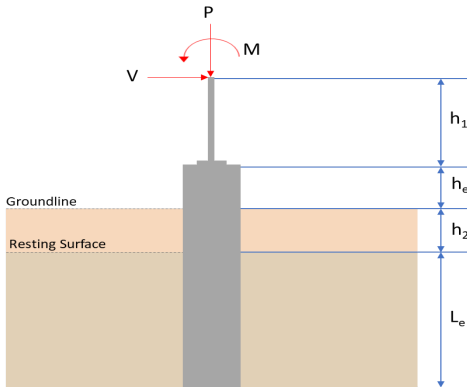
Design Ratio

Member ID	P	M _z	M _y	V _y	V _z	(P,M _z ,M _y)	Worst LC	KL/r	δ	Status
1	0.048	0.619	0.000	0.036	0.000	0.640	#13	0.510	Not Required	Pass
2	0.005	0.435	0.287	0.102	0.053	0.699	#13	0.035	Not Required	Pass
3	0.013	0.750	0.072	0.075	0.007	0.791	#13	0.045	Not Required	Pass
4	0.013	0.680	0.237	0.068	0.049	0.779	#21	0.080	Not Required	Pass
5	0.013	0.465	0.246	0.074	0.062	0.495	#13	0.074	Not Required	Pass
6	0.014	0.750	0.082	0.075	0.009	0.795	#13	0.045	Not Required	Pass
7	0.014	0.466	0.248	0.074	0.064	0.500	#13	0.074	Not Required	Pass
8	0.000	0.052	0.211	0.048	0.024	0.252	#21	0.063	Not Required	Pass
9	0.022	0.056	0.064	0.001	0.000	0.121	#13	0.204	Not Required	Pass
10	0.014	0.675	0.240	0.068	0.051	0.785	#21	0.080	Not Required	Pass
11	0.000	0.056	0.216	0.053	0.024	0.259	#21	0.095	Not Required	Pass
12	0.005	0.435	0.282	0.103	0.052	0.693	#13	0.035	Not Required	Pass
13	0.011	0.297	0.585	0.067	0.031	0.833	#21	0.286	Not Required	Pass
14	0.011	0.278	0.585	0.061	0.031	0.822	#21	0.190	Not Required	Pass
15	0.000	0.115	0.313	0.040	0.018	0.414	#21	Not Required	Not Required	Pass
16	0.000	0.105	0.313	0.036	0.018	0.409	#21	Not Required	Not Required	Pass
101	0.050	0.637	0.000	0.037	0.000	0.660	#13	0.510	Not Required	Pass
102	0.004	0.457	0.290	0.108	0.054	0.718	#13	0.035	Not Required	Pass
103	0.015	0.781	0.090	0.078	0.014	0.830	#13	0.045	Not Required	Pass
104	0.015	0.711	0.231	0.071	0.049	0.815	#21	0.080	Not Required	Pass
105	0.015	0.485	0.239	0.077	0.060	0.516	#13	0.074	Not Required	Pass
106	0.015	0.781	0.090	0.078	0.014	0.830	#13	0.045	Not Required	Pass
107	0.015	0.485	0.239	0.077	0.060	0.516	#13	0.074	Not Required	Pass
108	0.000	0.064	0.211	0.045	0.024	0.240	#21	0.063	Not Required	Pass
109	0.019	0.050	0.060	0.001	0.000	0.115	#13	0.204	Not Required	Pass
110	0.015	0.711	0.231	0.071	0.049	0.815	#21	0.080	Not Required	Pass
111	0.000	0.073	0.214	0.049	0.024	0.244	#21	0.095	Not Required	Pass
112	0.004	0.457	0.290	0.108	0.054	0.718	#13	0.035	Not Required	Pass
113	0.010	0.229	0.554	0.064	0.031	0.744	#21	0.286	Not Required	Pass
114	0.011	0.221	0.551	0.059	0.031	0.732	#21	0.190	Not Required	Pass
115	0.001	0.274	0.307	0.049	0.024	0.548	#21	0.473	Not Required	Pass
116	0.000	0.248	0.310	0.045	0.024	0.538	#21	0.316	Not Required	Pass
201	0.048	0.619	0.000	0.036	0.000	0.640	#13	0.510	Not Required	Pass
202	0.005	0.435	0.282	0.103	0.052	0.693	#13	0.035	Not Required	Pass
203	0.014	0.750	0.082	0.075	0.009	0.795	#13	0.045	Not Required	Pass
204	0.014	0.675	0.240	0.068	0.051	0.785	#21	0.080	Not Required	Pass
205	0.014	0.466	0.248	0.074	0.064	0.500	#13	0.074	Not Required	Pass
206	0.013	0.750	0.072	0.075	0.007	0.791	#13	0.045	Not Required	Pass
207	0.013	0.465	0.246	0.074	0.062	0.495	#13	0.074	Not Required	Pass
208	0.000	0.105	0.313	0.036	0.018	0.409	#21	Not Required	Not Required	Pass
209	0.022	0.056	0.064	0.001	0.000	0.121	#13	0.204	Not Required	Pass
210	0.013	0.680	0.237	0.068	0.049	0.779	#21	0.080	Not Required	Pass
211	0.000	0.115	0.313	0.040	0.018	0.414	#21	Not Required	Not Required	Pass
212	0.005	0.435	0.287	0.102	0.053	0.699	#13	0.035	Not Required	Pass
213	0.011	0.297	0.585	0.067	0.031	0.833	#21	0.190	Not Required	Pass
214	0.011	0.278	0.585	0.061	0.031	0.822	#21	0.190	Not Required	Pass
215	0.001	0.271	0.307	0.053	0.024	0.543	#21	0.473	Not Required	Pass
216	0.000	0.245	0.310	0.048	0.024	0.533	#21	0.316	Not Required	Pass

Definitions

Φ_t Safety factor for tensile

Φ_c	Safety factor for compression
Φ_b	Safety factor for flexure
Φ_v	Safety factor for shear
E	Modulus of elasticity
F_y	Specified minimum yield stress
F_u	Specified minimum tensile strength
A	Cross-sectional area
J	Torsional constant
I_{yp}	Moment of inertia about the Y axes
I_{zp}	Moment of inertia about the Z axes
I_w	Warping constant
S_{yp}	Plastic section modulus about the Y axis
S_{zp}	Plastic section modulus about the Z axis
KL	Effective length
C_b	Buckling modification factor (from all load combinations)
L_b	Length between braced points
LST	Limited slenderness for tension
LSC	Limited slenderness for compression
LD	Limited deflection
P_n	Nominal axial strength (tension/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 = 7.5 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>8.514</td><td>12.802</td></tr><tr><td>Vx (kip)</td><td>-3.729</td><td>-6.220</td></tr><tr><td>Vz (kip)</td><td>0.002</td><td>0.003</td></tr><tr><td>Mx (kipft)</td><td>0.017</td><td>0.027</td></tr><tr><td>Mz (kipft)</td><td>45.383</td><td>76.658</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)	8.514	12.802	Vx (kip)	-3.729	-6.220	Vz (kip)	0.002	0.003	Mx (kipft)	0.017	0.027	Mz (kipft)	45.383	76.658	
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Mx (kipft)	0.017	0.027																										
Mz (kipft)	45.383	76.658																										
	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}$$H_o = \frac{(-3.729 \text{ kip})}{1.57 \times (48 \text{ in})}$$H_o = -0.59379 \text{ kip/ft}$ Mo - Moment per length of pile, $M_o = \frac{M_z + (V_x H)}{1.57 D}$																											

	$M_o = \frac{(45.383 \text{ kipft}) + ((-3.729 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 7.2266 \text{ kipft/ft}$ 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: $L_{e,x} = 6.9212 \text{ ft}$ - Required depth in x-direction, Considering z-direction: H_o - Lateral force per length of pile, $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(0.002 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = 0.00031847 \text{ kip/ft}$ M_o - Moment per length of pile, $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(0.017 \text{ kipft}) + ((0.002 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.002707 \text{ kipft/ft}$ 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: $L_{e,z} = 0.61139 \text{ ft}$ - Required depth in z-direction, Minimum embedded depth required: $L_{e,req}$ - Depth of pile required, $L_{e,req} = \text{MAX}[L_{e,x}, L_{e,z}]$ $L_{e,req} = \text{MAX}[(6.9212 \text{ ft}), (0.61139 \text{ ft})]$ $L_{e,req} = 6.921 \text{ ft}$ L_e - Actual embedded length of pile, $L_e = L - h_c - h_2$ $L_e = (7.5 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 7.5 \text{ ft}$ Ratio - Embedded depth $\text{Ratio} = \frac{L_{e,req}}{L_e}$ $\text{Ratio} = \frac{(6.921 \text{ ft})}{(7.5 \text{ ft})}$ $\text{Ratio} = 0.9228$	Status: PASS Ratio: 0.920
	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 $q = \frac{P_o}{A}$ $q = \frac{(8.514 \text{ kip})}{(16 \text{ ft}^2)}$ $q = 0.532125 \text{ kips/ft}^2$	

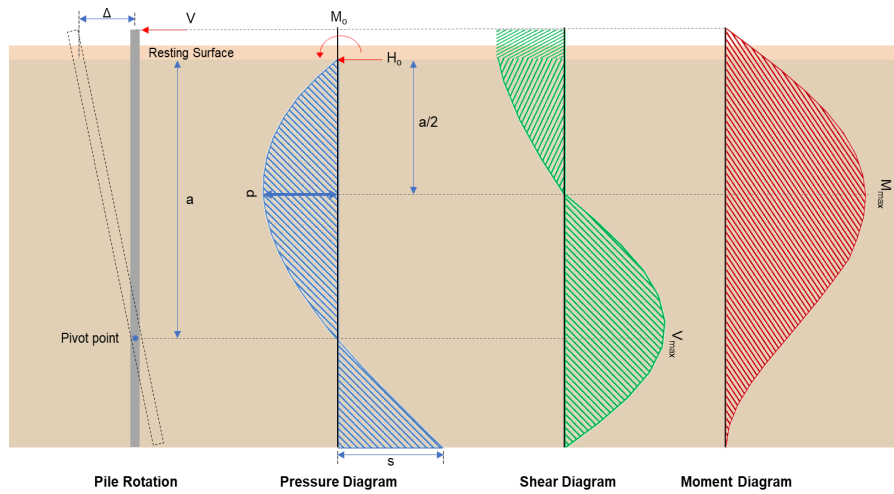
	$q = 0.00210 \text{ kip/ft}$	
	Check bearing capacity ratio: Ratio - Capacity $\text{Ratio} = \frac{q}{q_a}$ $\text{Ratio} = \frac{(0.53213 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $\text{Ratio} = 0.26606$	Status: PASS Ratio: 0.270
Czerniak	Lateral Soil Pressure (ASD): L/D - Length to least lateral dimension ratio, $L/D = \frac{L}{D}$ $L/D = \frac{(7.5 \text{ ft})}{(48 \text{ in})}$ $L/D = 1.875$ Since $L/D \leq 10$, Pile is short. Considering x-direction: $H_o = -0.59379 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 7.2266 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point, $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (7.2266 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (-0.59379 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (7.2266 \text{ kipft/ft})) + (4 \times (-0.59379 \text{ kip/ft}) \times (7.5 \text{ ft}))}$ $a = 5.182 \text{ ft}$ p - Earth pressure against the pile at distance $a/2$ from resting surface, $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^3 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 [(4 \times (7.2266 \text{ kipft/ft})) + (3 \times (-0.59379 \text{ kip/ft}) \times (7.5 \text{ ft}))]^2}{(7.5 \text{ ft})^3 [(3 \times (7.2266 \text{ kipft/ft})) + (2 \times (-0.59379 \text{ kip/ft}) \times (7.5 \text{ ft}))]}$ $p = 0.25228 \text{ kip/ft}^2$ s - Earth pressure against the pile at distance L_e, $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (7.2266 \text{ kipft/ft})) + ((-0.59379 \text{ kip/ft}) \times (7.5 \text{ ft}))]}{(7.5 \text{ ft})^2}$ $s = 1.0666 \text{ kip/ft}^2$ Check lateral soil pressure capacity: p_a - Allowable lateral soil pressure at depth $a/2$, $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(5.182 \text{ ft})}{2}$ $p_a = 0.38865 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{p}{p_a}$ $\text{Ratio} = \frac{(0.25228 \text{ kip/ft}^2)}{(0.38865 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.64913$ p_s - Allowable lateral soil pressure at depth L_e,	Status: PASS Ratio: 0.650

	$p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (7.5 \text{ ft})$ $p_s = 1.125 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{s}{p_s}$ $\text{Ratio} = \frac{(1.0666 \text{ kip/ft}^2)}{(1.125 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.94813$	Status: PASS Ratio: 0.950
	Considering z-direction: $H_o = 0.00031847 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 0.002707 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point, $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.002707 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (0.00031847 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (0.002707 \text{ kipft/ft})) + (4 \times (0.00031847 \text{ kip/ft}) \times (7.5 \text{ ft}))}$ $a = 5.2315 \text{ ft}$ p - Earth pressure against the pile at distance $a/2$ from resting surface, $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^3 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.002707 \text{ kipft/ft})) + (3 \times (0.00031847 \text{ kip/ft}) \times (7.5 \text{ ft}))]^2}{(7.5 \text{ ft})^3 \times [(3 \times (0.002707 \text{ kipft/ft})) + (2 \times (0.00031847 \text{ kip/ft}) \times (7.5 \text{ ft}))]}$ $p = 0.0003347 \text{ kip/ft}^2$ s - Earth pressure against the pile at distance L_e, $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.002707 \text{ kipft/ft})) + ((0.00031847 \text{ kip/ft}) \times (7.5 \text{ ft}))]}{(7.5 \text{ ft})^2}$ $s = 0.00083227 \text{ kip/ft}^2$ Check lateral soil pressure capacity: p_a - Allowable lateral soil pressure at depth $a/2$, $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(5.2315 \text{ ft})}{2}$ $p_a = 0.39236 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{p}{p_a}$ $\text{Ratio} = \frac{(0.0003347 \text{ kip/ft}^2)}{(0.39236 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.00085303$ p_s - Allowable lateral soil pressure at depth L_e, $p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (7.5 \text{ ft})$ $p_s = 1.125 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{s}{p_s}$	Status: PASS Ratio: 0.000

$$Ratio = \frac{(0.00083227 \text{ kip/ft}^2)}{(1.125 \text{ kip/ft}^2)}$$

$$Ratio = 0.0007398$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-6.22 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.99045 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(76.658 \text{ kipft}) + ((-6.22 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 12.207 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(12.207 \text{ kipft/ft})}{(-0.99045 \text{ kip/ft})}$$

$$E = 12.324 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (12.207 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (-0.99045 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (12.207 \text{ kipft/ft})) + (4 \times (-0.99045 \text{ kip/ft}) \times (7.5 \text{ ft}))}$$

$$a = 5.1804 \text{ ft}$$

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

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

$$V_{max} = ((-0.99045 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (12.324 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.1804 \text{ ft})}{(7.5 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (12.324 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.1804 \text{ ft})}{(7.5 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 14.132 \text{ kip}$$

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

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

$$M_{max} = ((-0.99045 \text{ kip/ft}) \times (48 \text{ in}) \times (7.5 \text{ ft})) \times \left[\left(\frac{(12.324 \text{ ft})}{(7.5 \text{ ft})} + \frac{(5.1804 \text{ ft})}{2 \times (7.5 \text{ ft})} \right) - \left[\left(\frac{4 \times (12.324 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.1804 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (12.324 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.1804 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 50.301 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.003 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.00047771 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.027 \text{ kipft}) + ((0.003 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.0042994 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.0042994 \text{ kipft/ft})}{(0.00047771 \text{ kip/ft})}$$

$$E = 9 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.0042994 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (0.00047771 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (0.0042994 \text{ kipft/ft})) + (4 \times (0.00047771 \text{ kip/ft}) \times (7.5 \text{ ft}))}$$

$$a = 5.2232 \text{ ft}$$

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

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

$$V_{max} = ((0.00047771 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (9 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.2232 \text{ ft})}{(7.5 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (9 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.2232 \text{ ft})}{(7.5 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.005318 \text{ kip}$$

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

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

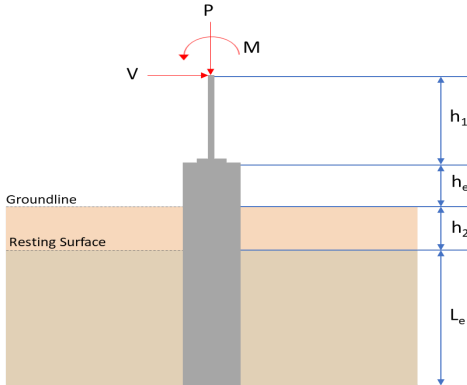
$$M_{max} = ((0.00047771 \text{ kip/ft}) \times (48 \text{ in}) \times (7.5 \text{ ft})) \times \left[\left(\frac{(9 \text{ ft})}{(7.5 \text{ ft})} + \frac{(5.2232 \text{ ft})}{2 \times (7.5 \text{ ft})} \right) - \left[\left(\frac{4 \times (9 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.2232 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (9 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.2232 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^4 \right] \right]$$

		$M_{max} = 0.018648 \text{ kipft}$	
		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, $A_{st,required}$ 22.4.2.2, 10.6.1.1 $A_{st,required} = \text{Min} \left[\frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = \text{Min} \left[\frac{\frac{(12.802 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -84.171 \text{ in}^2$ A_{min} - Governing minimum reinforcement area, $A_{min} = \text{Max} [A_{st,required}, (0.0018 A_g)]$ $A_{min} = \text{Max} [(-84.171 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ 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 $Ratio = \frac{P}{\phi P_N}$$Ratio = \frac{(12.802 \text{ kip})}{(2675.2 \text{ kip})}$$Ratio = 0.0047855$	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 $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 12.802 \text{ kip} \rightarrow 12802 \text{ lbf}$, $V_{c,a}$ - Shear strength of concrete (a) $V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(12802 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$$V_{c,a} = 120.19 \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}]$$V_c = Min [(296.21 \text{ kip}), (120.19 \text{ kip}), (348.89 \text{ kip})]$$V_c = 120.19 \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 $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((120.19 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 111.21 \text{ kip}$ Considering x-direction: $V_{max} = 14.132 \text{ kip}$ - Maximum shear force in the x-direction, <i>Ratio</i> - Capacity $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(14.132 \text{ kip})}{(111.21 \text{ kip})}$ $Ratio = 0.12708$ Considering z-direction: $V_{max} = 0.005318 \text{ kip}$ - Maximum shear force in the z-direction, <i>Ratio</i> - Capacity $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.005318 \text{ kip})}{(111.21 \text{ kip})}$ $Ratio = 0.000047821$	Status: PASS Ratio: 0.130 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: $M_{max} = 50.301 \text{ kipft}$ - Maximum moment in the x-direction, Ratio - Capacity $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(50.301 \text{ kipft})}{(249.6 \text{ kipft})}$ $\text{Ratio} = 0.20153$	Status: PASS Ratio: 0.200
	Considering z-direction: $M_{max} = 0.018648 \text{ kipft}$ - Maximum moment in the z-direction, Ratio - Capacity $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(0.018648 \text{ kipft})}{(249.6 \text{ kipft})}$ $\text{Ratio} = 0.000074711$	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 = 7.5 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>8.962</td><td>13.511</td></tr><tr><td>Vx (kip)</td><td>-3.857</td><td>-6.439</td></tr><tr><td>Vz (kip)</td><td>0.000</td><td>0.000</td></tr><tr><td>Mx (kipft)</td><td>0.000</td><td>0.000</td></tr><tr><td>Mz (kipft)</td><td>46.844</td><td>78.971</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)	8.962	13.511	Vx (kip)	-3.857	-6.439	Vz (kip)	0.000	0.000	Mx (kipft)	0.000	0.000	Mz (kipft)	46.844	78.971	
Layer	Label	Allowable Bearing Pressure (qa) (psf)	Allowable Lateral Pressure (R) (psf/ft)																									
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Mx (kipft)	0.000	0.000																										
Mz (kipft)	46.844	78.971																										
	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, $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-3.857 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.61417 \text{ kip/ft}$ Mo - Moment per length of pile, $M_o = \frac{M_z + (V_x H)}{1.57 D}$																											

	$M_o = \frac{(46.844 \text{ kipft}) + ((-3.857 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 7.4592 \text{ kipft/ft}$ 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: $L_{e,x} = 6.977 \text{ ft} - \text{Required depth in x-direction,}$ Considering z-direction: $L_{e,z} = 0 \text{ ft} - \text{Required depth in z-direction,}$ Minimum embedded depth required: $L_{e,req} - \text{Depth of pile required,}$ $L_{e,req} = \text{MAX}[L_{e,x}, L_{e,z}]$ $L_{e,req} = \text{MAX}[(6.977 \text{ ft}), (0 \text{ ft})]$ $L_{e,req} = 6.977 \text{ ft}$ L_e - Actual embedded length of pile, $L_e = L - h_e - h_2$ $L_e = (7.5 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 7.5 \text{ ft}$ <i>Ratio</i> - Embedded depth $\text{Ratio} = \frac{L_{e,req}}{L_e}$ $\text{Ratio} = \frac{(6.977 \text{ ft})}{(7.5 \text{ ft})}$ $\text{Ratio} = 0.93027$	Status: PASS Ratio: 0.930
	End-bearing Capacity (ASD) A - Pile cross-section area $A = b \ D$ $A = (48 \text{ in}) \times (48 \text{ in})$ $A = 16 \text{ ft}^2$ q - End-bearing pressure $q = \frac{P_v}{A}$ $q = \frac{(8.962 \text{ kip})}{(16 \text{ ft}^2)}$ $q = 0.56012 \text{ kip/ft}^2$ Check bearing capacity ratio: <i>Ratio</i> - Capacity $\text{Ratio} = \frac{q}{q_a}$ $\text{Ratio} = \frac{(0.56012 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $\text{Ratio} = 0.28006$	Status: PASS Ratio: 0.280
Czerniak	Lateral Soil Pressure (ASD): L/D - Length to least lateral dimension ratio, $L/D = \frac{L}{D}$ $L/D = \frac{(7.5 \text{ ft})}{(48 \text{ in})}$	

$$L/D = 1.875$$

Since $L/D \leq 10$,

Pile is short.

Considering x-direction:

$H_o = -0.61417$ kip/ft - Lateral force per length of pile,

$M_o = 7.4592$ kipft/ft - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (7.4592 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (-0.61417 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (7.4592 \text{ kipft/ft})) + (4 \times (-0.61417 \text{ kip/ft}) \times (7.5 \text{ ft}))}$$

$$a = 5.1823 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (7.4592 \text{ kipft/ft})) + (3 \times (-0.61417 \text{ kip/ft}) \times (7.5 \text{ ft}))]^2}{(7.5 \text{ ft})^3 \times [(3 \times (7.4592 \text{ kipft/ft})) + (2 \times (-0.61417 \text{ kip/ft}) \times (7.5 \text{ ft}))]}$$

$$p = 0.25986 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

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

$$s = \frac{6 \times [(2 \times (7.4592 \text{ kipft/ft})) + ((-0.61417 \text{ kip/ft}) \times (7.5 \text{ ft}))]}{(7.5 \text{ ft})^2}$$

$$s = 1.1 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(5.1823 \text{ ft})}{2}$$

$$p_a = 0.38867 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.25986 \text{ kip/ft}^2)}{(0.38867 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.66858$$

p_s - Allowable lateral soil pressure at depth L_e ,

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (7.5 \text{ ft})$$

$$p_s = 1.125 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

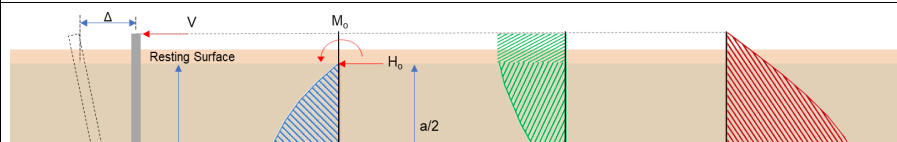
$$\text{Ratio} = \frac{s}{p_s}$$

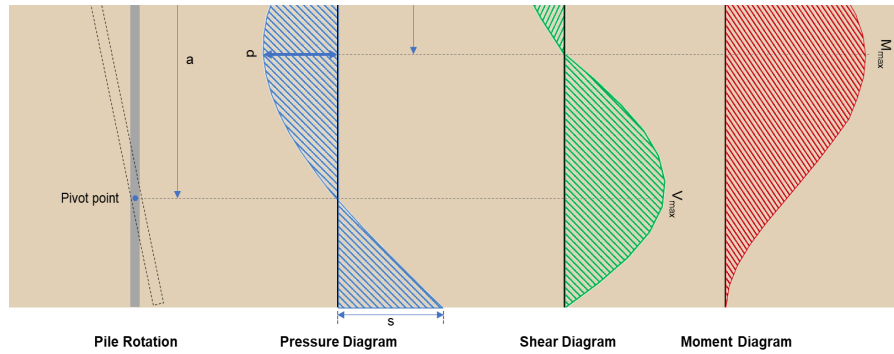
$$\text{Ratio} = \frac{(1.1 \text{ kip/ft}^2)}{(1.125 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.97775$$

Status: **PASS**
Ratio: **0.670**

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





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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-6.439 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -1.0253 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(78.971 \text{ kipft}) + ((-6.439 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 12.575 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(12.575 \text{ kipft/ft})}{(-1.0253 \text{ kip/ft})}$$

$$E = 12.264 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (12.575 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (-1.0253 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (12.575 \text{ kipft/ft})) + (4 \times (-1.0253 \text{ kip/ft}) \times (7.5 \text{ ft}))}$$

$$a = 5.181 \text{ ft}$$

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

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

$$V_{max} = ((-1.0253 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (12.264 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.181 \text{ ft})}{(7.5 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (12.264 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.181 \text{ ft})}{(7.5 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 14.572 \text{ kip}$$

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

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

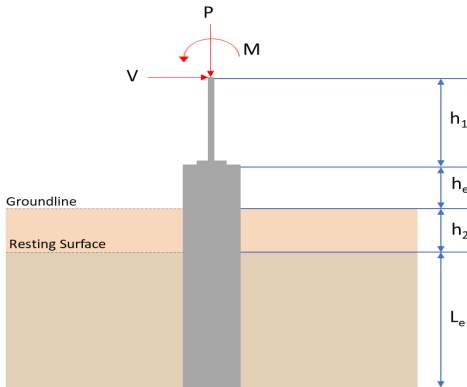
$$M_{max} = ((-1.0253 \text{ kip/ft}) \times (48 \text{ in}) \times (7.5 \text{ ft})) \times \left[\left(\frac{(12.264 \text{ ft})}{(7.5 \text{ ft})} + \frac{(5.181 \text{ ft})}{2 \times (7.5 \text{ ft})} \right) - \left[\left(\frac{4 \times (12.264 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.181 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (12.264 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.181 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^4 \right] \right]$$

		$M_{max} = 51.854 \text{ kipft}$	
		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, $A_{st,required}$ $A_{st,required}$ $A_{st,required} = \text{Min} \left[\frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = \text{Min} \left[\frac{\frac{(13.511 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -84.147 \text{ in}^2$ A_{min} - Governing minimum reinforcement area, $A_{min} = \text{Max} [A_{st,required}, (0.0018 A_g)]$ $A_{min} = \text{Max} [(-84.147 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ 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 $\text{Ratio} = \frac{P}{\phi P_N}$ $\text{Ratio} = \frac{(13.511 \text{ kip})}{(2675.2 \text{ kip})}$ $\text{Ratio} = 0.0050505$	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 $\lambda_s = \text{MIN} \left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = \text{MIN} \left[\sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.64282$	
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 $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 13.511 \text{ kip} \rightarrow 13511 \text{ lbf}$, $V_{c,a}$ - Shear strength of concrete (a) $V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(13511 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 120.29 \text{ kip}$	
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 $V_c = \text{Min} [V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = \text{Min} [(296.21 \text{ kip}), (120.29 \text{ kip}), (348.89 \text{ kip})]$ $V_c = 120.29 \text{ kip}$	

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, $A_v = \frac{\pi d_{ties}^2}{4}$ $A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$ $A_v = 0.11045 \text{ in}^2$ 22.5.8.5.3 $V_{s,b}$ - Shear strength of steel (b) $V_{s,b} = \frac{2 A_v f_{ywk} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$ 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 $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((120.29 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 111.27 \text{ kip}$ Considering x-direction: $V_{max} = 14.572 \text{ kip}$ - Maximum shear force in the x-direction, $Ratio$ - Capacity $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(14.572 \text{ kip})}{(111.27 \text{ kip})}$ $Ratio = 0.13096$	Status: PASS Ratio: 0.130
14.5.2.1b	Flexural Strength (ACI 318-19, LRFD) S_m - Section modulus $S_m = \frac{b D^2}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$ $\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$ $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 \text{ ksi})} \times 18432.001 \text{ in}^3$ $\phi M_{n,1} = 249.600 \text{ kipft}$ $\phi M_{n,2}$ $\phi M_{n,2} = 0.85 f'_t S_m$	

	$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (18432 \text{ in}^3)$ $\phi M_{n,2} = 2121.6 \text{ kipft}$ 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: $M_{max} = 51.854 \text{ kipft}$ - Maximum moment in the x-direction, <i>Ratio</i> - Capacity $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(51.854 \text{ kipft})}{(249.6 \text{ kipft})}$ $\text{Ratio} = 0.20775$	
		Status: PASS Ratio: 0.210

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 = 7.5 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>8.514</td><td>12.802</td></tr><tr><td>Vx (kip)</td><td>-3.729</td><td>-6.220</td></tr><tr><td>Vz (kip)</td><td>-0.002</td><td>-0.003</td></tr><tr><td>Mx (kipft)</td><td>-0.017</td><td>-0.027</td></tr><tr><td>Mz (kipft)</td><td>45.383</td><td>76.658</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)	8.514	12.802	Vx (kip)	-3.729	-6.220	Vz (kip)	-0.002	-0.003	Mx (kipft)	-0.017	-0.027	Mz (kipft)	45.383	76.658	
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Mz (kipft)	45.383	76.658																										
	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, $H_o = \frac{V_x}{1.57\text{ }D}$ $H_o = \frac{(-3.729\text{ kip})}{1.57 \times (48\text{ in})}$ $H_o = -0.59379\text{ kip/ft}$ Mo - Moment per length of pile, $M_o = \frac{M_z + (V_x\text{ }H)}{1.57\text{ }D}$																											

	$M_o = \frac{(45.383 \text{ kipft}) + ((-3.729 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 7.2266 \text{ kipft/ft}$ 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: $L_{e,x} = 6.9212 \text{ ft}$ - Required depth in x-direction, Considering z-direction: H_o - Lateral force per length of pile, $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(-0.002 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.00031847 \text{ kip/ft}$ M_o - Moment per length of pile, $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(0.017 \text{ kipft}) + ((-0.002 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.002707 \text{ kipft/ft}$ 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: $L_{e,z} = 0.59009 \text{ ft}$ - Required depth in z-direction, Minimum embedded depth required: $L_{e,req}$ - Depth of pile required, $L_{e,req} = \text{MAX}[L_{e,x}, L_{e,z}]$ $L_{e,req} = \text{MAX}[(6.9212 \text{ ft}), (0.59009 \text{ ft})]$ $L_{e,req} = 6.921 \text{ ft}$ L_e - Actual embedded length of pile, $L_e = L - h_c - h_2$ $L_e = (7.5 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 7.5 \text{ ft}$ Ratio - Embedded depth $\text{Ratio} = \frac{L_{e,req}}{L_e}$ $\text{Ratio} = \frac{(6.921 \text{ ft})}{(7.5 \text{ ft})}$ $\text{Ratio} = 0.9228$	Status: PASS Ratio: 0.920
	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 $q = \frac{P_o}{A}$ $q = \frac{(8.514 \text{ kip})}{(16 \text{ ft}^2)}$ $q = 0.532125 \text{ kips/ft}^2$	

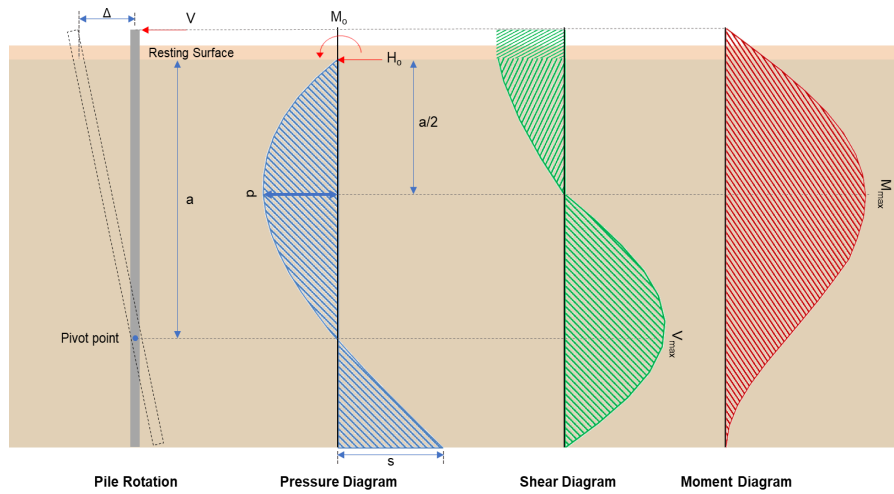
	$q = 0.00210 \text{ kip/ft}$	
	Check bearing capacity ratio: Ratio - Capacity $\text{Ratio} = \frac{q}{q_a}$ $\text{Ratio} = \frac{(0.53213 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $\text{Ratio} = 0.26606$	Status: PASS Ratio: 0.270
Czerniak	Lateral Soil Pressure (ASD): L/D - Length to least lateral dimension ratio, $L/D = \frac{L}{D}$ $L/D = \frac{(7.5 \text{ ft})}{(48 \text{ in})}$ $L/D = 1.875$ Since $L/D \leq 10$, Pile is short. Considering x-direction: $H_o = -0.59379 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 7.2266 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point, $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (7.2266 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (-0.59379 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (7.2266 \text{ kipft/ft})) + (4 \times (-0.59379 \text{ kip/ft}) \times (7.5 \text{ ft}))}$ $a = 5.182 \text{ ft}$ p - Earth pressure against the pile at distance $a/2$ from resting surface, $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^3 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 [(4 \times (7.2266 \text{ kipft/ft})) + (3 \times (-0.59379 \text{ kip/ft}) \times (7.5 \text{ ft}))]^2}{(7.5 \text{ ft})^3 [(3 \times (7.2266 \text{ kipft/ft})) + (2 \times (-0.59379 \text{ kip/ft}) \times (7.5 \text{ ft}))]}$ $p = 0.25228 \text{ kip/ft}^2$ s - Earth pressure against the pile at distance L_e, $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (7.2266 \text{ kipft/ft})) + ((-0.59379 \text{ kip/ft}) \times (7.5 \text{ ft}))]}{(7.5 \text{ ft})^2}$ $s = 1.0666 \text{ kip/ft}^2$ Check lateral soil pressure capacity: p_a - Allowable lateral soil pressure at depth $a/2$, $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(5.182 \text{ ft})}{2}$ $p_a = 0.38865 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{p}{p_a}$ $\text{Ratio} = \frac{(0.25228 \text{ kip/ft}^2)}{(0.38865 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.64913$ p_s - Allowable lateral soil pressure at depth L_e,	Status: PASS Ratio: 0.650

	$p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (7.5 \text{ ft})$ $p_s = 1.125 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{s}{p_s}$ $\text{Ratio} = \frac{(1.0666 \text{ kip/ft}^2)}{(1.125 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.94813$	Status: PASS Ratio: 0.950
	Considering z-direction: $H_o = -0.00031847 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 0.002707 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point, $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.002707 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (-0.00031847 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (0.002707 \text{ kipft/ft})) + (4 \times (-0.00031847 \text{ kip/ft}) \times (7.5 \text{ ft}))}$ $a = 5.2315 \text{ ft}$ p - Earth pressure against the pile at distance $a/2$ from resting surface, $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^3 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.002707 \text{ kipft/ft})) + (3 \times (-0.00031847 \text{ kip/ft}) \times (7.5 \text{ ft}))]^2}{(7.5 \text{ ft})^3 \times [(3 \times (0.002707 \text{ kipft/ft})) + (2 \times (-0.00031847 \text{ kip/ft}) \times (7.5 \text{ ft}))]}$ $p = 0.000053483 \text{ kip/ft}^2$ s - Earth pressure against the pile at distance L_e, $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.002707 \text{ kipft/ft})) + ((-0.00031847 \text{ kip/ft}) \times (7.5 \text{ ft}))]}{(7.5 \text{ ft})^2}$ $s = 0.00032272 \text{ kip/ft}^2$ Check lateral soil pressure capacity: p_a - Allowable lateral soil pressure at depth $a/2$, $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(5.2315 \text{ ft})}{2}$ $p_a = 0.39236 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{p}{p_a}$ $\text{Ratio} = \frac{(0.000053483 \text{ kip/ft}^2)}{(0.39236 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.00013631$ p_s - Allowable lateral soil pressure at depth L_e, $p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (7.5 \text{ ft})$ $p_s = 1.125 \text{ kip/ft}^2$ Ratio - Lateral soil capacity $\text{Ratio} = \frac{s}{p_s}$	Status: PASS Ratio: 0.000

$$Ratio = \frac{(0.00032272 \text{ kip/ft}^2)}{(1.125 \text{ kip/ft}^2)}$$

$$Ratio = 0.00028686$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-6.22 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.99045 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(76.658 \text{ kipft}) + ((-6.22 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 12.207 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(12.207 \text{ kipft/ft})}{(-0.99045 \text{ kip/ft})}$$

$$E = 12.324 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (12.207 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (-0.99045 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (12.207 \text{ kipft/ft})) + (4 \times (-0.99045 \text{ kip/ft}) \times (7.5 \text{ ft}))}$$

$$a = 5.1804 \text{ ft}$$

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

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

$$V_{max} = ((-0.99045 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (12.324 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.1804 \text{ ft})}{(7.5 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (12.324 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.1804 \text{ ft})}{(7.5 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 14.132 \text{ kip}$$

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

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

$$M_{max} = ((-0.99045 \text{ kip/ft}) \times (48 \text{ in}) \times (7.5 \text{ ft})) \times \left[\left(\frac{(12.324 \text{ ft})}{(7.5 \text{ ft})} + \frac{(5.1804 \text{ ft})}{2 \times (7.5 \text{ ft})} \right) - \left[\left(\frac{4 \times (12.324 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.1804 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (12.324 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.1804 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 50.301 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.003 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.00047771 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.027 \text{ kipft}) + ((-0.003 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.0042994 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.0042994 \text{ kipft/ft})}{(-0.00047771 \text{ kip/ft})}$$

$$E = 9 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.0042994 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (-0.00047771 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (0.0042994 \text{ kipft/ft})) + (4 \times (-0.00047771 \text{ kip/ft}) \times (7.5 \text{ ft}))}$$

$$a = 5.2232 \text{ ft}$$

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

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

$$V_{max} = ((-0.00047771 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (9 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.2232 \text{ ft})}{(7.5 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (9 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.2232 \text{ ft})}{(7.5 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.005318 \text{ kip}$$

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

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

$$M_{max} = ((-0.00047771 \text{ kip/ft}) \times (48 \text{ in}) \times (7.5 \text{ ft})) \times \left[\left(\frac{(9 \text{ ft})}{(7.5 \text{ ft})} + \frac{(5.2232 \text{ ft})}{2 \times (7.5 \text{ ft})} \right) - \left[\left(\frac{4 \times (9 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.2232 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (9 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.2232 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^4 \right] \right]$$

		$M_{max} = 0.018648 \text{ kipft}$	
		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, $A_{st,required}$ $A_{st,required}$ $A_{st,required} = \text{Min} \left[\frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = \text{Min} \left[\frac{\frac{(12.802 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -84.171 \text{ in}^2$ A_{min} - Governing minimum reinforcement area, $A_{min} = \text{Max} [A_{st,required}, (0.0018 A_g)]$ $A_{min} = \text{Max} [(-84.171 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ 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 $\text{Ratio} = \frac{P}{\phi P_N}$ $\text{Ratio} = \frac{(12.802 \text{ kip})}{(2675.2 \text{ kip})}$ $\text{Ratio} = 0.0047855$	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 $\lambda_s = \text{MIN} \left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = \text{MIN} \left[\sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.64282$	
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 $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 12.802 \text{ kip} \rightarrow 12802 \text{ lbf}$, $V_{c,a}$ - Shear strength of concrete (a) $V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(12802 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 120.19 \text{ kip}$	
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 $V_c = \text{Min} [V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = \text{Min} [(296.21 \text{ kip}), (120.19 \text{ kip}), (348.89 \text{ kip})]$ $V_c = 120.19 \text{ kip}$	

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 $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((120.19 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 111.21 \text{ kip}$ Considering x-direction: $V_{max} = 14.132 \text{ kip}$ - Maximum shear force in the x-direction, <i>Ratio</i> - Capacity $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(14.132 \text{ kip})}{(111.21 \text{ kip})}$ $Ratio = 0.12708$ Considering z-direction: $V_{max} = 0.005318 \text{ kip}$ - Maximum shear force in the z-direction, <i>Ratio</i> - Capacity $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.005318 \text{ kip})}{(111.21 \text{ kip})}$ $Ratio = 0.000047821$	Status: PASS Ratio: 0.130 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: $M_{max} = 50.301 \text{ kipft}$ - Maximum moment in the x-direction, Ratio - Capacity $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(50.301 \text{ kipft})}{(249.6 \text{ kipft})}$ $\text{Ratio} = 0.20153$	Status: PASS Ratio: 0.200
	Considering z-direction: $M_{max} = 0.018648 \text{ kipft}$ - Maximum moment in the z-direction, Ratio - Capacity $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(0.018648 \text{ kipft})}{(249.6 \text{ kipft})}$ $\text{Ratio} = 0.000074711$	Status: PASS Ratio: 0.000