Your Project Calculations

Project Name: MTSOLAR_G559KJ9FL79

S3D Model Link:
https://platform.skyciv.com/structural?preload_name=MTSOLAR_G559KJ9FL79&preload_path=Shared%20Enterprise%20Folder/MT_Solar_Projects/4_2024

Public Model Link:
https://platform.skyciv.com/structural-viewer?project_id=3AicJd0Y340bRPGryG3J5iLcAlPHZKYuBXlKjBMtLfwPoWojribmEG7NkH03SrEO

Array Specification

Product:	Beam
Unique ID:	4P-19.75-8TOP-XD-72-L-4Hx13W-STRUTS-EF19
Duty Classification:	XD
Module Width:	42.00 in
Module Length:	74.00in
Number of Rows:	4
Number of Columns:	13
Total Number of Modules:	52
Desired Tilt Angle:	46
Front Edge Clearance:	3
Total Array Height at Tilt:	13.13 ft
Total Frame Length:	78.75 ft
Frame Weight:	4188 lbs
Array Dimensions N/S:	14.17 ft
Array Dimensions E/W:	81.25 ft
Rail Length:	170.00 in
Rail Spacing:	3.08 ft
Rail Check:	Not Checked

Support Specifications

Pole Size:	8in Pipe Sch 40
Pole Length above Grade:	8.10 ft
Number of Poles:	4
Pole Spacing:	19.75 ft

Foundation Specifications

Foundation Type:	Square
Foundation Dimensions:	48 x 48 in
Foundation Depth (below grade):	Pile 1: 5.75 ft Pile 2: 5.75 ft Pile 3: 5.75 ft Pile 4: 5.75 ft
Foundation Volume:	13.630 y^3
Foundation Result:	PASSED
Mount Twist:	0.774494 kip

Site Info

Risk Category:	I
Exposure:	C
Soil Classification:	sand
Site Location:	5371 Corrinne Ct, Carson City, NV 89706, USA
Wind Speed:	120 mph
Snow Load:	30 psf
Design Uplift Pressure:	0.021578 ksf
Design Downforce Pressure:	-0.021578 ksf
Design Snow Pressure:	0.007917 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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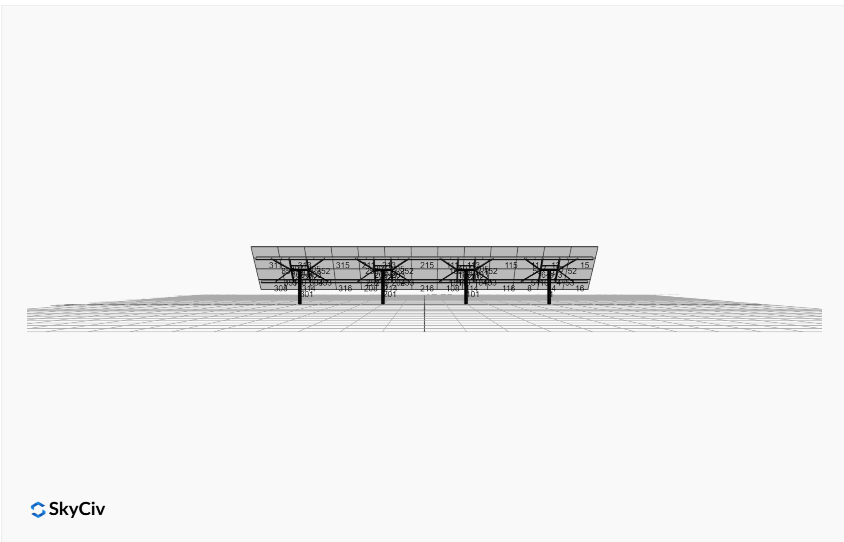
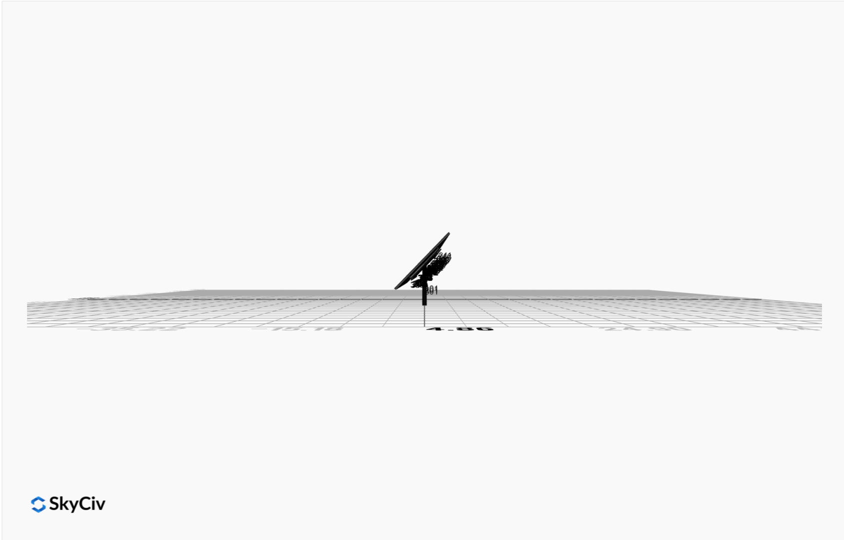
Design Notes:

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

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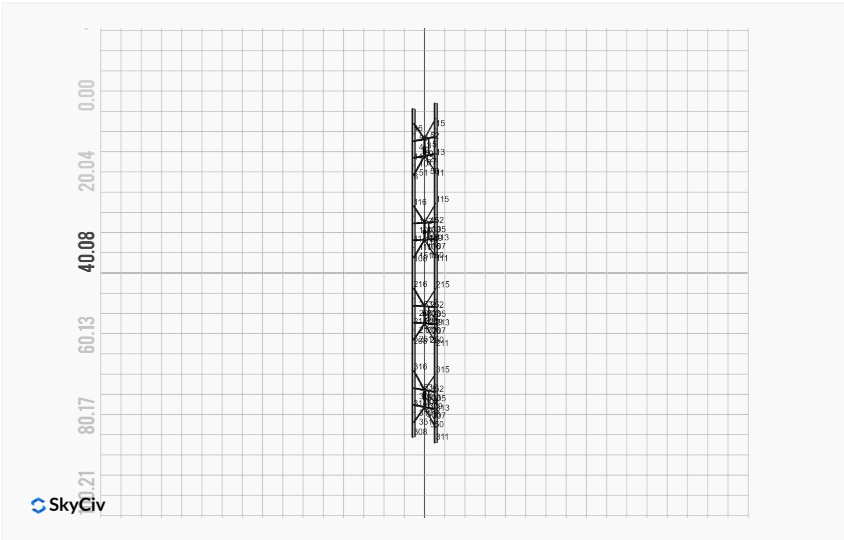
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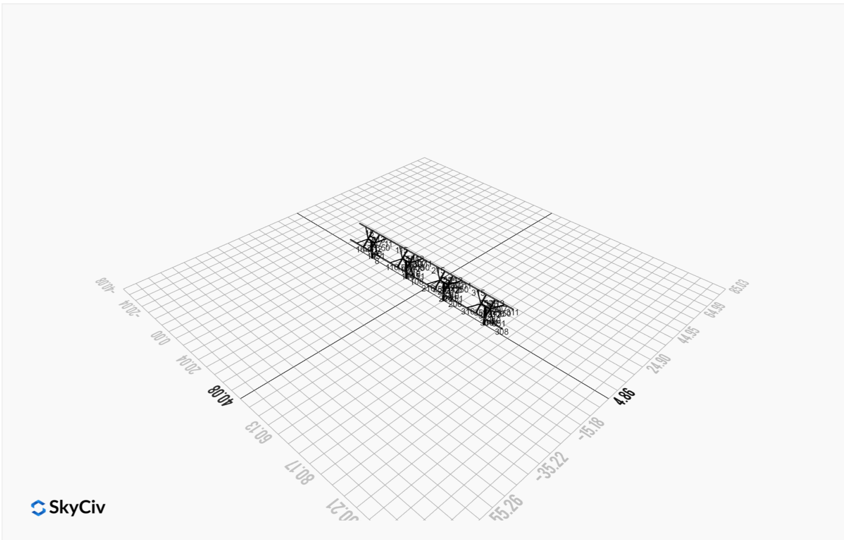
60.13
80.17
SkyCiv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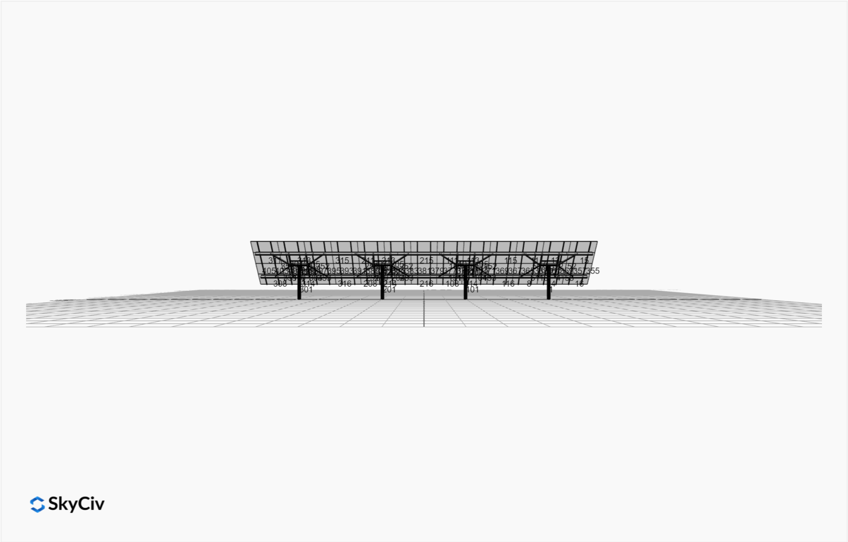
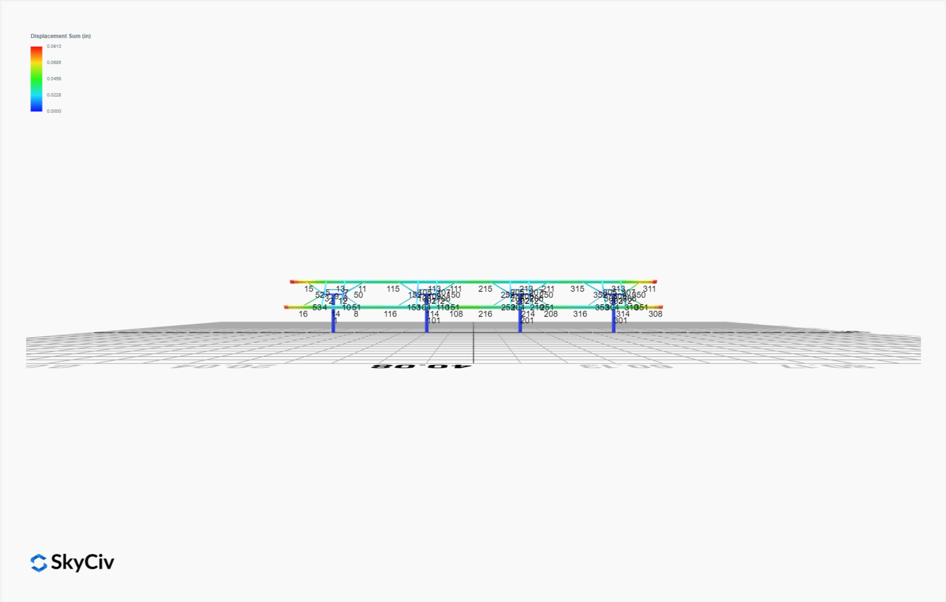
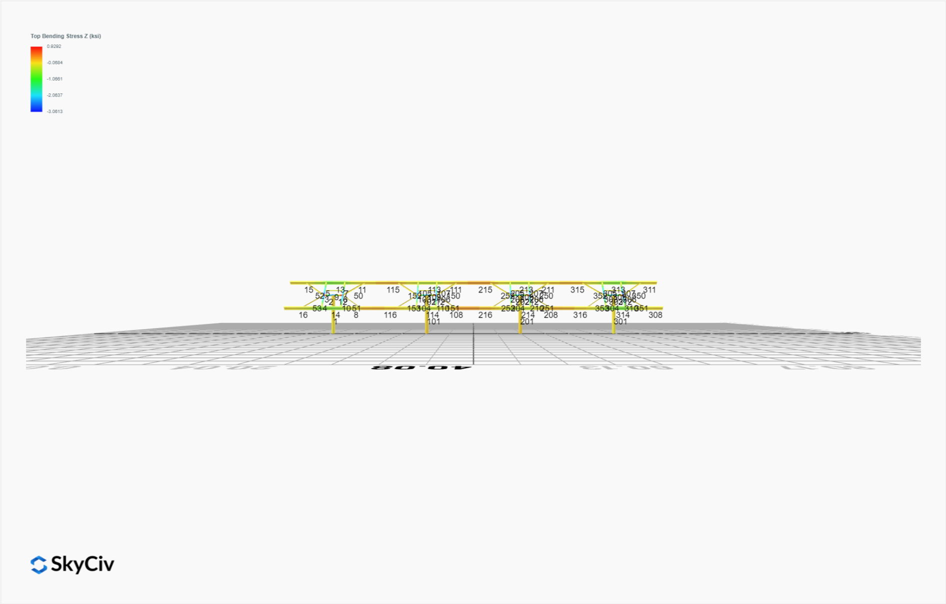
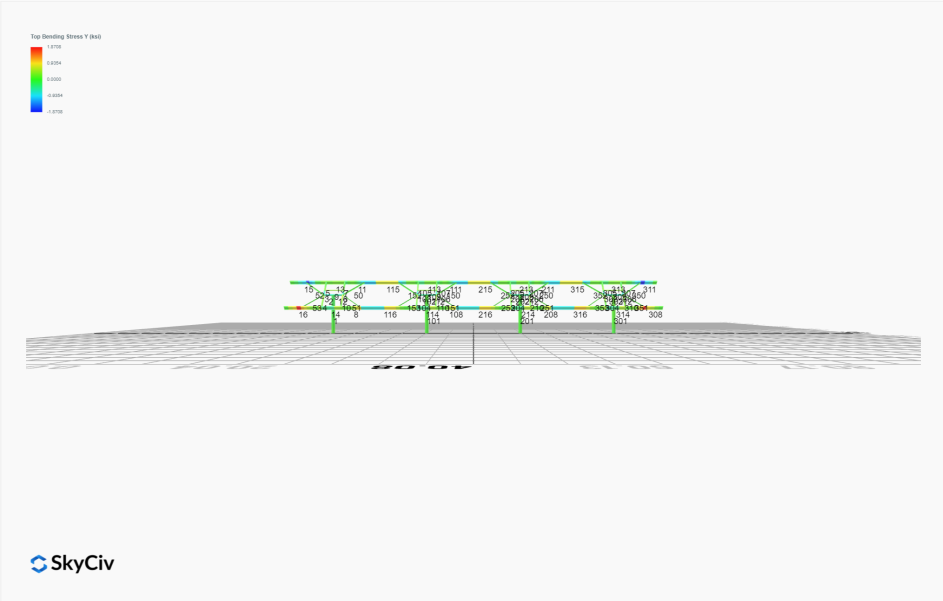


FEM Results (Envelope Worst Case for each member)



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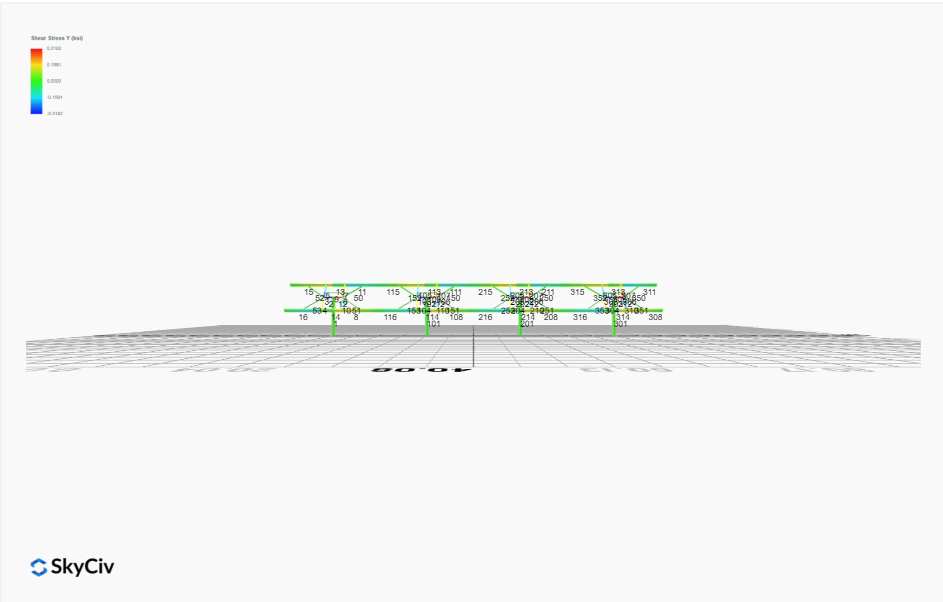
-1.8708
SkyCiv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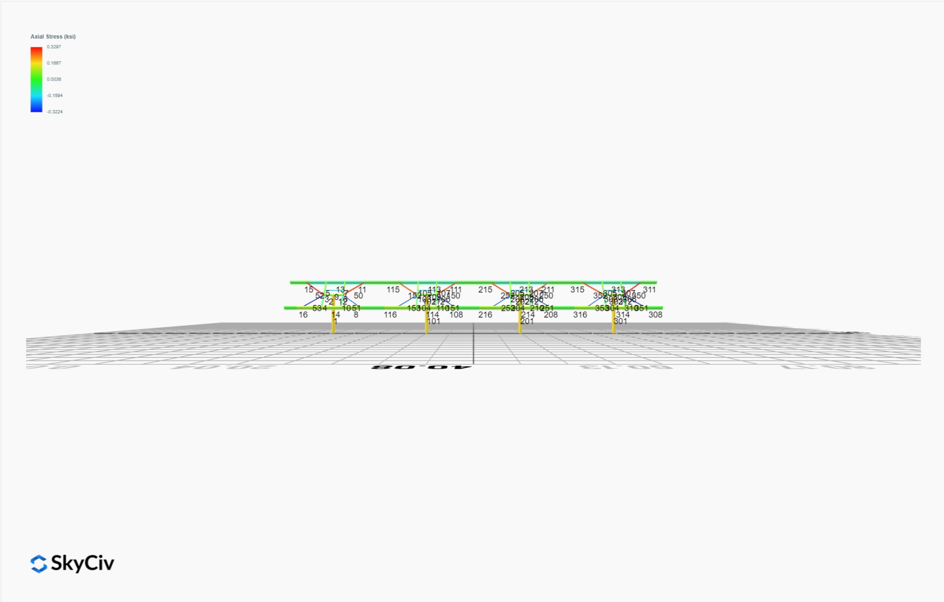
SkyCiv



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	-0.0239	2.4196	-0.0337	-0.0595	0.1189	0.2083
ULS: 2. D + L	-0.0239	2.4196	-0.0337	-0.0595	0.1189	0.2083
ULS: 3. D + (S or Lr or R)	-0.0435	3.9750	-0.0612	-0.1080	0.2162	0.3612
ULS: 3. D + (S or Lr or R)	-0.0239	2.4196	-0.0337	-0.0595	0.1189	0.2083
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0386	3.5861	-0.0544	-0.0959	0.1919	0.3229
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0239	2.4196	-0.0337	-0.0595	0.1189	0.2083
ULS: 5b. D + 0.7E	-0.0239	2.4196	-0.0337	-0.0595	0.1189	0.2083
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0386	3.5861	-0.0544	-0.0959	0.1919	0.3229
ULS: 8. 0.6D + 0.7E	-0.0144	1.4517	-0.0202	-0.0357	0.0713	0.1250
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.7687	5.0871	-0.1281	-0.2293	0.4668	22.5459
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.0239	2.4196	-0.0337	-0.0595	0.1189	0.2083
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.7213	-0.2480	0.0603	0.1095	-0.2282	-21.8394
ULS: 5a. D + 0.6W_Wind uplift Case B only	-0.0239	2.4196	-0.0337	-0.0595	0.1189	0.2083
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.0972	5.5868	-0.1252	-0.2233	0.4528	17.0762
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0386	3.5861	-0.0544	-0.0959	0.1919	0.3229
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.0203	1.5855	0.0161	0.0309	-0.0684	-16.2128
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0386	3.5861	-0.0544	-0.0959	0.1919	0.3229
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.0825	4.4202	-0.1045	-0.1869	0.3798	16.9615
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0239	2.4196	-0.0337	-0.0595	0.1189	0.2083
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.0350	0.4189	0.0368	0.0673	-0.1414	-16.3275
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0239	2.4196	-0.0337	-0.0595	0.1189	0.2083
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.7591	4.1193	-0.1146	-0.2056	0.4193	22.4626
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.0144	1.4517	-0.0202	-0.0357	0.0713	0.1250
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.7309	-1.2158	0.0738	0.1333	-0.2757	-21.9227
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	-0.0144	1.4517	-0.0202	-0.0357	0.0713	0.1250

Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	8.1277
Shear X	-4.6130
Shear Z	-0.2126
Moment X	-0.3808
Moment Y (Twist)	0.7747
Moment Z	37.8132

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	5.5868
Shear X	-2.7687
Shear Z	-0.1281
Moment X	-0.2293
Moment Y (Twist)	0.4668
Moment Z	22.5459

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	0.0239	2.3667	0.0053	0.0079	-0.0225	-0.1581
ULS: 2. D + L	0.0239	2.3667	0.0053	0.0079	-0.0225	-0.1581
ULS: 3. D + (S or Lr or R)	0.0435	3.8791	0.0096	0.0144	-0.0409	-0.3050
ULS: 3. D + (S or Lr or R)	0.0239	2.3667	0.0053	0.0079	-0.0225	-0.1581
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0386	3.5010	0.0085	0.0128	-0.0363	-0.2683
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0239	2.3667	0.0053	0.0079	-0.0225	-0.1581
ULS: 5b. D + 0.7E	0.0239	2.3667	0.0053	0.0079	-0.0225	-0.1581

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0386	3.5010	0.0085	0.0128	-0.0363	-0.2683
ULS: 8. 0.6D + 0.7E	0.0144	1.4200	0.0032	0.0047	-0.0135	-0.0948
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.5912	4.8750	0.0226	0.0355	-0.0809	21.1764
ULS: 5a. D + 0.6W_Wind downforce Case B only	0.0239	2.3667	0.0053	0.0079	-0.0225	-0.1581
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.6385	-0.1417	-0.0121	-0.0198	0.0365	-21.2219
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.0239	2.3667	0.0053	0.0079	-0.0225	-0.1581
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.9227	5.3823	0.0215	0.0335	-0.0801	15.7326
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0386	3.5010	0.0085	0.0128	-0.0363	-0.2683
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.9995	1.6197	-0.0045	-0.0080	0.0079	-16.0662
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0386	3.5010	0.0085	0.0128	-0.0363	-0.2683
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.9374	4.2479	0.0183	0.0286	-0.0663	15.8428
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0239	2.3667	0.0053	0.0079	-0.0225	-0.1581
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.9849	0.4854	-0.0078	-0.0129	0.0217	-15.9559
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0239	2.3667	0.0053	0.0079	-0.0225	-0.1581
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.6007	3.9284	0.0205	0.0323	-0.0719	21.2396
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	0.0144	1.4200	0.0032	0.0047	-0.0135	-0.0948
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.6289	-1.0884	-0.0142	-0.0230	0.0455	-21.1587
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.0144	1.4200	0.0032	0.0047	-0.0135	-0.0948

Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	7.7762
Shear X	-4.3960
Shear Z	0.0374
Moment X	0.0587
Moment Y (Twist)	0.1332
Moment Z	35.5825

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	5.3823
Shear X	-2.6385
Shear Z	0.0226
Moment X	0.0355
Moment Y (Twist)	0.0809
Moment Z	21.2396

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	0.0239	2.3667	-0.0053	-0.0079	0.0225	-0.1581
ULS: 2. D + L	0.0239	2.3667	-0.0053	-0.0079	0.0225	-0.1581
ULS: 3. D + (S or Lr or R)	0.0435	3.8791	-0.0096	-0.0144	0.0409	-0.3050
ULS: 3. D + (S or Lr or R)	0.0239	2.3667	-0.0053	-0.0079	0.0225	-0.1581
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0386	3.5010	-0.0085	-0.0128	0.0363	-0.2683
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0239	2.3667	-0.0053	-0.0079	0.0225	-0.1581
ULS: 5b. D + 0.7E	0.0239	2.3667	-0.0053	-0.0079	0.0225	-0.1581
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0386	3.5010	-0.0085	-0.0128	0.0363	-0.2683
ULS: 8. 0.6D + 0.7E	0.0144	1.4200	-0.0032	-0.0047	0.0135	-0.0948
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.5912	4.8750	-0.0226	-0.0355	0.0809	21.1764
ULS: 5a. D + 0.6W_Wind downforce Case B only	0.0239	2.3667	-0.0053	-0.0079	0.0225	-0.1581
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.6385	-0.1417	0.0121	0.0199	-0.0365	-21.2219
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.0239	2.3667	-0.0053	-0.0079	0.0225	-0.1581
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.9227	5.3823	-0.0215	-0.0335	0.0801	15.7326
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0386	3.5010	-0.0085	-0.0128	0.0363	-0.2683
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.9995	1.6197	0.0045	0.0080	-0.0079	-16.0662
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0386	3.5010	-0.0085	-0.0128	0.0363	-0.2683

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	-1.9374	4.2479	-0.0183	-0.0286	0.0663	15.8428
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0239	2.3667	-0.0053	-0.0079	0.0225	-0.1581
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.9849	0.4854	0.0078	0.0129	-0.0217	-15.9559
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0239	2.3667	-0.0053	-0.0079	0.0225	-0.1581
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.6007	3.9284	-0.0205	-0.0323	0.0719	21.2396
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	0.0144	1.4200	-0.0032	-0.0047	0.0135	-0.0948
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.6289	-1.0884	0.0142	0.0230	-0.0455	-21.1587
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.0144	1.4200	-0.0032	-0.0047	0.0135	-0.0948

Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	7.7762
Shear X	-4.3961
Shear Z	-0.0374
Moment X	-0.0588
Moment Y (Twist)	0.1335
Moment Z	35.5825

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	5.3823
Shear X	-2.6385
Shear Z	-0.0226
Moment X	-0.0355
Moment Y (Twist)	0.0809
Moment Z	21.2396

Reaction Forces for Foundation 4 (Node ID#301), (kip, kip-ft)

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	-0.0239	2.4196	0.0337	0.0595	-0.1189	0.2083
ULS: 2. D + L	-0.0239	2.4196	0.0337	0.0595	-0.1189	0.2083
ULS: 3. D + (S or Lr or R)	-0.0435	3.9750	0.0612	0.1080	-0.2162	0.3612
ULS: 3. D + (S or Lr or R)	-0.0239	2.4196	0.0337	0.0595	-0.1189	0.2083
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0386	3.5861	0.0544	0.0959	-0.1919	0.3230
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0239	2.4196	0.0337	0.0595	-0.1189	0.2083
ULS: 5b. D + 0.7E	-0.0239	2.4196	0.0337	0.0595	-0.1189	0.2083
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0386	3.5861	0.0544	0.0959	-0.1919	0.3230
ULS: 8. 0.6D + 0.7E	-0.0144	1.4517	0.0202	0.0357	-0.0713	0.1250
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.7687	5.0871	0.1281	0.2294	-0.4668	22.5459
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.0239	2.4196	0.0337	0.0595	-0.1189	0.2083
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.7213	-0.2480	-0.0603	-0.1095	0.2282	-21.8394
ULS: 5a. D + 0.6W_Wind uplift Case B only	-0.0239	2.4196	0.0337	0.0595	-0.1189	0.2083
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.0972	5.5868	0.1252	0.2233	-0.4528	17.0762
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0386	3.5861	0.0544	0.0959	-0.1919	0.3230
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.0203	1.5855	-0.0161	-0.0309	0.0684	-16.2128
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0386	3.5861	0.0544	0.0959	-0.1919	0.3230
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.0825	4.4202	0.1045	0.1869	-0.3798	16.9615
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0239	2.4196	0.0337	0.0595	-0.1189	0.2083
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.0350	0.4189	-0.0368	-0.0673	0.1414	-16.3275
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0239	2.4196	0.0337	0.0595	-0.1189	0.2083
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.7591	4.1193	0.1146	0.2056	-0.4193	22.4626
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.0144	1.4517	0.0202	0.0357	-0.0713	0.1250
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.7309	-1.2158	-0.0738	-0.1333	0.2757	-21.9227
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	-0.0144	1.4517	0.0202	0.0357	-0.0713	0.1250

Worst Case Reactions LRFD

Worst Case Reactions ASD

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

Result	Value (kip, kip-ft)
Axial	8.1278
Shear X	-4.6130
Shear Z	0.2126
Moment X	0.3808
Moment Y (Twist)	0.7745
Moment Z	37.8137

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	5.5868
Shear X	-2.7687
Shear Z	0.1281
Moment X	0.2294
Moment Y (Twist)	0.4668
Moment Z	22.5459

Project Details

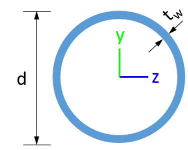
Design Code:	AISC 360-16 LRFD
Provision:	LRFD
Country:	United States
User Name:	sales@mtsolar.us
Unit System:	imperial

Design Input Information

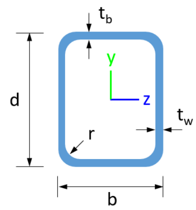
Design Factors			
Φ_t	Φ_c	Φ_b	Φ_v
0.9	0.9	0.9	0.9

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

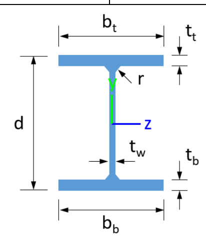
Section Dimensions



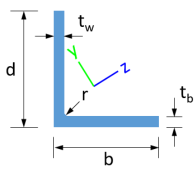
ID	Name	d (in)	t_w (in)					
3	2in Pipe Sch 120	2.38	0.25					
6	4in Pipe Sch 120	4.50	0.44					
9	8in Pipe Sch 40	8.63	0.32					



ID	Name	d (in)	b (in)	t_w (in)	t_b (in)	r (in)		
17	HSS5x3x1/4	5.00	3.00	0.23	0.23	0.23		



ID	Name	d (in)	t_w (in)	b_t (in)	b_b (in)	t_t (in)	t_b (in)	r (in)
20	W10x12	9.87	0.19	3.96	3.96	0.21	0.21	0.30



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

Section Properties								
ID	Name	A (in^2)	J (in^4)	I_{yp} (in^4)	I_{zp} (in^4)	I_w (in^6)	S_{yp} (in^3)	S_{zp} (in^3)
3	2in Pipe Sch 120	1.67	1.91	0.96	0.96	0.00	1.13	1.13
6	4in Pipe Sch 120	5.58	23.29	11.64	11.64	0.00	7.24	7.24
9	8in Pipe Sch 40	8.40	144.98	72.49	72.49	0.00	22.21	22.21
17	HSS5x3x1/4	3.37	11.00	4.81	10.70	0.93	3.77	5.38
20	W10x12	3.54	0.05	2.18	53.80	50.90	1.74	12.60
34	L3x2x3/16	0.92	0.01	0.17	0.98	0.01	0.33	0.82

Member Properties								
Member ID	Section ID	K_zL (ft)	K_yL (ft)	L_b(ft)	C_b	LST	LSC	LD
1	9	17.00	17.00	8.10	-	300	200	1
2	6	1.30	1.30	2.00	-	300	200	1
3	17	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.18,1.26,1.18,1.18,1.19,1.17,1.19,1.18,1.19,1.18,1.19	300	200	1
4	17	2.44	2.44	3.75	1.69,1.68,1.69,1.68,1.68,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.68,1.84,1.68,1.67,1.69,1.65,1.69,1.67,1.69,1.66,1.69	300	200	1
5	17	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.79,1.67,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68	300	200	1
6	17	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.17,1.19,1.18,1.18,1.26,1.18,1.18,1.19,1.16,1.19,1.18,1.19,1.17,1.19	300	200	1
7	17	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.80,1.67,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68	300	200	1
8	20	1.33	1.33	2.05	1.75,1.75,1.75,1.74,1.75,1.75,1.74,1.75,1.73,1.75,1.74,1.75,1.73,1.75,1.74,1.74,1.89,1.74,1.74,1.75,1.72,1.75,1.74,1.75,1.73,1.75	300	200	1
9	3	2.60	2.60	4.00	-	300	200	1
10	17	2.44	2.44	3.75	1.69,1.68,1.69,1.68,1.69,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.68,1.86,1.68,1.67,1.69,1.64,1.69,1.67,1.69,1.66,1.69	300	200	1
11	20	1.33	1.33	2.05	1.77,1.77,1.77,1.76,1.77,1.77,1.76,1.77,1.75,1.77,1.76,1.77,1.75,1.77,1.76,1.76,1.92,1.76,1.76,1.77,1.74,1.77,1.76,1.77,1.75,1.77	300	200	1
12	6	2.00	1.30	2.00	-	300	200	1
13	20	4.88	4.00	7.50	1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.07,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08	300	200	1
14	20	4.88	4.00	7.50	1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.07,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08	300	200	1
15	20	6.00	6.00	6.00	2.33,2.32,2.33,2.32,2.33,2.33,2.31,2.32,2.31,2.32,2.31,2.33,2.30,2.33,2.32,2.32,2.44,2.32,2.32,2.33,2.29,2.33,2.31,2.33,2.31,2.33	300	200	1
16	20	6.00	6.00	6.00	2.33,2.32,2.33,2.32,2.32,2.33,2.31,2.32,2.30,2.32,2.31,2.33,2.30,2.33,2.31,2.32,2.44,2.32,2.31,2.33,2.29,2.33,2.31,2.33,2.30,2.33	300	200	1
50	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
51	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250

52	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
53	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
101	9	17.00	17.00	8.10	-	300	200	1
102	6	1.30	1.30	2.00	-	300	200	1
103	17	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.19,1.17,1.19,1.18,1.19,1.17,1.19,1.18,1.18,1.26,1.18,1.18,1.19,1.17,1.19,1.18,1.19,1.18,1.19	300	200	1
104	17	2.44	2.44	3.75	1.69,1.68,1.69,1.68,1.69,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.68,1.86,1.68,1.67,1.69,1.64,1.69,1.67,1.69,1.66,1.69	300	200	1
105	17	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.80,1.67,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68	300	200	1
106	17	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.19,1.17,1.19,1.18,1.19,1.17,1.19,1.18,1.18,1.26,1.18,1.18,1.19,1.17,1.19,1.18,1.19,1.18,1.19	300	200	1
107	17	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.80,1.67,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68	300	200	1
108	20	1.33	1.33	2.05	1.90,1.91,1.90,1.91,1.91,1.90,1.91,1.91,1.92,1.91,1.91,1.90,1.92,1.90,1.91,1.91,1.79,1.91,1.91,1.90,1.93,1.90,1.91,1.90,1.92,1.90	300	200	1
109	3	2.60	2.60	4.00	-	300	200	1
110	17	2.44	2.44	3.75	1.69,1.68,1.69,1.68,1.69,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.68,1.86,1.68,1.67,1.69,1.64,1.69,1.67,1.69,1.66,1.69	300	200	1
111	20	1.33	1.33	2.05	2.06,2.06,2.06,2.06,2.06,2.06,2.06,2.06,2.06,2.06,2.06,2.06,2.06,2.06,2.06,2.06,2.08,2.06,2.06,2.06,2.06,2.06,2.06,2.06,2.06,2.06	300	200	1
112	6	2.00	1.30	2.00	-	300	200	1
113	20	4.88	4.00	7.50	1.05,1.05,1.05,1.05,1.05,1.05,1.05,1.05,1.06,1.05,1.05,1.05,1.06,1.05,1.05,1.05,1.04,1.05,1.05,1.05,1.06,1.05,1.05,1.05,1.06,1.05	300	200	1
114	20	4.88	4.00	7.50	1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.05,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06	300	200	1
115	20	10.20	10.20	10.20	1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.19,1.18,1.18,1.18,1.19,1.18,1.18,1.18,1.15,1.18,1.18,1.18,1.19,1.18,1.18,1.18,1.19,1.18	300	200	1
116	20	10.20	10.20	10.20	1.17,1.18,1.17,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.17,1.18,1.18,1.14,1.18,1.18,1.17,1.19,1.17,1.18,1.17,1.18,1.17	300	200	1
150	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
151	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
152	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
153	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
201	9	17.00	17.00	8.10	-	300	200	1
202	6	2.00	1.30	2.00	-	300	200	1
203	17	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.19,1.17,1.19,1.18,1.19,1.17,1.19,1.18,1.18,1.26,1.18,1.18,1.19,1.17,1.19,1.18,1.19,1.18,1.19	300	200	1
204	17	2.44	2.44	3.75	1.69,1.68,1.69,1.68,1.69,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.68,1.86,1.68,1.67,1.69,1.64,1.69,1.67,1.69,1.66,1.69	300	200	1
				2.3	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.80,1.67,1.6	3	2	

205	17	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.80,1.67,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68	300	200	1
206	17	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.19,1.17,1.19,1.18,1.19,1.17,1.19,1.18,1.18,1.26,1.18,1.18,1.19,1.17,1.19,1.18,1.19,1.18,1.19	300	200	1
207	17	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.80,1.67,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68	300	200	1
208	20	1.33	1.33	2.05	2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.09,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08	300	200	1
209	3	2.60	2.60	4.00	-	300	200	1
210	17	2.44	2.44	3.75	1.69,1.68,1.69,1.68,1.69,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.68,1.86,1.68,1.67,1.69,1.64,1.69,1.67,1.69,1.66,1.69	300	200	1
211	20	1.33	1.33	2.05	2.14,2.15,2.14,2.17,2.15,2.14,2.16,2.15,2.16,2.15,2.16,2.14,2.16,2.14,2.17,2.17,2.23,2.17,2.16,2.14,2.18,2.14,2.16,2.14,2.16,2.14	300	200	1
212	6	1.30	1.30	2.00	-	300	200	1
213	20	4.88	4.00	7.50	1.05,1.05,1.05,1.05,1.05,1.05,1.05,1.05,1.06,1.05,1.05,1.05,1.06,1.05,1.05,1.05,1.05,1.05,1.05,1.05,1.06,1.05,1.05,1.05,1.06,1.05	300	200	1
214	20	4.88	4.00	7.50	1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.05,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06,1.06	300	200	1
215	20	10.20	10.20	10.20	1.11,1.11,1.11,1.11,1.11,1.11,1.12,1.11,1.12,1.11,1.12,1.11,1.12,1.11,1.12,1.11,1.10,1.11,1.12,1.11,1.12,1.11,1.12,1.11,1.12,1.11	300	200	1
216	20	10.20	10.20	10.20	1.11,1.11,1.11,1.11,1.11,1.11,1.11,1.11,1.11,1.11,1.11,1.11,1.11,1.11,1.11,1.11,1.09,1.11,1.11,1.11,1.11,1.11,1.11,1.11,1.11,1.11	300	200	1
250	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
251	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
252	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
253	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
301	9	17.00	17.00	8.10	-	300	200	1
302	6	2.00	1.30	2.00	-	300	200	1
303	17	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.17,1.19,1.18,1.18,1.26,1.18,1.18,1.19,1.16,1.19,1.18,1.19,1.17,1.19	300	200	1
304	17	2.44	2.44	3.75	1.69,1.68,1.69,1.68,1.69,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.68,1.86,1.68,1.67,1.69,1.64,1.69,1.67,1.69,1.66,1.69	300	200	1
305	17	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.80,1.67,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68	300	200	1
306	17	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.18,1.26,1.18,1.18,1.19,1.17,1.19,1.18,1.19,1.18,1.19	300	200	1
307	17	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.79,1.67,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68	300	200	1
308	20	6.00	6.00	6.00	2.33,2.32,2.33,2.32,2.32,2.33,2.31,2.32,2.30,2.32,2.31,2.33,2.30,2.33,2.31,2.32,2.44,2.32,2.31,2.33,2.29,2.33,2.31,2.33,2.30,2.33	300	200	1
309	3	2.60	2.60	4.00	-	300	200	1
310	17	2.44	2.44	3.75	1.69,1.68,1.69,1.68,1.68,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.68,1.84,1.68,1.67,1.69,1.65,1.69,1.67,1.69,1.66,1.69	300	200	1
311	20	6.00	6.00	6.0	2.33,2.32,2.33,2.32,2.33,2.33,2.31,2.32,2.31,2.32,2.31,2.33,2.30,2.33,2.32,2.32,2.44,2.32,2.3	3	2	1

311	20	6.00	6.00	0	2,2.33,2.29,2.33,2.31,2.33,2.31,2.33	0 0	0 0	1
312	6	1.30	1.30	2.00	-	300	200	1
313	20	4.88	4.00	7.50	1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.07,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08	300	200	1
314	20	4.88	4.00	7.50	1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.07,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08	300	200	1
315	20	10.20	10.20	10.20	1.41,1.41,1.41,1.41,1.41,1.41,1.42,1.41,1.43,1.41,1.42,1.41,1.42,1.41,1.42,1.41,1.25,1.41,1.41,1.41,1.43,1.41,1.42,1.41,1.42,1.41	300	200	1
316	20	10.20	10.20	10.20	1.42,1.42,1.42,1.43,1.42,1.42,1.43,1.42,1.44,1.42,1.43,1.42,1.44,1.42,1.43,1.43,1.28,1.43,1.43,1.42,1.45,1.42,1.43,1.42,1.44,1.42	300	200	1
350	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
351	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
352	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250
353	34	5.67	5.67	5.67	1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14	300	200	250

Member Design Capacity

Member ID	$\Phi_t P_n$ (kip)	$\Phi_c P_n$ (kip)	$\Phi_b M_{zn}$ (k-ft)	$\Phi_b M_{yn}$ (k-ft)	$\Phi_v V_{yn}$ (kip)	$\Phi_v V_{zn}$ (kip)
1	377.97	265.66	83.29	83.29	113.39	113.39
2	251.01	248.88	27.16	27.16	75.30	75.30
3	151.65	150.70	20.17	14.14	54.12	28.95
4	151.65	145.15	20.17	14.14	54.12	28.95
5	151.65	149.10	20.17	14.14	54.12	28.95
6	151.65	150.70	20.17	14.14	54.12	28.95
7	151.65	149.10	20.17	14.14	54.12	28.95
8	159.30	142.47	46.90	6.46	56.26	44.91
9	75.10	66.32	4.25	4.25	22.53	22.53
10	151.65	145.15	20.17	14.14	54.12	28.95
11	159.30	142.47	46.90	6.46	56.26	44.91
12	251.01	246.00	27.16	27.16	75.30	75.30
13	159.30	116.35	32.74	6.46	56.26	44.91
14	159.30	116.35	32.70	6.46	56.26	44.91
15	159.30	86.08	46.90	6.46	56.26	44.91
16	159.30	86.08	46.90	6.46	56.26	44.91
50	41.27	8.45	1.63	0.88	15.23	10.15
51	41.27	8.45	1.63	0.88	15.23	10.15
52	41.27	8.45	1.63	0.88	15.23	10.15
53	41.27	8.45	1.63	0.88	15.23	10.15
101	377.97	265.66	83.29	83.29	113.39	113.39
102	251.01	248.88	27.16	27.16	75.30	75.30
103	151.65	150.70	20.17	14.14	54.12	28.95
104	151.65	145.15	20.17	14.14	54.12	28.95
105	151.65	149.10	20.17	14.14	54.12	28.95
106	151.65	150.70	20.17	14.14	54.12	28.95
107	151.65	149.10	20.17	14.14	54.12	28.95
108	159.30	142.47	46.90	6.46	56.26	44.91
109	75.10	66.32	4.25	4.25	22.53	22.53
110	151.65	145.15	20.17	14.14	54.12	28.95

110	151.65	145.15	20.17	14.14	54.12	28.95
111	159.30	142.47	46.90	6.46	56.26	44.91
112	251.01	246.00	27.16	27.16	75.30	75.30
113	159.30	116.35	31.91	6.46	56.26	44.91
114	159.30	116.35	32.08	6.46	56.26	44.91
115	159.30	32.87	22.08	6.46	56.26	44.91
116	159.30	32.87	21.91	6.46	56.26	44.91
150	41.27	8.45	1.63	0.88	15.23	10.15
151	41.27	8.45	1.63	0.88	15.23	10.15
152	41.27	8.45	1.63	0.88	15.23	10.15
153	41.27	8.45	1.63	0.88	15.23	10.15
201	377.97	265.66	83.29	83.29	113.39	113.39
202	251.01	246.00	27.16	27.16	75.30	75.30
203	151.65	150.70	20.17	14.14	54.12	28.95
204	151.65	145.15	20.17	14.14	54.12	28.95
205	151.65	149.10	20.17	14.14	54.12	28.95
206	151.65	150.70	20.17	14.14	54.12	28.95
207	151.65	149.10	20.17	14.14	54.12	28.95
208	159.30	142.47	46.90	6.46	56.26	44.91
209	75.10	66.32	4.25	4.25	22.53	22.53
210	151.65	145.15	20.17	14.14	54.12	28.95
211	159.30	142.47	46.90	6.46	56.26	44.91
212	251.01	248.88	27.16	27.16	75.30	75.30
213	159.30	116.35	31.97	6.46	56.26	44.91
214	159.30	116.35	31.99	6.46	56.26	44.91
215	159.30	32.87	21.09	6.46	56.26	44.91
216	159.30	32.87	20.92	6.46	56.26	44.91
250	41.27	8.45	1.63	0.88	15.23	10.15
251	41.27	8.45	1.63	0.88	15.23	10.15
252	41.27	8.45	1.63	0.88	15.23	10.15
253	41.27	8.45	1.63	0.88	15.23	10.15
301	377.97	265.66	83.29	83.29	113.39	113.39
302	251.01	246.00	27.16	27.16	75.30	75.30
303	151.65	150.70	20.17	14.14	54.12	28.95
304	151.65	145.15	20.17	14.14	54.12	28.95
305	151.65	149.10	20.17	14.14	54.12	28.95
306	151.65	150.70	20.17	14.14	54.12	28.95
307	151.65	149.10	20.17	14.14	54.12	28.95
308	159.30	86.08	46.90	6.46	56.26	44.91
309	75.10	66.32	4.25	4.25	22.53	22.53
310	151.65	145.15	20.17	14.14	54.12	28.95
311	159.30	86.08	46.90	6.46	56.26	44.91
312	251.01	248.88	27.16	27.16	75.30	75.30
313	159.30	116.35	32.79	6.46	56.26	44.91
314	159.30	116.35	32.64	6.46	56.26	44.91
315	159.30	32.87	24.06	6.46	56.26	44.91
316	159.30	32.87	24.61	6.46	56.26	44.91
350	41.27	8.45	1.63	0.88	15.23	10.15
351	41.27	8.45	1.63	0.88	15.23	10.15
352	41.27	8.45	1.63	0.88	15.23	10.15
353	41.27	8.45	1.63	0.88	15.23	10.15

Design Ratio

Member ID	P	M_z	M_y	V_y	V_z	(P,M_z,M_y)	Worst LC	KL/r	δ	Status
1	0.031	0.454	0.016	0.041	0.002	0.474	#13	0.347	Not Required	Pass
2	0.003	0.265	0.180	0.055	0.033	0.446	#13	0.054	Not Required	Pass
3	0.002	0.426	0.068	0.043	0.027	0.474	#13	0.046	Not Required	Pass
4	0.002	0.424	0.022	0.043	0.003	0.428	#13	0.082	Not Required	Pass
5	0.002	0.264	0.012	0.042	0.004	0.271	#13	0.076	Not Required	Pass
6	0.002	0.375	0.067	0.037	0.027	0.416	#13	0.046	Not Required	Pass
7	0.002	0.232	0.014	0.037	0.004	0.243	#13	0.076	Not Required	Pass
8	0.005	0.054	0.041	0.025	0.005	0.057	#13	0.102	Not Required	Pass
9	0.012	0.041	0.041	0.001	0.001	0.086	#13	0.137	Not Required	Pass
10	0.002	0.376	0.035	0.038	0.006	0.406	#13	0.082	Not Required	Pass
11	0.004	0.052	0.036	0.025	0.005	0.056	#13	0.068	Not Required	Pass
12	0.003	0.216	0.152	0.049	0.029	0.368	#13	0.083	Not Required	Pass
13	0.004	0.200	0.019	0.032	0.004	0.209	#13	0.204	Not Required	Pass
14	0.006	0.203	0.025	0.032	0.005	0.230	#13	0.306	Not Required	Pass
15	0.004	0.081	0.080	0.023	0.007	0.104	#21	0.306	Not Required	Pass
16	0.008	0.081	0.080	0.023	0.007	0.105	#21	0.306	Not Required	Pass
50	0.103	0.009	0.004	0.001	0.000	0.063	#21	0.783	Not Required	Pass
51	0.021	0.005	0.014	0.000	0.001	0.026	#21	0.522	Not Required	Pass
52	0.110	0.009	0.004	0.001	0.001	0.067	#23	0.783	Not Required	Pass
53	0.022	0.005	0.014	0.000	0.001	0.027	#23	0.522	Not Required	Pass
101	0.029	0.427	0.003	0.039	0.000	0.442	#13	0.347	Not Required	Pass
102	0.003	0.221	0.150	0.049	0.029	0.372	#13	0.054	Not Required	Pass
103	0.002	0.377	0.065	0.038	0.026	0.418	#13	0.046	Not Required	Pass
104	0.002	0.372	0.028	0.037	0.004	0.393	#13	0.082	Not Required	Pass
105	0.002	0.233	0.012	0.037	0.003	0.242	#13	0.076	Not Required	Pass
106	0.002	0.385	0.066	0.039	0.026	0.430	#13	0.046	Not Required	Pass
107	0.002	0.238	0.011	0.038	0.003	0.245	#13	0.076	Not Required	Pass
108	0.004	0.036	0.032	0.023	0.004	0.061	#21	0.102	Not Required	Pass
109	0.011	0.028	0.031	0.001	0.000	0.063	#13	0.137	Not Required	Pass
110	0.002	0.383	0.026	0.038	0.004	0.398	#13	0.082	Not Required	Pass
111	0.004	0.033	0.032	0.023	0.004	0.060	#21	0.068	Not Required	Pass
112	0.003	0.230	0.155	0.050	0.029	0.386	#13	0.083	Not Required	Pass
113	0.004	0.118	0.020	0.030	0.004	0.133	#13	0.204	Not Required	Pass
114	0.006	0.115	0.021	0.030	0.004	0.121	#13	0.306	Not Required	Pass
115	0.004	0.098	0.052	0.021	0.007	0.119	#13	0.520	Not Required	Pass
116	0.020	0.101	0.057	0.021	0.007	0.123	#13	0.780	Not Required	Pass
150	0.100	0.009	0.004	0.001	0.000	0.061	#21	0.783	Not Required	Pass
151	0.020	0.005	0.015	0.000	0.001	0.026	#23	0.522	Not Required	Pass
152	0.098	0.009	0.004	0.001	0.000	0.061	#23	0.783	Not Required	Pass
153	0.020	0.005	0.015	0.000	0.001	0.026	#23	0.522	Not Required	Pass
201	0.029	0.427	0.003	0.039	0.000	0.442	#13	0.347	Not Required	Pass
202	0.003	0.230	0.155	0.050	0.029	0.386	#13	0.083	Not Required	Pass
203	0.002	0.385	0.066	0.039	0.026	0.430	#13	0.046	Not Required	Pass
204	0.002	0.383	0.026	0.038	0.004	0.398	#13	0.082	Not Required	Pass
205	0.002	0.238	0.011	0.038	0.003	0.245	#13	0.076	Not Required	Pass
206	0.002	0.377	0.065	0.038	0.026	0.418	#13	0.046	Not Required	Pass
207	0.002	0.233	0.012	0.037	0.003	0.242	#13	0.076	Not Required	Pass
208	0.004	0.023	0.031	0.021	0.004	0.044	#21	0.102	Not Required	Pass
209	0.011	0.028	0.031	0.001	0.000	0.063	#13	0.137	Not Required	Pass
210	0.002	0.372	0.028	0.037	0.004	0.393	#13	0.082	Not Required	Pass
211	0.004	0.022	0.031	0.021	0.004	0.045	#21	0.068	Not Required	Pass
212	0.003	0.221	0.150	0.049	0.029	0.372	#13	0.054	Not Required	Pass

213	0.004	0.118	0.020	0.030	0.004	0.133	#13	0.204	Not Required	Pass
214	0.006	0.115	0.021	0.030	0.004	0.121	#13	0.306	Not Required	Pass
215	0.004	0.147	0.048	0.023	0.007	0.165	#13	0.520	Not Required	Pass
216	0.019	0.154	0.046	0.023	0.007	0.174	#13	0.780	Not Required	Pass
250	0.098	0.009	0.004	0.001	0.000	0.061	#23	0.783	Not Required	Pass
251	0.020	0.005	0.015	0.000	0.001	0.026	#23	0.522	Not Required	Pass
252	0.100	0.009	0.004	0.001	0.000	0.061	#21	0.783	Not Required	Pass
253	0.020	0.005	0.015	0.000	0.001	0.026	#6	0.522	Not Required	Pass
301	0.031	0.454	0.016	0.041	0.002	0.474	#13	0.347	Not Required	Pass
302	0.003	0.216	0.152	0.049	0.029	0.368	#13	0.083	Not Required	Pass
303	0.002	0.375	0.067	0.037	0.027	0.416	#13	0.046	Not Required	Pass
304	0.002	0.376	0.035	0.038	0.006	0.406	#13	0.082	Not Required	Pass
305	0.002	0.232	0.014	0.037	0.004	0.243	#13	0.076	Not Required	Pass
306	0.002	0.426	0.068	0.043	0.027	0.474	#13	0.046	Not Required	Pass
307	0.002	0.264	0.012	0.042	0.004	0.271	#13	0.076	Not Required	Pass
308	0.008	0.081	0.080	0.023	0.007	0.105	#21	0.459	Not Required	Pass
309	0.012	0.041	0.041	0.001	0.001	0.086	#13	0.137	Not Required	Pass
310	0.002	0.424	0.022	0.043	0.003	0.428	#13	0.082	Not Required	Pass
311	0.004	0.081	0.080	0.023	0.007	0.104	#21	0.306	Not Required	Pass
312	0.003	0.265	0.180	0.055	0.033	0.446	#13	0.054	Not Required	Pass
313	0.004	0.200	0.019	0.032	0.004	0.210	#13	0.204	Not Required	Pass
314	0.006	0.203	0.025	0.032	0.005	0.230	#13	0.306	Not Required	Pass
315	0.004	0.091	0.052	0.025	0.007	0.103	#13	0.520	Not Required	Pass
316	0.020	0.092	0.057	0.025	0.007	0.105	#13	0.780	Not Required	Pass
350	0.110	0.009	0.004	0.001	0.001	0.067	#23	0.783	Not Required	Pass
351	0.022	0.005	0.014	0.000	0.001	0.027	#23	0.522	Not Required	Pass
352	0.103	0.009	0.004	0.001	0.000	0.063	#21	0.783	Not Required	Pass
353	0.021	0.005	0.015	0.000	0.001	0.026	#21	0.522	Not Required	Pass

Definitions

Φ_t	Safety factor for tensile
Φ_c	Safety factor for compression
Φ_b	Safety factor for flexure
Φ_v	Safety factor for shear
E	Modulus of elasticity
F_y	Specified minimum yield stress
F_u	Specified minimum tensile strength
A	Cross-sectional area
J	Torsional constant
I_{yp}	Moment of inertia about the Y axes
I_{zp}	Moment of inertia about the Z axes
I_w	Warping constant
S_{yp}	Plastic section modulus about the Y axis
S_{zp}	Plastic section modulus about the Z axis
KL	Effective length
C_b	Buckling modification factor (from all load combinations)
L_b	Length between braced points
LST	Limited slenderness for tension
LSC	Limited slenderness for compression
LD	Limited deflection
P_n	Nominal axial strength (tension/comression)
M_n	Nominal flexural strength (about Z/Y axis)
V_n	Nominal shear strength (along Z/Y axis)
P	Design ratio in case of axial force
M_z	Design ratio in case of bending about Z axis
M_y	Design ratio in case of bending about Y axis
V_y	Design ratio in case of shear along Y axis
V_z	Design ratio in case of shear along Z axis
(P,M_z,M_y)	Design ratio in case of axial force and bending action
KL/r	Design ratio in case of section slenderness
δ	Design ratio in case of member deflection
OK	Capacity is provided

OK	Capacity is provided
NG	Capacity is not provided

REFERENCES	CALCULATIONS	RESULTS

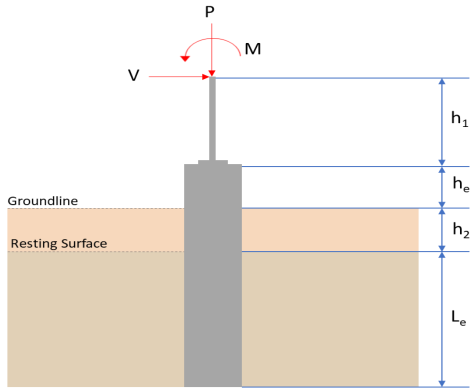
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: rectangular
$b = 48\ \mathrm{in}$ - Pile width
$D = 48\ \mathrm{in}$ - Pile depth
$L = 5.75\ \mathrm{ft}$ - Total pile length
$h_1 = 0\ \mathrm{ft}$ - Lateral load height from the top of the pile,
$h_2 = 0\ \mathrm{ft}$ - Depth to resisting surface
$h_e = 0\ \mathrm{ft}$ - Length of pile above the ground

Tabulation of Soil Parameters

Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) (psf/ft)
1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000

Tabulation of Loads

Load Component	ASD	LRFD
P (kip)	5.587	8.128
V_x (kip)	-2.769	-4.613
V_z (kip)	-0.128	-0.213
M_x (kipft)	-0.229	-0.381
M_z (kipft)	22.546	37.813

Material Properties

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

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

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

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

Considering x-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-2.769\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.44092\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(22.546\ \mathrm{kipft}) + ((-2.769\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 3.5901\ \mathrm{kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:
$L_{e,x} = 5.283\ \mathrm{ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.128\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.020382\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.229\ \mathrm{kipft}) + ((-0.128\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 0.036465\ \mathrm{kipft/ft}$$

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:
$L_{e,z} = 1.148\ \mathrm{ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(5.283\ \mathrm{ft}), (1.148\ \mathrm{ft})]$$

$$L_{e,req} = 5.283\ \mathrm{ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (5.75\ \mathrm{ft}) - (0\ \mathrm{ft}) - (0\ \mathrm{ft})$$

$$L_e = 5.75\ \mathrm{ft}$$

$Ratio$ - Embedded depth

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

$$Ratio = \frac{(5.283\ \mathrm{ft})}{(5.75\ \mathrm{ft})}$$

$$Ratio = 0.91878$$

Status: PASS
Ratio: 0.920

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = b\, D$$

$$A = (48\ \mathrm{in}) \times (48\ \mathrm{in})$$

$$A = 16\ \mathrm{ft}^2$$

q - End-bearing pressure

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

$$q = \frac{(5.587\ \mathrm{kip})}{(16\ \mathrm{ft}^2)}$$

$$q = 0.34919\ \mathrm{kip/ft}^2$$

$q = 0.34919 \text{ kip/ft}$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{(0.34919 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$Ratio = 0.17459$$

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

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(5.75 \text{ ft})}{(48 \text{ in})}$$

$$L/D = 1.4375$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.44092 \text{ kip/ft}$ - Lateral force per length of pile,
$M_o = 3.5901 \text{ kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (3.5901 \text{ kipft/ft}) \times (5.75 \text{ ft})) + \left(3 \times (-0.44092 \text{ kip/ft}) \times (5.75 \text{ ft})^2\right)}{(6 \times (3.5901 \text{ kipft/ft})) + (4 \times (-0.44092 \text{ kip/ft}) \times (5.75 \text{ ft}))}$$

$$a = 3.9867 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (3.5901 \text{ kipft/ft})) + (3 \times (-0.44092 \text{ kip/ft}) \times (5.75 \text{ ft}))]^2}{(5.75 \text{ ft})^2 \times [(3 \times (3.5901 \text{ kipft/ft})) + (2 \times (-0.44092 \text{ kip/ft}) \times (5.75 \text{ ft}))]}$$

$$p = 0.18158 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (3.5901 \text{ kipft/ft})) + ((-0.44092 \text{ kip/ft}) \times (5.75 \text{ ft}))]}{(5.75 \text{ ft})^2}$$

$$s = 0.84294 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(3.9867 \text{ ft})}{2}$$

$$p_a = 0.299 \text{ kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.18158 \text{ kip/ft}^2)}{(0.299 \text{ kip/ft}^2)}$$

$$Ratio = 0.60728$$

Status: **PASS**
Ratio: **0.610**

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (5.75\ \mathrm{ft})$$

$$p_s = 0.8625\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.84294\ \mathrm{kip/ft^2}\right)}{\left(0.8625\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.97732$$

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

Considering z-direction:

$H_o = -0.020382\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 0.036465\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.036465\ \mathrm{kipft/ft}) \times (5.75\ \mathrm{ft})) + \left(3 \times (-0.020382\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft})^2\right)}{(6 \times (0.036465\ \mathrm{kipft/ft})) + (4 \times (-0.020382\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))}$$

$$a = 4.16\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.036465\ \mathrm{kipft/ft})) + (3 \times (-0.020382\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))]^{\ 2}}{(5.75\ \mathrm{ft})^2 \times [(3 \times (0.036465\ \mathrm{kipft/ft})) + (2 \times (-0.020382\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))]}$$

$$p = -0.0076811\ \mathrm{kip/ft^2}$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (0.036465\ \mathrm{kipft/ft})) + ((-0.020382\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))]}{(5.75\ \mathrm{ft})^2}$$

$$s = -0.0080334\ \mathrm{kip/ft^2}$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \mathrm{psf/ft}) \times \frac{(4.16\ \mathrm{ft})}{2}$$

$$p_a = 0.312\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(-0.0076811\ \mathrm{kip/ft^2}\right)}{\left(0.312\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = -0.024619$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (5.75\ \mathrm{ft})$$

$$p_s = 0.8625\ \mathrm{kip/ft^2}$$

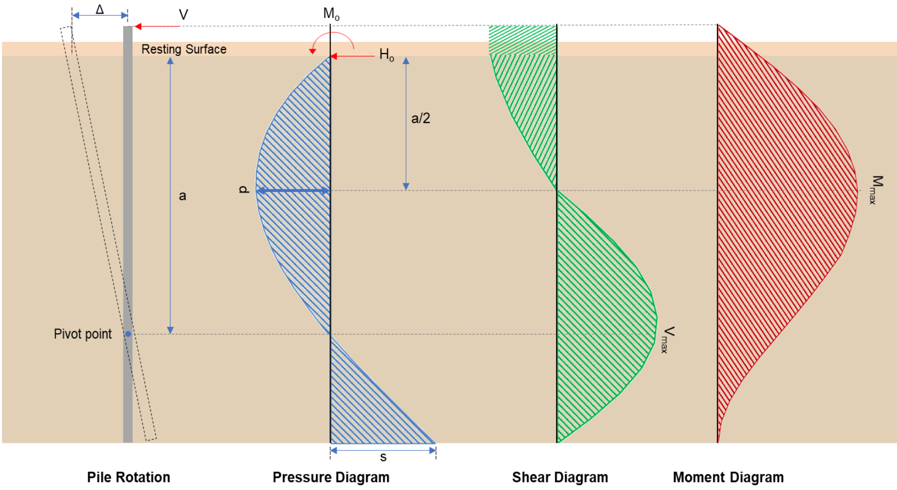
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(-0.0080334\ \mathrm{kip/ft^2})}{(0.8625\ \mathrm{kip/ft^2})}$$

$$Ratio = -0.0093141$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-4.613\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.73455\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(37.813\ \mathrm{kipft}) + ((-4.613\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 6.0212\ \mathrm{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(6.0212\ \mathrm{kipft/ft})}{(-0.73455\ \mathrm{kip/ft})}$$

$$E = 8.1971\ \mathrm{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (6.0212\ \mathrm{kipft/ft}) \times (5.75\ \mathrm{ft})) + \left(3 \times (-0.73455\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft})^2\right)}{(6 \times (6.0212\ \mathrm{kipft/ft})) + (4 \times (-0.73455\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))}$$

$$a = 3.986\ \mathrm{ft}$$

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

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

$$V_{max} = ((-0.73455\ \mathrm{kip/ft}) \times (48\ \mathrm{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (8.1971\ \mathrm{ft})}{(5.75\ \mathrm{ft})} + 3\right) \times \left(\frac{(3.986\ \mathrm{ft})}{(5.75\ \mathrm{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (8.1971\ \mathrm{ft})}{(5.75\ \mathrm{ft})} + 2\right) \times \left(\frac{(3.986\ \mathrm{ft})}{(5.75\ \mathrm{ft})}\right)^3\right]\right]$$

$$V_{max} = 9.3492\ \mathrm{kip}$$

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

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

$$M_{max} = ((-0.73455 \text{ kip/ft}) \times (48 \text{ in}) \times (5.75 \text{ ft})) \times \left[\left(\frac{(8.1971 \text{ ft})}{(5.75 \text{ ft})} + \frac{(3.986 \text{ ft})}{2 \times (5.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (8.1971 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(3.986 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (8.1971 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(3.986 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 25.349 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.213 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.033917 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.381 \text{ kipft}) + ((-0.213 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.060669 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.060669 \text{ kipft/ft})}{(-0.033917 \text{ kip/ft})}$$

$$E = 1.7887 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.060669 \text{ kipft/ft}) \times (5.75 \text{ ft})) + \left(3 \times (-0.033917 \text{ kip/ft}) \times (5.75 \text{ ft})^2\right)}{(6 \times (0.060669 \text{ kipft/ft})) + (4 \times (-0.033917 \text{ kip/ft}) \times (5.75 \text{ ft}))}$$

$$a = 4.16 \text{ ft}$$

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

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

$$V_{max} = ((-0.033917 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (1.7887 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.16 \text{ ft})}{(5.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (1.7887 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.16 \text{ ft})}{(5.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.16574 \text{ kip}$$

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

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

$$M_{max} = ((-0.033917 \text{ kip/ft}) \times (48 \text{ in}) \times (5.75 \text{ ft})) \times \left[\left(\frac{(1.7887 \text{ ft})}{(5.75 \text{ ft})} + \frac{(4.16 \text{ ft})}{2 \times (5.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (1.7887 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.16 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (1.7887 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.16 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.40732 \text{ kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

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

Longitudinal reinforcement:

Required reinforcement due to axial load, $A_{st,required}$
22.4.2.2, 10.6.1.1 $A_{st,required}$

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

$$A_{st,required} = Min\left[\frac{\frac{(8.128 \text{ kip})}{(0.65)\times(0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2))\right]$$

$$A_{st,required} = -84.326 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[(-84.326 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))\right]$$

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

n_{rebar} - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

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

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

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

$Ratio$ - Capacity

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

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

$$Ratio = 0.96556$$

Status: **PASS**
Ratio: **0.970**

25.2.3 s_{rebar} - Minimum spacing of reinforcement,

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

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

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

Ties:

25.7.2.2 Since longitudinal reinforcement is $\leq$ No. 10ø: Use #3(0.375 in)
25.7.2.1 s_{ties} - Maximum spacing of ties,

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

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

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

Summary:

Main reinforcement: **14 - #5 (0.625 in)**

	Ties: **#3(0.375 in) - 10 in**	

Axial Compression Strength (ACI 318-19, LRFD)

22.4.2.2 ϕP_N - Allowable axial compressive strength

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

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

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

$Ratio$ - Capacity

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

$$Ratio = \frac{(8.128\ \mathrm{kip})}{(2675.2\ \mathrm{kip})}$$

$$Ratio = 0.0030383$$

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

Shear Strength (ACI 318-19, LRFD)

Parameters:

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

22.5.2.2 d - Effective depth

$$d = 0.80\, D$$

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

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

22.5.5.1.3 λ_s - size effect modification factor

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

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

$$\lambda_s = 0.64282$$

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

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

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

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

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

The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5\ \mathrm{ksi} \rightarrow 2500\ \mathrm{psi}$, $P = 8.128\ \mathrm{kip} \rightarrow 8128\ \mathrm{lbf}$,

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

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500\ \mathrm{psi})} + \frac{(8128\ \mathrm{lbf})}{6 \times (2304\ \mathrm{in}^2)}\right] \times (48\ \mathrm{in}) \times (38.4\ \mathrm{in})$$

$$V_{c,a} = 119.57\ \mathrm{kip}$$

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

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

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

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

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

V_c - Governing shear strength of concrete

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

$$V_c = Min\left[(296.21\ \mathrm{kip}), (119.57\ \mathrm{kip}), (348.89\ \mathrm{kip})\right]$$

$$V_c = 119.57\ \mathrm{kip}$$

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

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

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

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

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

A_v - Ties rebar area,

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

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

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

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

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

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

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

V_s - Governing shear strength of steel

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

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

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

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((119.57\ \text{kip}) + (50.894\ \text{kip}))$$

$$\phi V_n = 110.8\ \text{kip}$$

Considering x-direction:

$V_{max} = 9.3492\ \text{kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(9.3492\ \text{kip})}{(110.8\ \text{kip})}$$

$$Ratio = 0.084378$$

Status: **PASS**
Ratio: **0.080**

Considering z-direction:

$V_{max} = 0.16574\ \text{kip}$ - Maximum shear force in the z-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(0.16574\ \text{kip})}{(110.8\ \text{kip})}$$

$$Ratio = 0.0014958$$

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

Flexural Strength (ACI 318-19, LRFD)

S_m - Section modulus

$$S_m = \frac{b\, D^2}{6}$$

$$S_m = \frac{(48\ \text{in}) \times (48\ \text{in})^2}{6}$$

$$S_m = 18432\ \text{in}^3$$

	$\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$ $$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f_c')} \times S_m$$ $$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5ksi)} \times 18432.001in^3$$ $$\phi M_{n,1} = 249.600kipft$$	
14.5.2.1b	$\phi M_{n,2}$ $$\phi M_{n,2} = \phi\, 0.85\, f_{ck}'\, S_m$$ $$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5\text{ ksi}) \times \left(18432\text{ in}^3\right)$$ $$\phi M_{n,2} = 2121.6\text{ kipft}$$ Therefore, ϕM_n - Allowable flexural strength, $$\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$$ $$\phi M_n = MIN[(249.6\text{ kipft}), (2121.6\text{ kipft})]$$ $$\phi M_n = 249.6\text{ kipft}$$ **Considering x-direction:** $M_{max} = 25.349\text{ kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(25.349\text{ kipft})}{(249.6\text{ kipft})}$$ $$Ratio = 0.10156$$	Status: **PASS** Ratio: **0.100**
	Considering z-direction: $M_{max} = 0.40732\text{ kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(0.40732\text{ kipft})}{(249.6\text{ kipft})}$$ $$Ratio = 0.0016319$$	Status: **PASS** Ratio: **0.000**

REFERENCES	CALCULATIONS	RESULTS

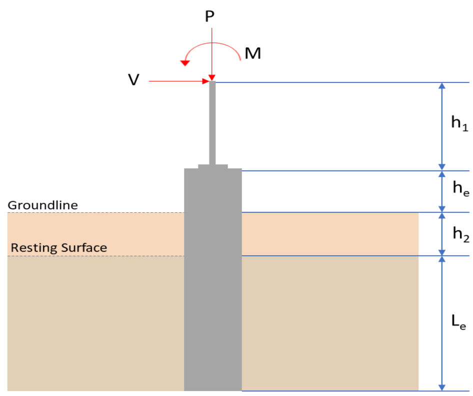
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: rectangular
$b = 48\ \mathrm{in}$ - Pile width
$D = 48\ \mathrm{in}$ - Pile depth
$L = 5.75\ \mathrm{ft}$ - Total pile length
$h_1 = 0\ \mathrm{ft}$ - Lateral load height from the top of the pile,
$h_2 = 0\ \mathrm{ft}$ - Depth to resisting surface
$h_e = 0\ \mathrm{ft}$ - Length of pile above the ground

Tabulation of Soil Parameters

Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) (psf/ft)
1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000

Tabulation of Loads

Load Component	ASD	LRFD
P (kip)	5.382	7.776
V_x (kip)	-2.639	-4.396
V_z (kip)	0.023	0.037
M_x (kipft)	0.035	0.059
M_z (kipft)	21.240	35.582

Material Properties

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

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

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

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

Considering x-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-2.639\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.42022\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(21.24 \text{ kipft}) + ((-2.639 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 3.3822 \text{ kipft/ft}$$

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:
$L_{e,x} = 5.1892 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.023 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.0036624 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.035 \text{ kipft}) + ((0.023 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.0055732 \text{ kipft/ft}$$

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:
$L_{e,z} = 0.8592 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(5.1892 \text{ ft}), (0.8592 \text{ ft})]$$

$$L_{e,req} = 5.189 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (5.75 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$$

$$L_e = 5.75 \text{ ft}$$

$Ratio$ - Embedded depth

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

$$Ratio = \frac{(5.189 \text{ ft})}{(5.75 \text{ ft})}$$

$$Ratio = 0.90243$$

Status: **PASS**
Ratio: **0.900**

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

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

$$q = \frac{(5.382 \text{ kip})}{(16 \text{ ft}^2)}$$

$$q = 0.33638 \text{ kip/ft}^2$$

$$q = 0.33638 \text{ kip/ft}^2$$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{\left(0.33638 \text{ kip/ft}^2\right)}{(2000 \text{ psf})}$$

$$Ratio = 0.16819$$

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

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(5.75 \text{ ft})}{(48 \text{ in})}$$

$$L/D = 1.4375$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.42022 \text{ kip/ft}$ - Lateral force per length of pile,
$M_o = 3.3822 \text{ kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (3.3822 \text{ kipft/ft}) \times (5.75 \text{ ft})) + \left(3 \times (-0.42022 \text{ kip/ft}) \times (5.75 \text{ ft})^2\right)}{(6 \times (3.3822 \text{ kipft/ft})) + (4 \times (-0.42022 \text{ kip/ft}) \times (5.75 \text{ ft}))}$$

$$a = 3.9879 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (3.3822 \text{ kipft/ft})) + (3 \times (-0.42022 \text{ kip/ft}) \times (5.75 \text{ ft}))]^2}{(5.75 \text{ ft})^2 \times [(3 \times (3.3822 \text{ kipft/ft})) + (2 \times (-0.42022 \text{ kip/ft}) \times (5.75 \text{ ft}))]}$$

$$p = 0.16835 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (3.3822 \text{ kipft/ft})) + ((-0.42022 \text{ kip/ft}) \times (5.75 \text{ ft}))]}{(5.75 \text{ ft})^2}$$

$$s = 0.78906 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(3.9879 \text{ ft})}{2}$$

$$p_a = 0.2991 \text{ kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.16835 \text{ kip/ft}^2\right)}{\left(0.2991 \text{ kip/ft}^2\right)}$$

$$Ratio = 0.56285$$

Status: **PASS**
Ratio: **0.560**

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (5.75\ \mathrm{ft})$$

$$p_s = 0.8625\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.78906\ \mathrm{kip/ft^2})}{(0.8625\ \mathrm{kip/ft^2})}$$

$$Ratio = 0.91485$$

Status: PASS
Ratio: 0.910

Considering z-direction:

$H_o = 0.0036624\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 0.0055732\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.0055732\ \mathrm{kipft/ft}) \times (5.75\ \mathrm{ft})) + \left(3 \times (0.0036624\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft})^2\right)}{(6 \times (0.0055732\ \mathrm{kipft/ft})) + (4 \times (0.0036624\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))}$$

$$a = 4.1763\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.0055732\ \mathrm{kipft/ft})) + (3 \times (0.0036624\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))]^{\ 2}}{(5.75\ \mathrm{ft})^2 \times [(3 \times (0.0055732\ \mathrm{kipft/ft})) + (2 \times (0.0036624\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))]}$$

$$p = 0.0028164\ \mathrm{kip/ft^2}$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (0.0055732\ \mathrm{kipft/ft})) + ((0.0036624\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))]}{(5.75\ \mathrm{ft})^2}$$

$$s = 0.0058445\ \mathrm{kip/ft^2}$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \mathrm{psf/ft}) \times \frac{(4.1763\ \mathrm{ft})}{2}$$

$$p_a = 0.31323\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.0028164\ \mathrm{kip/ft^2})}{(0.31323\ \mathrm{kip/ft^2})}$$

$$Ratio = 0.0089916$$

Status: PASS
Ratio: 0.010

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (5.75\ \mathrm{ft})$$

$$p_s = 0.8625\ \mathrm{kip/ft^2}$$

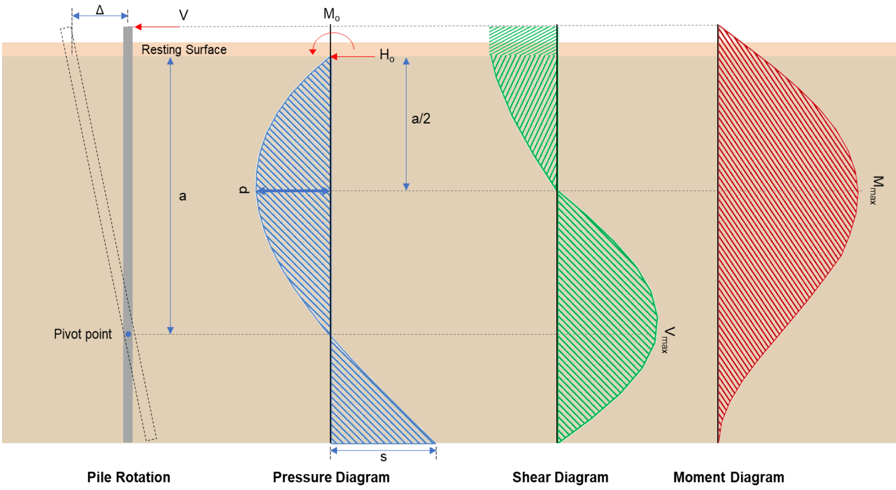
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.0058445 \text{ kip/ft}^2\right)}{\left(0.8625 \text{ kip/ft}^2\right)}$$

$$Ratio = 0.0067762$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-4.396 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.7 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(35.582 \text{ kipft}) + ((-4.396 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 5.6659 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(5.6659 \text{ kipft/ft})}{(-0.7 \text{ kip/ft})}$$

$$E = 8.0942 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.6659 \text{ kipft/ft}) \times (5.75 \text{ ft})) + \left(3 \times (-0.7 \text{ kip/ft}) \times (5.75 \text{ ft})^2\right)}{(6 \times (5.6659 \text{ kipft/ft})) + (4 \times (-0.7 \text{ kip/ft}) \times (5.75 \text{ ft}))}$$

$$a = 3.9873 \text{ ft}$$

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

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

$$V_{max} = ((-0.7 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (8.0942 \text{ ft})}{(5.75 \text{ ft})} + 3\right) \times \left(\frac{(3.9873 \text{ ft})}{(5.75 \text{ ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (8.0942 \text{ ft})}{(5.75 \text{ ft})} + 2\right) \times \left(\frac{(3.9873 \text{ ft})}{(5.75 \text{ ft})}\right)^3\right]\right]$$

$$V_{max} = 8.8208 \text{ kip}$$

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

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

$$M_{max} = ((-0.7\text{ kip/ft}) \times (48\text{ in}) \times (5.75\text{ ft})) \times \left[\left(\frac{(8.0942\text{ ft})}{(5.75\text{ ft})} + \frac{(3.9873\text{ ft})}{2 \times (5.75\text{ ft})}\right) - \left[\left(\frac{4 \times (8.0942\text{ ft})}{(5.75\text{ ft})} + 3\right) \times \left(\frac{(3.9873\text{ ft})}{2 \times (5.75\text{ ft})}\right)^3\right] + \left[\left(\frac{3 \times (8.0942\text{ ft})}{(5.75\text{ ft})} + 2\right) \times \left(\frac{(3.9873\text{ ft})}{2 \times (5.75\text{ ft})}\right)^4\right]\right]$$

$$M_{max} = 23.902\text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.037\text{ kip})}{1.57 \times (48\text{ in})}$$

$$H_o = 0.0058917\text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.059\text{ kipft}) + ((0.037\text{ kip}) \times (0\text{ ft}))}{1.57 \times (48\text{ in})}$$

$$M_o = 0.009395\text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.009395\text{ kipft/ft})}{(0.0058917\text{ kip/ft})}$$

$$E = 1.5946\text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.009395\text{ kipft/ft}) \times (5.75\text{ ft})) + \left(3 \times (0.0058917\text{ kip/ft}) \times (5.75\text{ ft})^2\right)}{(6 \times (0.009395\text{ kipft/ft})) + (4 \times (0.0058917\text{ kip/ft}) \times (5.75\text{ ft}))}$$

$$a = 4.1717\text{ ft}$$

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

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

$$V_{max} = ((0.0058917\text{ kip/ft}) \times (48\text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (1.5946\text{ ft})}{(5.75\text{ ft})} + 3\right) \times \left(\frac{(4.1717\text{ ft})}{(5.75\text{ ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (1.5946\text{ ft})}{(5.75\text{ ft})} + 2\right) \times \left(\frac{(4.1717\text{ ft})}{(5.75\text{ ft})}\right)^3\right]\right]$$

$$V_{max} = 0.027409\text{ kip}$$

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

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

$$M_{max} = ((0.0058917\text{ kip/ft}) \times (48\text{ in}) \times (5.75\text{ ft})) \times \left[\left(\frac{(1.5946\text{ ft})}{(5.75\text{ ft})} + \frac{(4.1717\text{ ft})}{2 \times (5.75\text{ ft})}\right) - \left[\left(\frac{4 \times (1.5946\text{ ft})}{(5.75\text{ ft})} + 3\right) \times \left(\frac{(4.1717\text{ ft})}{2 \times (5.75\text{ ft})}\right)^3\right] + \left[\left(\frac{3 \times (1.5946\text{ ft})}{(5.75\text{ ft})} + 2\right) \times \left(\frac{(4.1717\text{ ft})}{2 \times (5.75\text{ ft})}\right)^4\right]\right]$$

$$M_{max} = 0.0668 \text{ kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

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

Longitudinal reinforcement:

Required reinforcement due to axial load, $A_{st,required}$
22.4.2.2, 10.6.1.1 $A_{st,required}$

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

$$A_{st,required} = Min\left[\frac{\frac{(7.776 \text{ kip})}{(0.65)\times(0.8)} - \left(0.85 \times (2.5 \text{ ksi}) \times \left(2304 \text{ in}^2\right)\right)}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, \left(0.08 \times \left(2304 \text{ in}^2\right)\right)\right]$$

$$A_{st,required} = -84.338 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[\left(-84.338 \text{ in}^2\right), \left(0.0018 \times \left(2304 \text{ in}^2\right)\right)\right]$$

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

n_{rebar} - Required number of reinforcement,

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

$$n_{rebar} = \frac{\left(4.1472 \text{ in}^2\right)}{\left(0.3068 \text{ in}^2\right)}$$

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

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

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

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

$Ratio$ - Capacity

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

$$Ratio = \frac{\left(4.1472 \text{ in}^2\right)}{\left(4.2951 \text{ in}^2\right)}$$

$$Ratio = 0.96556$$

Status: **PASS**
Ratio: **0.970**

25.2.3 s_{rebar} - Minimum spacing of reinforcement,

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

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

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

Ties:

25.7.2.2 Since longitudinal reinforcement is $\leq$ No. 10ø: Use #3(0.375 in)
25.7.2.1 s_{ties} - Maximum spacing of ties,

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

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

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

Summary:

Main reinforcement: **14 - #5 (0.625 in)**

Ties: **#3(0.375 in) - 10 in**

Axial Compression Strength (ACI 318-19, LRFD)

22.4.2.2 ϕP_N - Allowable axial compressive strength

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

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

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

$Ratio$ - Capacity

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

$$Ratio = \frac{(7.776\text{ kip})}{(2675.2\text{ kip})}$$

$$Ratio = 0.0029067$$

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

Shear Strength (ACI 318-19, LRFD)

Parameters:

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

$$d = 0.80\, D$$

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

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

22.5.5.1.3 λ_s - size effect modification factor

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

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

$$\lambda_s = 0.64282$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5\text{ ksi} \to 2500\text{ psi}$,
22.5.5.1.1 $V_{c,max}$ - Max shear strength of concrete

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

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

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

The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5\text{ ksi} \to 2500\text{ psi}$, $P = 7.776\text{ kip} \to 7776\text{ lbf}$,
22.5.5.1.1(a) $V_{c,a}$ - Shear strength of concrete (a)

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500\text{ psi})} + \frac{(7776\text{ lbf})}{6 \times \left(2304\text{ in}^2\right)}\right] \times (48\text{ in}) \times (38.4\text{ in})$$

$$V_{c,a} = 119.52\text{ kip}$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5\text{ ksi} \to 2500\text{ psi}$,
22.5.5.1.2 $V_{c,b}$ - Shear strength of concrete (b)

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

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

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

V_c - Governing shear strength of concrete

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

$$V_c = Min\left[(296.21\text{ kip}), (119.52\text{ kip}), (348.89\text{ kip})\right]$$

$$V_c = 119.52\text{ kip}$$

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

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

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

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

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

A_v - Ties rebar area,

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

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

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

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

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

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

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

V_s - Governing shear strength of steel

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

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

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

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((119.52 \text{ kip}) + (50.894 \text{ kip}))$$

$$\phi V_n = 110.77 \text{ kip}$$

Considering x-direction:

$V_{max} = 8.8208 \text{ kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(8.8208 \text{ kip})}{(110.77 \text{ kip})}$$

$$Ratio = 0.079631$$

Status: **PASS**
Ratio: **0.080**

Considering z-direction:

$V_{max} = 0.027409 \text{ kip}$ - Maximum shear force in the z-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(0.027409 \text{ kip})}{(110.77 \text{ kip})}$$

$$Ratio = 0.00024744$$

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

Flexural Strength (ACI 318-19, LRFD)

S_m - Section modulus

$$S_m = \frac{b\, D^2}{6}$$

$$S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$$

$$S_m = 18432 \text{ in}^3$$

	$\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$ $$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f_c')} \times S_m$$ $$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5ksi)} \times 18432.001in^3$$ $$\phi M_{n,1} = 249.600kipft$$	
14.5.2.1b	$\phi M_{n,2}$ $$\phi M_{n,2} = \phi\, 0.85\, f_{ck}'\, S_m$$ $$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5\ \mathrm{ksi}) \times \left(18432\ \mathrm{in}^3\right)$$ $$\phi M_{n,2} = 2121.6\ \mathrm{kipft}$$ Therefore, ϕM_n - Allowable flexural strength, $$\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$$ $$\phi M_n = MIN[(249.6\ \mathrm{kipft}), (2121.6\ \mathrm{kipft})]$$ $$\phi M_n = 249.6\ \mathrm{kipft}$$ **Considering x-direction:** $M_{max} = 23.902\ \mathrm{kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(23.902\ \mathrm{kipft})}{(249.6\ \mathrm{kipft})}$$ $$Ratio = 0.095761$$	Status: **PASS** Ratio: **0.100**
	Considering z-direction: $M_{max} = 0.0668\ \mathrm{kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(0.0668\ \mathrm{kipft})}{(249.6\ \mathrm{kipft})}$$ $$Ratio = 0.00026763$$	Status: **PASS** Ratio: **0.000**

REFERENCES	CALCULATIONS	RESULTS

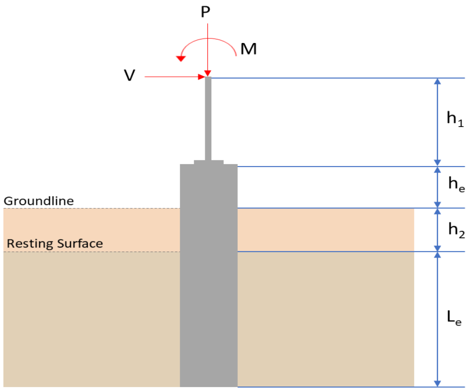
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: rectangular
$b = 48\ \mathrm{in}$ - Pile width
$D = 48\ \mathrm{in}$ - Pile depth
$L = 5.75\ \mathrm{ft}$ - Total pile length
$h_1 = 0\ \mathrm{ft}$ - Lateral load height from the top of the pile,
$h_2 = 0\ \mathrm{ft}$ - Depth to resisting surface
$h_e = 0\ \mathrm{ft}$ - Length of pile above the ground

Tabulation of Soil Parameters

Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) $(\mathrm{psf/ft})$
1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000

Tabulation of Loads

Load Component	ASD	LRFD
P (kip)	5.382	7.776
V_x (kip)	-2.639	-4.396
V_z (kip)	-0.023	-0.037
M_x (kipft)	-0.035	-0.059
M_z (kipft)	21.240	35.582

Material Properties

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

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

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

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

Considering x-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-2.639\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.42022\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(21.24\ \mathrm{kipft}) + ((-2.639\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 3.3822\ \mathrm{kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:
$L_{e,x} = 5.1892\ \mathrm{ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.023\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.0036624\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.035\ \mathrm{kipft}) + ((-0.023\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 0.0055732\ \mathrm{kipft/ft}$$

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:
$L_{e,z} = 0.66853\ \mathrm{ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(5.1892\ \mathrm{ft}), (0.66853\ \mathrm{ft})]$$

$$L_{e,req} = 5.189\ \mathrm{ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (5.75\ \mathrm{ft}) - (0\ \mathrm{ft}) - (0\ \mathrm{ft})$$

$$L_e = 5.75\ \mathrm{ft}$$

$Ratio$ - Embedded depth

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

$$Ratio = \frac{(5.189\ \mathrm{ft})}{(5.75\ \mathrm{ft})}$$

$$Ratio = 0.90243$$

Status: **PASS**
Ratio: **0.900**

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = b\, D$$

$$A = (48\ \mathrm{in}) \times (48\ \mathrm{in})$$

$$A = 16\ \mathrm{ft}^2$$

q - End-bearing pressure

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

$$q = \frac{(5.382\ \mathrm{kip})}{(16\ \mathrm{ft}^2)}$$

$$q = 0.33638\ \mathrm{kip/ft}^2$$

$$q = 0.33638\ \mathrm{kip/ft^2}$$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{\left(0.33638\ \mathrm{kip/ft^2}\right)}{\left(2000\ \mathrm{psf}\right)}$$

$$Ratio = 0.16819$$

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

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{\left(5.75\ \mathrm{ft}\right)}{\left(48\ \mathrm{in}\right)}$$

$$L/D = 1.4375$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.42022\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 3.3822\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{\left(4 \times \left(3.3822\ \mathrm{kipft/ft}\right) \times \left(5.75\ \mathrm{ft}\right)\right) + \left(3 \times \left(-0.42022\ \mathrm{kip/ft}\right) \times \left(5.75\ \mathrm{ft}\right)^2\right)}{\left(6 \times \left(3.3822\ \mathrm{kipft/ft}\right)\right) + \left(4 \times \left(-0.42022\ \mathrm{kip/ft}\right) \times \left(5.75\ \mathrm{ft}\right)\right)}$$

$$a = 3.9879\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times \left[\left(4 \times \left(3.3822\ \mathrm{kipft/ft}\right)\right) + \left(3 \times \left(-0.42022\ \mathrm{kip/ft}\right) \times \left(5.75\ \mathrm{ft}\right)\right)\right]^{\ 2}}{\left(5.75\ \mathrm{ft}\right)^2 \times \left[\left(3 \times \left(3.3822\ \mathrm{kipft/ft}\right)\right) + \left(2 \times \left(-0.42022\ \mathrm{kip/ft}\right) \times \left(5.75\ \mathrm{ft}\right)\right)\right]}$$

$$p = 0.16835\ \mathrm{kip/ft^2}$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times \left[\left(2 \times \left(3.3822\ \mathrm{kipft/ft}\right)\right) + \left(\left(-0.42022\ \mathrm{kip/ft}\right) \times \left(5.75\ \mathrm{ft}\right)\right)\right]}{\left(5.75\ \mathrm{ft}\right)^2}$$

$$s = 0.78906\ \mathrm{kip/ft^2}$$

Check lateral soil pressure capacity:

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

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

$$p_a = \left(150\ \mathrm{psf/ft}\right) \times \frac{\left(3.9879\ \mathrm{ft}\right)}{2}$$

$$p_a = 0.2991\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.16835\ \mathrm{kip/ft^2}\right)}{\left(0.2991\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.56285$$

Status: **PASS**
Ratio: **0.560**

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\, L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (5.75\ \mathrm{ft})$$

$$p_s = 0.8625\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.78906\ \mathrm{kip/ft^2}\right)}{\left(0.8625\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.91485$$

Status: PASS
Ratio: 0.910

Considering z-direction:

$H_o = -0.0036624\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 0.0055732\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.0055732\ \mathrm{kipft/ft}) \times (5.75\ \mathrm{ft})) + \left(3 \times (-0.0036624\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft})^2\right)}{(6 \times (0.0055732\ \mathrm{kipft/ft})) + (4 \times (-0.0036624\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))}$$

$$a = 4.1763\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.0055732\ \mathrm{kipft/ft})) + (3 \times (-0.0036624\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))]^2}{(5.75\ \mathrm{ft})^2 \times [(3 \times (0.0055732\ \mathrm{kipft/ft})) + (2 \times (-0.0036624\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))]}$$

$$p = -0.0014929\ \mathrm{kip/ft^2}$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (0.0055732\ \mathrm{kipft/ft})) + ((-0.0036624\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))]}{(5.75\ \mathrm{ft})^2}$$

$$s = -0.0017989\ \mathrm{kip/ft^2}$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \mathrm{psf/ft}) \times \frac{(4.1763\ \mathrm{ft})}{2}$$

$$p_a = 0.31323\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(-0.0014929\ \mathrm{kip/ft^2}\right)}{\left(0.31323\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = -0.0047662$$

Status: PASS
Ratio: 0.000

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\, L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (5.75\ \mathrm{ft})$$

$$p_s = 0.8625\ \mathrm{kip/ft^2}$$

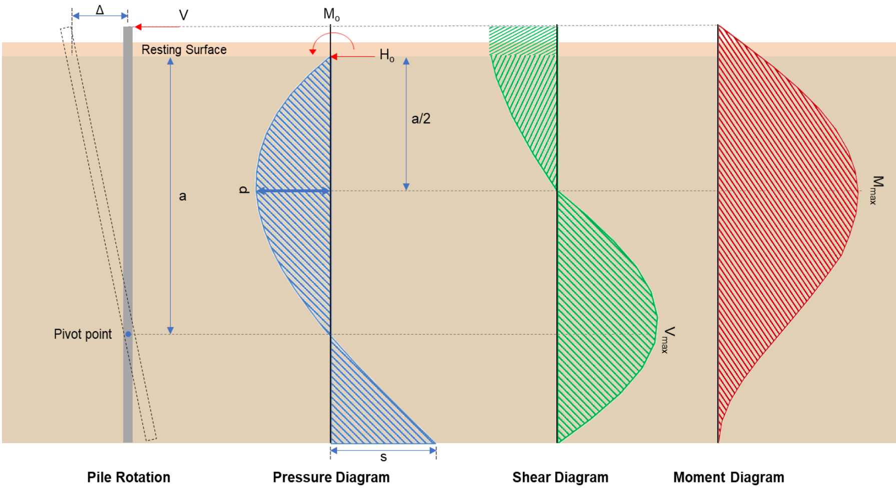
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(-0.0017989\ \mathrm{kip/ft^2}\right)}{\left(0.8625\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = -0.0020856$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{\left(-4.396\ \mathrm{kip}\right)}{1.57 \times \left(48\ \mathrm{in}\right)}$$

$$H_o = -0.7\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{\left(35.582\ \mathrm{kipft}\right) + \left(\left(-4.396\ \mathrm{kip}\right) \times \left(0\ \mathrm{ft}\right)\right)}{1.57 \times \left(48\ \mathrm{in}\right)}$$

$$M_o = 5.6659\ \mathrm{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{\left(5.6659\ \mathrm{kipft/ft}\right)}{\left(-0.7\ \mathrm{kip/ft}\right)}$$

$$E = 8.0942\ \mathrm{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{\left(4 \times \left(5.6659\ \mathrm{kipft/ft}\right) \times \left(5.75\ \mathrm{ft}\right)\right) + \left(3 \times \left(-0.7\ \mathrm{kip/ft}\right) \times \left(5.75\ \mathrm{ft}\right)^2\right)}{\left(6 \times \left(5.6659\ \mathrm{kipft/ft}\right)\right) + \left(4 \times \left(-0.7\ \mathrm{kip/ft}\right) \times \left(5.75\ \mathrm{ft}\right)\right)}$$

$$a = 3.9873\ \mathrm{ft}$$

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

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

$$V_{max} = \left(\left(-0.7\ \mathrm{kip/ft}\right) \times \left(48\ \mathrm{in}\right)\right) \times \left[1 - \left[3 \times \left(\frac{4 \times \left(8.0942\ \mathrm{ft}\right)}{\left(5.75\ \mathrm{ft}\right)} + 3\right) \times \left(\frac{\left(3.9873\ \mathrm{ft}\right)}{\left(5.75\ \mathrm{ft}\right)}\right)^2\right] + \left[4 \times \left(\frac{3 \times \left(8.0942\ \mathrm{ft}\right)}{\left(5.75\ \mathrm{ft}\right)} + 2\right) \times \left(\frac{\left(3.9873\ \mathrm{ft}\right)}{\left(5.75\ \mathrm{ft}\right)}\right)^3\right]\right]$$

$$V_{max} = 8.8208\ \mathrm{kip}$$

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

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

$$M_{max} = ((-0.7 \text{ kip/ft}) \times (48 \text{ in}) \times (5.75 \text{ ft})) \times \left[\left(\frac{(8.0942 \text{ ft})}{(5.75 \text{ ft})} + \frac{(3.9873 \text{ ft})}{2 \times (5.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (8.0942 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(3.9873 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (8.0942 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(3.9873 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 23.902 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.037 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.0058917 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.059 \text{ kipft}) + ((-0.037 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.009395 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.009395 \text{ kipft/ft})}{(-0.0058917 \text{ kip/ft})}$$

$$E = 1.5946 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.009395 \text{ kipft/ft}) \times (5.75 \text{ ft})) + \left(3 \times (-0.0058917 \text{ kip/ft}) \times (5.75 \text{ ft})^2\right)}{(6 \times (0.009395 \text{ kipft/ft})) + (4 \times (-0.0058917 \text{ kip/ft}) \times (5.75 \text{ ft}))}$$

$$a = 4.1717 \text{ ft}$$

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

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

$$V_{max} = ((-0.0058917 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (1.5946 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.1717 \text{ ft})}{(5.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (1.5946 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.1717 \text{ ft})}{(5.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.027409 \text{ kip}$$

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

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

$$M_{max} = ((-0.0058917 \text{ kip/ft}) \times (48 \text{ in}) \times (5.75 \text{ ft})) \times \left[\left(\frac{(1.5946 \text{ ft})}{(5.75 \text{ ft})} + \frac{(4.1717 \text{ ft})}{2 \times (5.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (1.5946 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.1717 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (1.5946 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.1717 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.0668 \text{ kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

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

Longitudinal reinforcement:

Required reinforcement due to axial load, $A_{st,required}$
22.4.2.2, 10.6.1.1 $A_{st,required}$

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

$$A_{st,required} = Min\left[\frac{\frac{(7.776 \text{ kip})}{(0.65)\times(0.8)} - \left(0.85 \times (2.5 \text{ ksi}) \times \left(2304 \text{ in}^2\right)\right)}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, \left(0.08 \times \left(2304 \text{ in}^2\right)\right)\right]$$

$$A_{st,required} = -84.338 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[\left(-84.338 \text{ in}^2\right), \left(0.0018 \times \left(2304 \text{ in}^2\right)\right)\right]$$

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

n_{rebar} - Required number of reinforcement,

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

$$n_{rebar} = \frac{\left(4.1472 \text{ in}^2\right)}{\left(0.3068 \text{ in}^2\right)}$$

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

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

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

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

$Ratio$ - Capacity

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

$$Ratio = \frac{\left(4.1472 \text{ in}^2\right)}{\left(4.2951 \text{ in}^2\right)}$$

$$Ratio = 0.96556$$

Status: **PASS**
Ratio: **0.970**

25.2.3 s_{rebar} - Minimum spacing of reinforcement,

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

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

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

Ties:

25.7.2.2 Since longitudinal reinforcement is $\leq$ No. 10ø: Use #3(0.375 in)
25.7.2.1 s_{ties} - Maximum spacing of ties,

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

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

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

Summary:

Main reinforcement: **14 - #5 (0.625 in)**

	Ties: **#3(0.375 in) - 10 in**	

	Axial Compression Strength (ACI 318-19, LRFD)	
22.4.2.2	ϕP_N - Allowable axial compressive strength	
	$$\phi P_N = \phi\ 0.80\ \left[\left(0.85\ f'_{ck}\ \left[A_g - A_{st}\right]\right) + \left(f_{yk}\ A_{st}\right)\right]$$	
	$$\phi P_N = (0.65) \times 0.80 \times \left[\left(0.85 \times (2.5\ \mathrm{ksi}) \times \left[\left(2304\ \mathrm{in}^2\right) - \left(4.2951\ \mathrm{in}^2\right)\right]\right) + \left((60\ \mathrm{ksi}) \times \left(4.2951\ \mathrm{in}^2\right)\right)\right]$$	
	$$\phi P_N = 2675.2\ \mathrm{kip}$$	
	$Ratio$ - Capacity	
	$$Ratio = \frac{P}{\phi P_N}$$	
	$$Ratio = \frac{(7.776\ \mathrm{kip})}{(2675.2\ \mathrm{kip})}$$	
	$$Ratio = 0.0029067$$	Status: **PASS** Ratio: **0.000**

	Shear Strength (ACI 318-19, LRFD)	
	Parameters:	
	$b_w = 48\ \mathrm{in}$ - Effective width,	
22.5.2.2	d - Effective depth	
	$$d = 0.80\ D$$	
	$$d = 0.80 \times (48\ \mathrm{in})$$	
	$$d = 38.4\ \mathrm{in}$$	
22.5.5.1.3	λ_s - size effect modification factor	
	$$\lambda_s = MIN\left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1\right]$$	
	$$\lambda_s = MIN\left[\sqrt{\frac{2}{1 + \frac{(38.4\ \mathrm{in})}{10}}}, 1\right]$$	
	$$\lambda_s = 0.64282$$	
	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5\ \mathrm{ksi} \rightarrow 2500\ \mathrm{psi}$,	
22.5.5.1.1	$V_{c,max}$ - Max shear strength of concrete	
	$$V_{c,max} = 5\ \lambda_s\ \sqrt{f'_{ck}}\ b_w\ d$$	
	$$V_{c,max} = 5 \times (0.64282) \times \sqrt{(2500\ \mathrm{psi})} \times (48\ \mathrm{in}) \times (38.4\ \mathrm{in})$$	
	$$V_{c,max} = 296.21\ \mathrm{kip}$$	
	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5\ \mathrm{ksi} \rightarrow 2500\ \mathrm{psi}$, $P = 7.776\ \mathrm{kip} \rightarrow 7776\ \mathrm{lbf}$,	
22.5.5.1.1(a)	$V_{c,a}$ - Shear strength of concrete (a)	
	$$V_{c,a} = \left[2\ \lambda_s\ \sqrt{f'_{ck}} + \frac{P}{6\ A_g}\right]\ b_w\ d$$	
	$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500\ \mathrm{psi})} + \frac{(7776\ \mathrm{lbf})}{6 \times \left(2304\ \mathrm{in}^2\right)}\right] \times (48\ \mathrm{in}) \times (38.4\ \mathrm{in})$$	
	$$V_{c,a} = 119.52\ \mathrm{kip}$$	
	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5\ \mathrm{ksi} \rightarrow 2500\ \mathrm{psi}$,	
22.5.5.1.2	$V_{c,b}$ - Shear strength of concrete (b)	
	$$V_{c,b} = \left[2\ \lambda_s\ \sqrt{f'_{ck}} + \left(0.05\ f'_{ck}\right)\right]\ b_w\ d$$	
	$$V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(2500\ \mathrm{psi})} + (0.05 \times (2500\ \mathrm{psi}))\right] \times (48\ \mathrm{in}) \times (38.4\ \mathrm{in})$$	
	$$V_{c,b} = 348.89\ \mathrm{kip}$$	
	V_c - Governing shear strength of concrete	
	$$V_c = Min\left[V_{c,max}, V_{c,a}, V_{c,b}\right]$$	
	$$V_c = Min\left[(296.21\ \mathrm{kip}), (119.52\ \mathrm{kip}), (348.89\ \mathrm{kip})\right]$$	
	$$V_c = 119.52\ \mathrm{kip}$$	

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

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

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

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

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

A_v - Ties rebar area,

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

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

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

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

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

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

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

V_s - Governing shear strength of steel

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

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

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

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((119.52\ \text{kip}) + (50.894\ \text{kip}))$$

$$\phi V_n = 110.77\ \text{kip}$$

Considering x-direction:

$V_{max} = 8.8208\ \text{kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(8.8208\ \text{kip})}{(110.77\ \text{kip})}$$

$$Ratio = 0.079631$$

Status: **PASS**
Ratio: **0.080**

Considering z-direction:

$V_{max} = 0.027409\ \text{kip}$ - Maximum shear force in the z-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(0.027409\ \text{kip})}{(110.77\ \text{kip})}$$

$$Ratio = 0.00024744$$

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

Flexural Strength (ACI 318-19, LRFD)

S_m - Section modulus

$$S_m = \frac{b\, D^2}{6}$$

$$S_m = \frac{(48\ \text{in}) \times (48\ \text{in})^2}{6}$$

$$S_m = 18432\ \text{in}^3$$

	$\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$ $$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f_c')} \times S_m$$ $$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5ksi)} \times 18432.001in^3$$ $$\phi M_{n,1} = 249.600kipft$$	
14.5.2.1b	$\phi M_{n,2}$ $$\phi M_{n,2} = \phi\, 0.85\, f_{ck}'\, S_m$$ $$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5\ \mathrm{ksi}) \times \left(18432\ \mathrm{in}^3\right)$$ $$\phi M_{n,2} = 2121.6\ \mathrm{kipft}$$ Therefore, ϕM_n - Allowable flexural strength, $$\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$$ $$\phi M_n = MIN[(249.6\ \mathrm{kipft}), (2121.6\ \mathrm{kipft})]$$ $$\phi M_n = 249.6\ \mathrm{kipft}$$ **Considering x-direction:** $M_{max} = 23.902\ \mathrm{kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(23.902\ \mathrm{kipft})}{(249.6\ \mathrm{kipft})}$$ $$Ratio = 0.095761$$	Status: **PASS** Ratio: **0.100**
	Considering z-direction: $M_{max} = 0.0668\ \mathrm{kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(0.0668\ \mathrm{kipft})}{(249.6\ \mathrm{kipft})}$$ $$Ratio = 0.00026763$$	Status: **PASS** Ratio: **0.000**

REFERENCES	CALCULATIONS	RESULTS

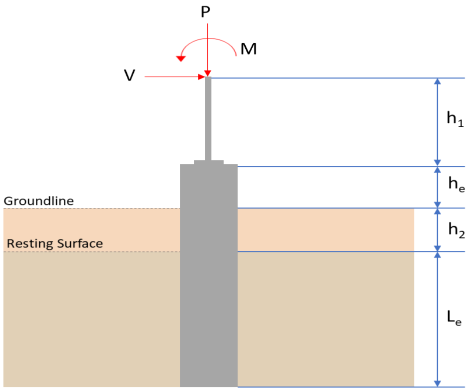
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: rectangular
$b = 48\ \mathrm{in}$ - Pile width
$D = 48\ \mathrm{in}$ - Pile depth
$L = 5.75\ \mathrm{ft}$ - Total pile length
$h_1 = 0\ \mathrm{ft}$ - Lateral load height from the top of the pile,
$h_2 = 0\ \mathrm{ft}$ - Depth to resisting surface
$h_e = 0\ \mathrm{ft}$ - Length of pile above the ground

Tabulation of Soil Parameters

Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) (psf/ft)
1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000

Tabulation of Loads

Load Component	ASD	LRFD
P (kip)	5.587	8.128
V_x (kip)	-2.769	-4.613
V_z (kip)	0.128	0.213
M_x (kipft)	0.229	0.381
M_z (kipft)	22.546	37.814

Material Properties

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

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

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

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

Considering x-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-2.769\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.44092\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(22.546\ \mathrm{kipft}) + ((-2.769\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 3.5901\ \mathrm{kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:
$L_{e,x} = 5.283\ \mathrm{ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.128\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = 0.020382\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.229\ \mathrm{kipft}) + ((0.128\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 0.036465\ \mathrm{kipft/ft}$$

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:
$L_{e,z} = 1.711\ \mathrm{ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(5.283\ \mathrm{ft}), (1.711\ \mathrm{ft})]$$

$$L_{e,req} = 5.283\ \mathrm{ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (5.75\ \mathrm{ft}) - (0\ \mathrm{ft}) - (0\ \mathrm{ft})$$

$$L_e = 5.75\ \mathrm{ft}$$

$Ratio$ - Embedded depth

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

$$Ratio = \frac{(5.283\ \mathrm{ft})}{(5.75\ \mathrm{ft})}$$

$$Ratio = 0.91878$$

Status: **PASS**
Ratio: **0.920**

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = b\, D$$

$$A = (48\ \mathrm{in}) \times (48\ \mathrm{in})$$

$$A = 16\ \mathrm{ft}^2$$

q - End-bearing pressure

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

$$q = \frac{(5.587\ \mathrm{kip})}{(16\ \mathrm{ft}^2)}$$

$$q = 0.34919\ \mathrm{kip/ft}^2$$

$$q = 0.34919 \text{ kip/ft}^2$$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{(0.34919 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$Ratio = 0.17459$$

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

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(5.75 \text{ ft})}{(48 \text{ in})}$$

$$L/D = 1.4375$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.44092 \text{ kip/ft}$ - Lateral force per length of pile,
$M_o = 3.5901 \text{ kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (3.5901 \text{ kipft/ft}) \times (5.75 \text{ ft})) + \left(3 \times (-0.44092 \text{ kip/ft}) \times (5.75 \text{ ft})^2\right)}{(6 \times (3.5901 \text{ kipft/ft})) + (4 \times (-0.44092 \text{ kip/ft}) \times (5.75 \text{ ft}))}$$

$$a = 3.9867 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (3.5901 \text{ kipft/ft})) + (3 \times (-0.44092 \text{ kip/ft}) \times (5.75 \text{ ft}))]^2}{(5.75 \text{ ft})^2 \times [(3 \times (3.5901 \text{ kipft/ft})) + (2 \times (-0.44092 \text{ kip/ft}) \times (5.75 \text{ ft}))]}$$

$$p = 0.18158 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (3.5901 \text{ kipft/ft})) + ((-0.44092 \text{ kip/ft}) \times (5.75 \text{ ft}))]}{(5.75 \text{ ft})^2}$$

$$s = 0.84294 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(3.9867 \text{ ft})}{2}$$

$$p_a = 0.299 \text{ kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.18158 \text{ kip/ft}^2)}{(0.299 \text{ kip/ft}^2)}$$

$$Ratio = 0.60728$$

Status: **PASS**
Ratio: **0.610**

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (5.75\ \mathrm{ft})$$

$$p_s = 0.8625\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.84294\ \mathrm{kip/ft^2}\right)}{\left(0.8625\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.97732$$

Status: PASS
Ratio: 0.980

Considering z-direction:

$H_o = 0.020382\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 0.036465\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.036465\ \mathrm{kipft/ft}) \times (5.75\ \mathrm{ft})) + \left(3 \times (0.020382\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft})^2\right)}{(6 \times (0.036465\ \mathrm{kipft/ft})) + (4 \times (0.020382\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))}$$

$$a = 4.16\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.036465\ \mathrm{kipft/ft})) + (3 \times (0.020382\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))]^2}{(5.75\ \mathrm{ft})^2 \times [(3 \times (0.036465\ \mathrm{kipft/ft})) + (2 \times (0.020382\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))]}$$

$$p = 0.016328\ \mathrm{kip/ft^2}$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (0.036465\ \mathrm{kipft/ft})) + ((0.020382\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))]}{(5.75\ \mathrm{ft})^2}$$

$$s = 0.034503\ \mathrm{kip/ft^2}$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \mathrm{psf/ft}) \times \frac{(4.16\ \mathrm{ft})}{2}$$

$$p_a = 0.312\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.016328\ \mathrm{kip/ft^2}\right)}{\left(0.312\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.052333$$

Status: PASS
Ratio: 0.050

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (5.75\ \mathrm{ft})$$

$$p_s = 0.8625\ \mathrm{kip/ft^2}$$

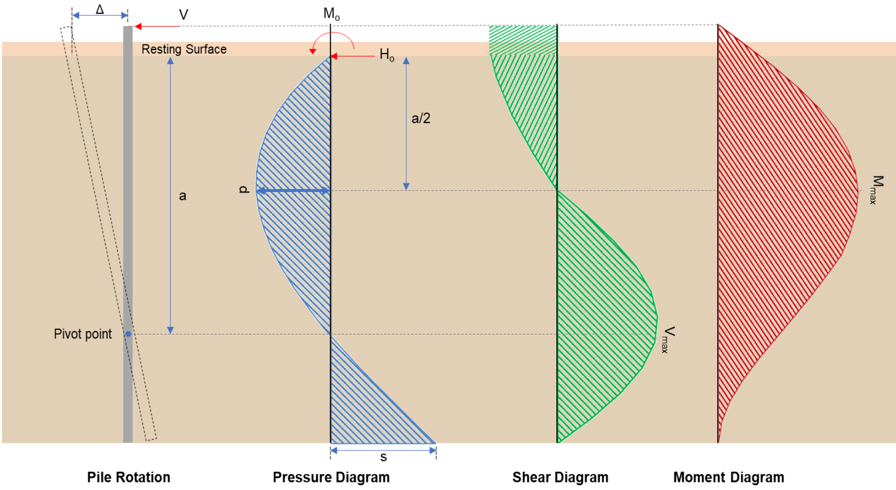
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.034503\ \mathrm{kip/ft^2})}{(0.8625\ \mathrm{kip/ft^2})}$$

$$Ratio = 0.040004$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-4.613\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.73455\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(37.814\ \mathrm{kipft}) + ((-4.613\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 6.0213\ \mathrm{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(6.0213\ \mathrm{kipft/ft})}{(-0.73455\ \mathrm{kip/ft})}$$

$$E = 8.1973\ \mathrm{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (6.0213\ \mathrm{kipft/ft}) \times (5.75\ \mathrm{ft})) + \left(3 \times (-0.73455\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft})^2\right)}{(6 \times (6.0213\ \mathrm{kipft/ft})) + (4 \times (-0.73455\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))}$$

$$a = 3.986\ \mathrm{ft}$$

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

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

$$V_{max} = ((-0.73455\ \mathrm{kip/ft}) \times (48\ \mathrm{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (8.1973\ \mathrm{ft})}{(5.75\ \mathrm{ft})} + 3\right) \times \left(\frac{(3.986\ \mathrm{ft})}{(5.75\ \mathrm{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (8.1973\ \mathrm{ft})}{(5.75\ \mathrm{ft})} + 2\right) \times \left(\frac{(3.986\ \mathrm{ft})}{(5.75\ \mathrm{ft})}\right)^3\right]\right]$$

$$V_{max} = 9.3494\ \mathrm{kip}$$

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

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

$$M_{max} = ((-0.73455\ \mathrm{kip/ft}) \times (48\ \mathrm{in}) \times (5.75\ \mathrm{ft})) \times \left[\left(\frac{(8.1973\ \mathrm{ft})}{(5.75\ \mathrm{ft})} + \frac{(3.986\ \mathrm{ft})}{2 \times (5.75\ \mathrm{ft})} \right) - \left[\left(\frac{4 \times (8.1973\ \mathrm{ft})}{(5.75\ \mathrm{ft})} + 3 \right) \times \left(\frac{(3.986\ \mathrm{ft})}{2 \times (5.75\ \mathrm{ft})} \right)^3 \right] + \left[\left(\frac{3 \times (8.1973\ \mathrm{ft})}{(5.75\ \mathrm{ft})} + 2 \right) \times \left(\frac{(3.986\ \mathrm{ft})}{2 \times (5.75\ \mathrm{ft})} \right)^4 \right] \right]$$

$$M_{max} = 25.35\ \mathrm{kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.213\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = 0.033917\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.381\ \mathrm{kipft}) + ((0.213\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 0.060669\ \mathrm{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.060669\ \mathrm{kipft/ft})}{(0.033917\ \mathrm{kip/ft})}$$

$$E = 1.7887\ \mathrm{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.060669\ \mathrm{kipft/ft}) \times (5.75\ \mathrm{ft})) + \left(3 \times (0.033917\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft})^2\right)}{(6 \times (0.060669\ \mathrm{kipft/ft})) + (4 \times (0.033917\ \mathrm{kip/ft}) \times (5.75\ \mathrm{ft}))}$$

$$a = 4.16\ \mathrm{ft}$$

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

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

$$V_{max} = ((0.033917\ \mathrm{kip/ft}) \times (48\ \mathrm{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (1.7887\ \mathrm{ft})}{(5.75\ \mathrm{ft})} + 3 \right) \times \left(\frac{(4.16\ \mathrm{ft})}{(5.75\ \mathrm{ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (1.7887\ \mathrm{ft})}{(5.75\ \mathrm{ft})} + 2 \right) \times \left(\frac{(4.16\ \mathrm{ft})}{(5.75\ \mathrm{ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.16574\ \mathrm{kip}$$

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

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

$$M_{max} = ((0.033917\ \mathrm{kip/ft}) \times (48\ \mathrm{in}) \times (5.75\ \mathrm{ft})) \times \left[\left(\frac{(1.7887\ \mathrm{ft})}{(5.75\ \mathrm{ft})} + \frac{(4.16\ \mathrm{ft})}{2 \times (5.75\ \mathrm{ft})} \right) - \left[\left(\frac{4 \times (1.7887\ \mathrm{ft})}{(5.75\ \mathrm{ft})} + 3 \right) \times \left(\frac{(4.16\ \mathrm{ft})}{2 \times (5.75\ \mathrm{ft})} \right)^3 \right] + \left[\left(\frac{3 \times (1.7887\ \mathrm{ft})}{(5.75\ \mathrm{ft})} + 2 \right) \times \left(\frac{(4.16\ \mathrm{ft})}{2 \times (5.75\ \mathrm{ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.40732 \text{ kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

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

Longitudinal reinforcement:

Required reinforcement due to axial load, $A_{st,required}$
22.4.2.2, 10.6.1.1 $A_{st,required}$

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

$$A_{st,required} = Min\left[\frac{\frac{(8.128 \text{ kip})}{(0.65)\times(0.8)} - \left(0.85 \times (2.5 \text{ ksi}) \times \left(2304 \text{ in}^2\right)\right)}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, \left(0.08 \times \left(2304 \text{ in}^2\right)\right)\right]$$

$$A_{st,required} = -84.326 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[\left(-84.326 \text{ in}^2\right), \left(0.0018 \times \left(2304 \text{ in}^2\right)\right)\right]$$

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

n_{rebar} - Required number of reinforcement,

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

$$n_{rebar} = \frac{\left(4.1472 \text{ in}^2\right)}{\left(0.3068 \text{ in}^2\right)}$$

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

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

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

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

$Ratio$ - Capacity

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

$$Ratio = \frac{\left(4.1472 \text{ in}^2\right)}{\left(4.2951 \text{ in}^2\right)}$$

$$Ratio = 0.96556$$

Status: **PASS**
Ratio: **0.970**

25.2.3 s_{rebar} - Minimum spacing of reinforcement,

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

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

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

Ties:

25.7.2.2 Since longitudinal reinforcement is $\leq$ No. 10ø: Use #3(0.375 in)
25.7.2.1 s_{ties} - Maximum spacing of ties,

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

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

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

Summary:

Main reinforcement: **14 - #5 (0.625 in)**

	Ties: **#3(0.375 in) - 10 in**	

Axial Compression Strength (ACI 318-19, LRFD)

22.4.2.2 ϕP_N - Allowable axial compressive strength

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

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

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

$Ratio$ - Capacity

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

$$Ratio = \frac{(8.128\ \mathrm{kip})}{(2675.2\ \mathrm{kip})}$$

$$Ratio = 0.0030383$$

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

Shear Strength (ACI 318-19, LRFD)

Parameters:

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

22.5.2.2 d - Effective depth

$$d = 0.80\, D$$

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

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

22.5.5.1.3 λ_s - size effect modification factor

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

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

$$\lambda_s = 0.64282$$

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

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

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

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

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

The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5\ \mathrm{ksi} \rightarrow 2500\ \mathrm{psi}$, $P = 8.128\ \mathrm{kip} \rightarrow 8128\ \mathrm{lbf}$,

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

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500\ \mathrm{psi})} + \frac{(8128\ \mathrm{lbf})}{6 \times (2304\ \mathrm{in}^2)}\right] \times (48\ \mathrm{in}) \times (38.4\ \mathrm{in})$$

$$V_{c,a} = 119.57\ \mathrm{kip}$$

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

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

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

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

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

V_c - Governing shear strength of concrete

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

$$V_c = Min\left[(296.21\ \mathrm{kip}), (119.57\ \mathrm{kip}), (348.89\ \mathrm{kip})\right]$$

$$V_c = 119.57\ \mathrm{kip}$$

	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5\ \mathrm{ksi} \rightarrow 2500\ \mathrm{psi}$,	
22.5.1.2	$V_{s,a}$ - Shear strength of steel (a) $$V_{s,a} = 8\sqrt{f'_{ck}}\ b_w\ d$$ $$V_{s,a} = 8 \times \sqrt{(2500\ \mathrm{psi})} \times (48\ \mathrm{in}) \times (38.4\ \mathrm{in})$$ $$V_{s,a} = 737.28\ \mathrm{kip}$$ A_v - Ties rebar area, $$A_v = \frac{\pi\ d_{ties}^2}{4}$$ $$A_v = \frac{\pi \times (0.375\ \mathrm{in})^2}{4}$$ $$A_v = 0.11045\ \mathrm{in}^2$$	
22.5.8.5.3	$V_{s,b}$ - Shear strength of steel (b) $$V_{s,b} = \frac{2\ A_v\ f_{ywk}\ d}{s_{ties}}$$ $$V_{s,b} = \frac{2 \times \left(0.11045\ \mathrm{in}^2\right) \times (60\ \mathrm{ksi}) \times (38.4\ \mathrm{in})}{(10\ \mathrm{in})}$$ $$V_{s,b} = 50.894\ \mathrm{kip}$$ V_s - Governing shear strength of steel $$V_s = MIN\left[V_{s,a}, V_{s,b}\right]$$ $$V_s = MIN\left[(737.28\ \mathrm{kip}), (50.894\ \mathrm{kip})\right]$$ $$V_s = 50.894\ \mathrm{kip}$$	
22.5.1.1	ϕV_n - Allowable shear strength $$\phi V_n = \phi\ (V_c + V_s)$$ $$\phi V_n = (0.65) \times ((119.57\ \mathrm{kip}) + (50.894\ \mathrm{kip}))$$ $$\phi V_n = 110.8\ \mathrm{kip}$$ **Considering x-direction:** $V_{max} = 9.3494\ \mathrm{kip}$ - Maximum shear force in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{V_{max}}{\phi V_n}$$ $$Ratio = \frac{(9.3494\ \mathrm{kip})}{(110.8\ \mathrm{kip})}$$ $$Ratio = 0.08438$$	Status: **PASS** Ratio: **0.080**
	Considering z-direction: $V_{max} = 0.16574\ \mathrm{kip}$ - Maximum shear force in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{V_{max}}{\phi V_n}$$ $$Ratio = \frac{(0.16574\ \mathrm{kip})}{(110.8\ \mathrm{kip})}$$ $$Ratio = 0.0014958$$	Status: **PASS** Ratio: **0.000**
	Flexural Strength (ACI 318-19, LRFD) S_m - Section modulus $$S_m = \frac{b\ D^2}{6}$$ $$S_m = \frac{(48\ \mathrm{in}) \times (48\ \mathrm{in})^2}{6}$$ $$S_m = 18432\ \mathrm{in}^3$$	

	$\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$ $$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f'_c)} \times S_m$$ $$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5ksi)} \times 18432.001in^3$$ $$\phi M_{n,1} = 249.600kipft$$	
14.5.2.1b	$\phi M_{n,2}$ $$\phi M_{n,2} = \phi\, 0.85\, f'_{ck}\, S_m$$ $$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5\ \mathrm{ksi}) \times \left(18432\ \mathrm{in}^3\right)$$ $$\phi M_{n,2} = 2121.6\ \mathrm{kipft}$$ Therefore, ϕM_n - Allowable flexural strength, $$\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$$ $$\phi M_n = MIN[(249.6\ \mathrm{kipft}), (2121.6\ \mathrm{kipft})]$$ $$\phi M_n = 249.6\ \mathrm{kipft}$$ **Considering x-direction:** $M_{max} = 25.35\ \mathrm{kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(25.35\ \mathrm{kipft})}{(249.6\ \mathrm{kipft})}$$ $$Ratio = 0.10156$$	Status: **PASS** Ratio: **0.100**
	Considering z-direction: $M_{max} = 0.40732\ \mathrm{kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(0.40732\ \mathrm{kipft})}{(249.6\ \mathrm{kipft})}$$ $$Ratio = 0.0016319$$	Status: **PASS** Ratio: **0.000**