Your Project Calculations

Project Name: 20230403 Sitterle

S3D Model Link:
https://platform.skyciv.com/structural?preload_name=20230403%20Sitterle&preload_path=Shared%20Enterprise%20Folder/MT_Solar_Projects/4_2023

Public Model Link:
https://platform.skyciv.com/structural-viewer?project_id=zjAEW4Ct1XhxrVOMvzQaQXHNie2rbkCrbPVwZBbNqLo6nSASvLKYIsmQp7G4og2U

Array Specification

Product:	Beam
Unique ID:	5P-19.75-8TOP-XD-45-L-5Hx15W-1AKE
Duty Classification:	XD
Module Width:	44.60 in
Module Length:	74.90in
Number of Rows:	5
Number of Columns:	15
Total Number of Modules:	75
Desired Tilt Angle:	30
Front Edge Clearance:	5
Total Array Height at Tilt:	14.34 ft
Total Frame Length:	94.00 ft
Frame Weight:	5004 lbs
Array Dimensions N/S:	18.79 ft
Array Dimensions E/W:	94.88 ft
Rail Length:	225.50 in
Rail Spacing:	3.12 ft
Rail Check:	Not Checked

Support Specifications

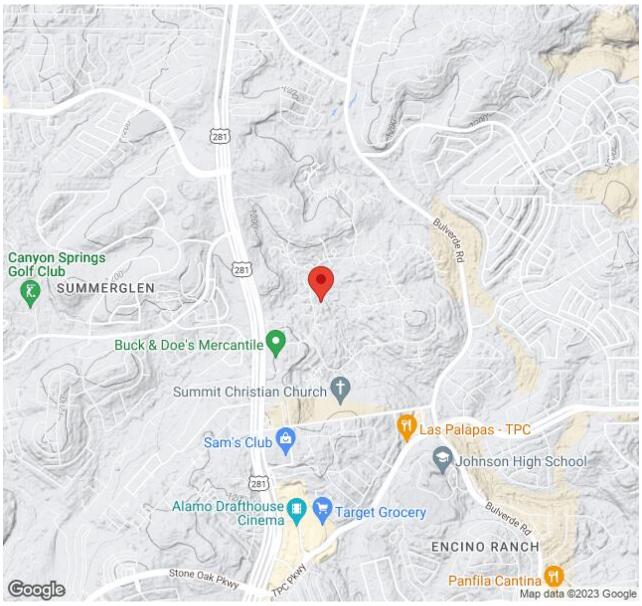
Pole Size:	8in Pipe Sch 40
Pole Length above Grade:	9.70 ft
Number of Poles:	5
Pole Spacing:	19.75 ft

Foundation Specifications

Foundation Type:	Square
Foundation Dimensions:	48 x 48 in
Foundation Depth (below grade):	Pile 1: 6.75 ft Pile 2: 7.00 ft Pile 3: 7.00 ft Pile 4: 7.00 ft Pile 5: 6.75 ft
Foundation Volume:	20.444 y^3
Foundation Result:	PASSED

Site Info

Risk Category:	I
Exposure:	C
Soil Classification:	sand
Site Location:	54 Sendero Verde, San Antonio, TX 78261, USA
Wind Speed:	100 mph
Snow Load:	5 psf
Design Uplift Pressure:	Multiple pressures
Design Downforce Pressure:	Multiple pressures
Design Snow Pressure:	0.001905 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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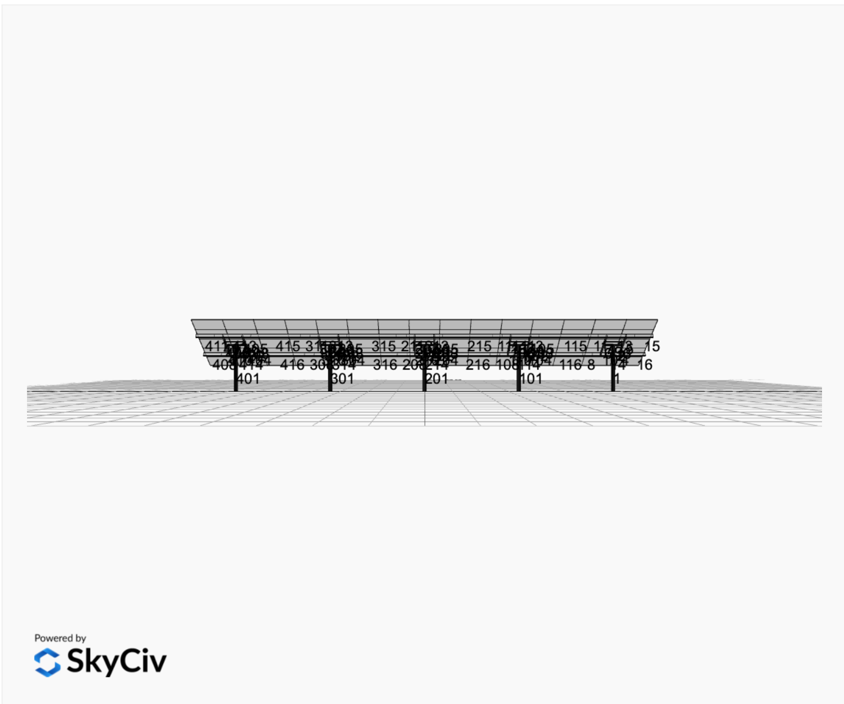
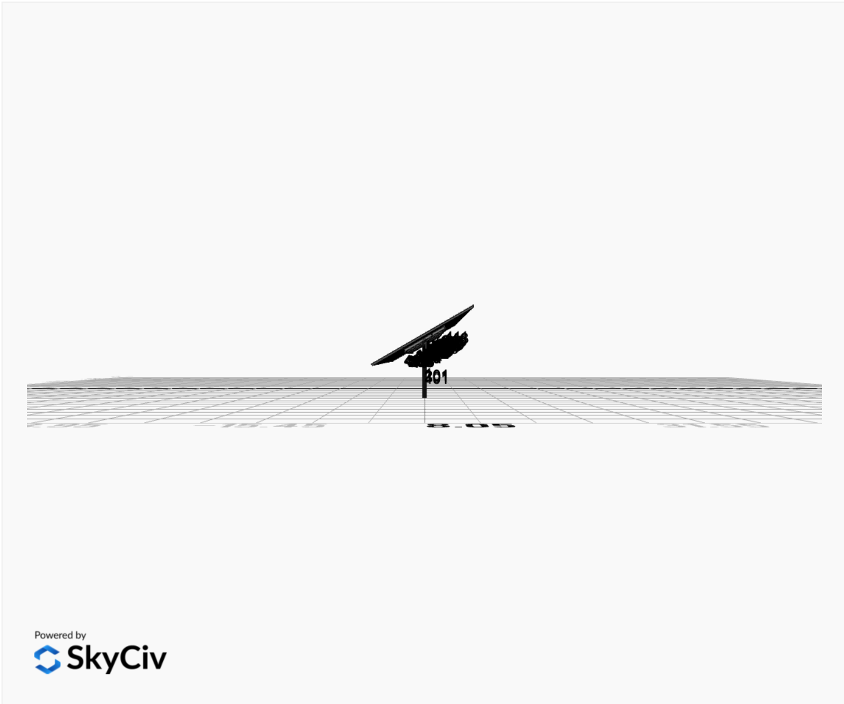
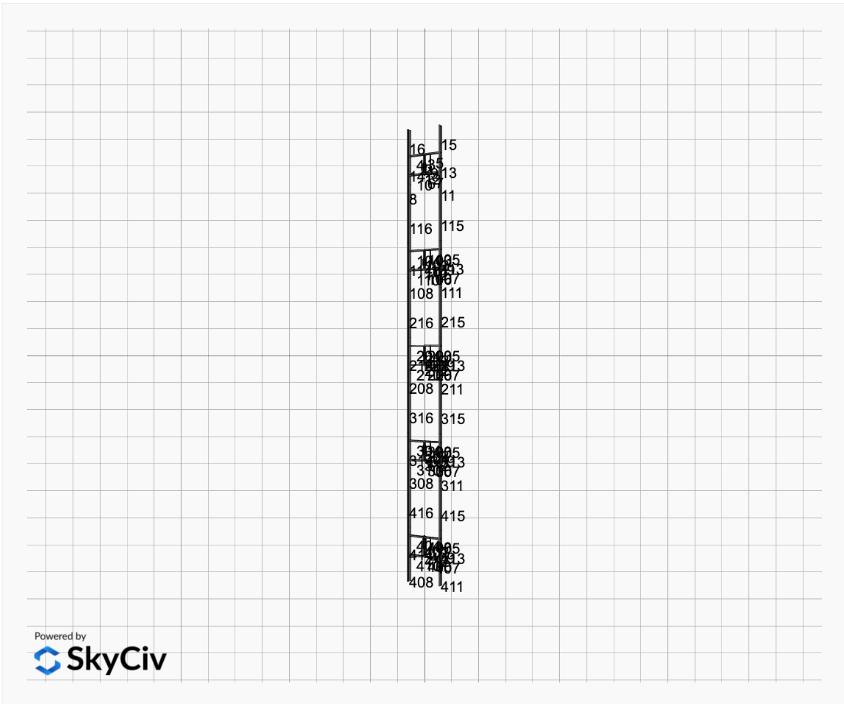
Design Notes:

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



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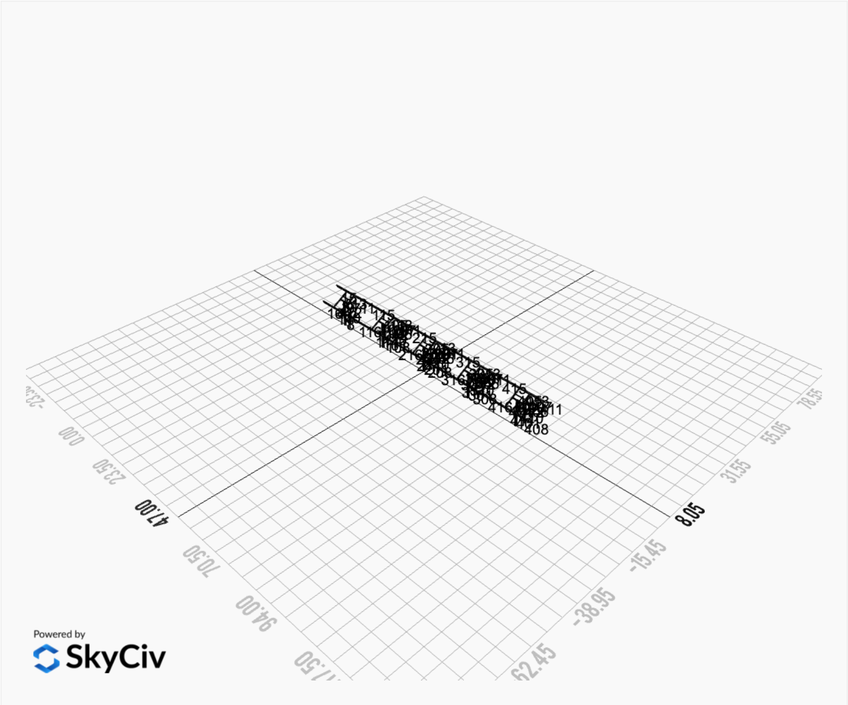
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47.00
70.50
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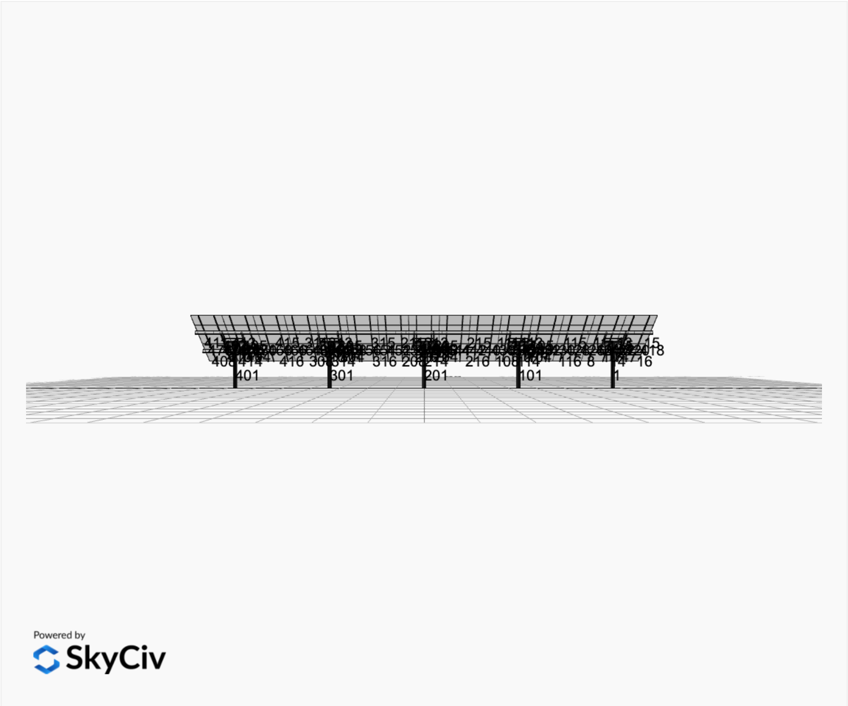
-15.45
-38.95
62.45
Powered by SkyCiv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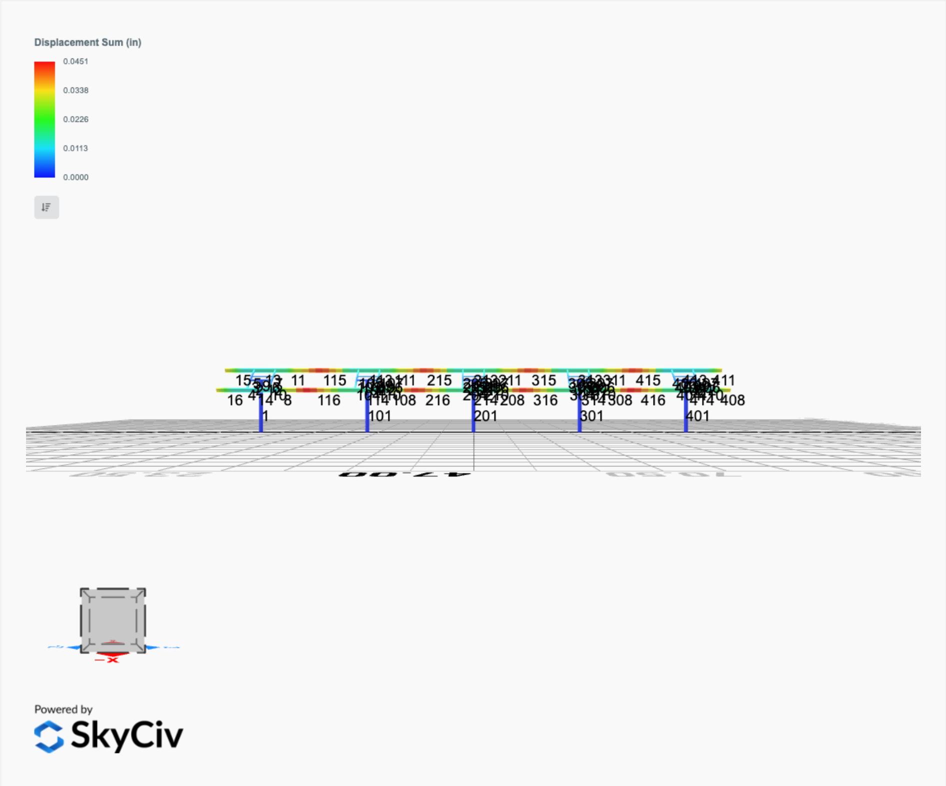
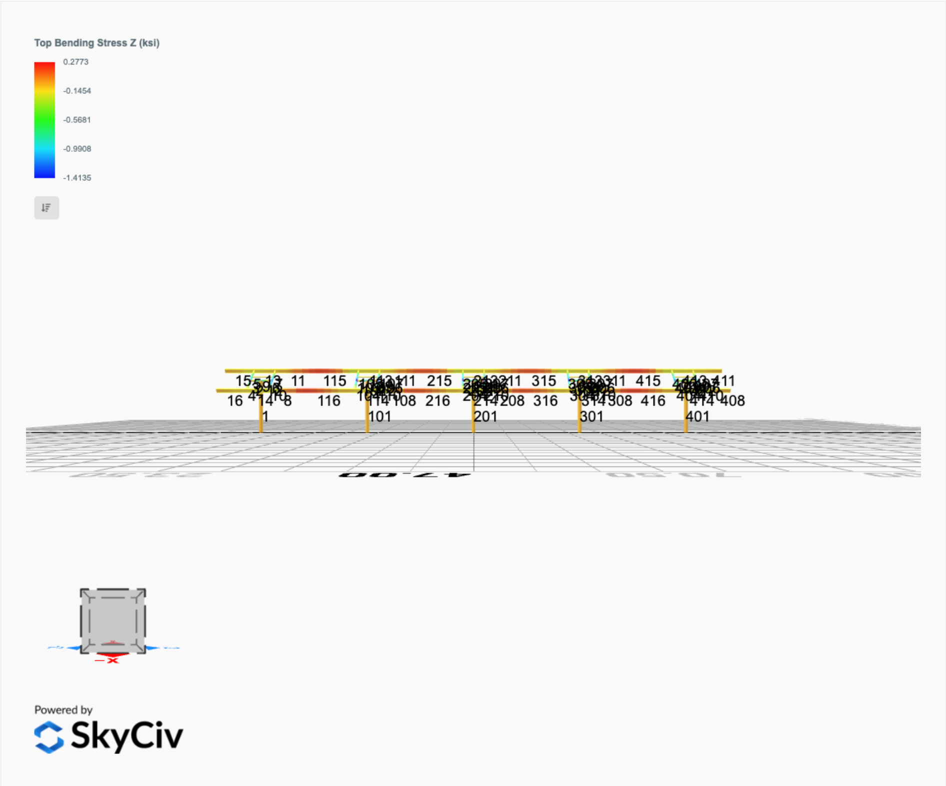
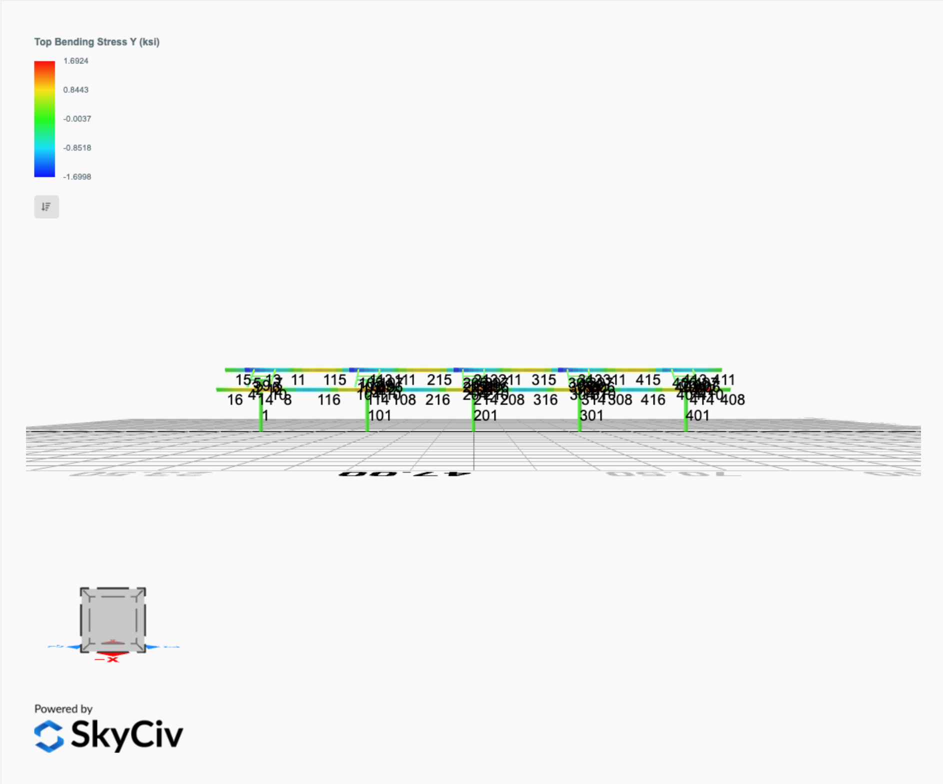
301
201
101
Powered by SkyCiv

FEM Results (Envelope Worst Case for each member)






Top Bending Stress Y (ksi)
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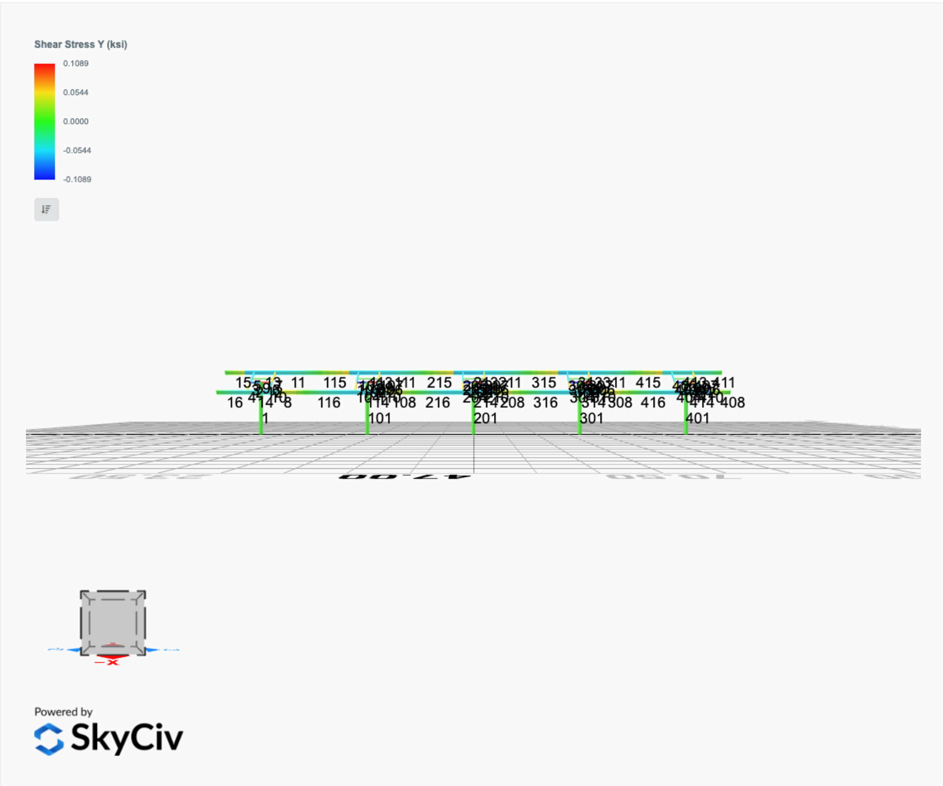
0.8443
-0.0037
-0.8518
-1.6998
Powered by
SkyCiv


Shear Stress Y (ksi)
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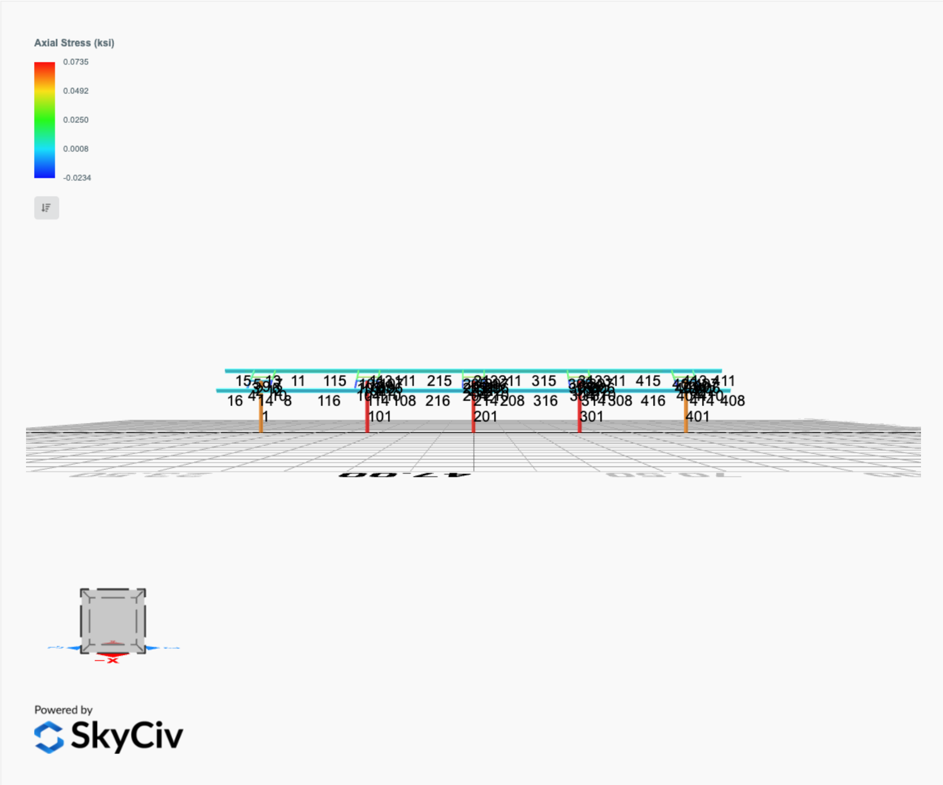
-0.0544
-0.1089
Powered by
SkyCiv


Axial Stress (ksi)
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0.0250
0.0008
-0.0234
Powered by
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	0.0091	2.4337	0.0327	0.0896	0.0011	-0.0524
ULS: 2. D + L	0.0091	2.4337	0.0327	0.0896	0.0011	-0.0524
ULS: 3. D + (S or Lr or R)	0.0117	2.9673	0.0420	0.1151	0.0013	-0.0757
ULS: 3. D + (S or Lr or R)	0.0091	2.4337	0.0327	0.0896	0.0011	-0.0524
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0110	2.8339	0.0397	0.1087	0.0012	-0.0699
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0091	2.4337	0.0327	0.0896	0.0011	-0.0524
ULS: 5b. D + 0.7E	0.0091	2.4337	0.0327	0.0896	0.0011	-0.0524
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0110	2.8339	0.0397	0.1087	0.0012	-0.0699
ULS: 8. 0.6D + 0.7E	0.0054	1.4602	0.0196	0.0538	0.0006	-0.0315
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.1094	7.8005	0.1546	0.3989	-0.2735	30.9223
ULS: 5a. D + 0.6W_Wind downforce Case B only	-3.1094	7.8005	0.1546	0.3989	-0.2735	30.9223
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.6801	-2.1651	-0.0689	-0.1678	0.2301	-25.6402
ULS: 5a. D + 0.6W_Wind uplift Case B only	2.2492	-1.4074	-0.0674	-0.1632	0.2328	-32.5385
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.3279	6.8590	0.1311	0.3407	-0.2047	23.1611
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.3279	6.8590	0.1311	0.3407	-0.2047	23.1611
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.0143	-0.6152	-0.0365	-0.0843	0.1730	-19.2607
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.6911	-0.0469	-0.0354	-0.0809	0.1750	-24.4344
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.3298	6.4588	0.1241	0.3216	-0.2049	23.1786
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.3298	6.4588	0.1241	0.3216	-0.2049	23.1786
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.0124	-1.0154	-0.0435	-0.1034	0.1729	-19.2433
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.6892	-0.4471	-0.0424	-0.1000	0.1749	-24.4170
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.1131	6.8270	0.1415	0.3631	-0.2740	30.9433
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-3.1131	6.8270	0.1415	0.3631	-0.2740	30.9433
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.6765	-3.1386	-0.0820	-0.2036	0.2297	-25.6193
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	2.2456	-2.3809	-0.0805	-0.1991	0.2324	-32.5175

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
Axial	12.1324
Shear X	-5.1975
Shear Z	0.2481
Moment X	0.6387
Moment Z	54.6756

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
Axial	7.8005
Shear X	-3.1131
Shear Z	0.1546
Moment X	0.3989
Moment Z	32.5385

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	-0.0088	2.7282	-0.0017	-0.0050	0.0032	0.1059
ULS: 2. D + L	-0.0088	2.7282	-0.0017	-0.0050	0.0032	0.1059
ULS: 3. D + (S or Lr or R)	-0.0113	3.3453	-0.0021	-0.0064	0.0041	0.1277
ULS: 3. D + (S or Lr or R)	-0.0088	2.7282	-0.0017	-0.0050	0.0032	0.1059
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0106	3.1910	-0.0020	-0.0060	0.0038	0.1222
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0088	2.7282	-0.0017	-0.0050	0.0032	0.1059
ULS: 5b. D + 0.7E	-0.0088	2.7282	-0.0017	-0.0050	0.0032	0.1059
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0106	3.1910	-0.0020	-0.0060	0.0038	0.1222

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 8. 0.6D + 0.7E	-0.0053	1.6369	-0.0010	-0.0030	0.0019	0.0635
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.5707	8.9294	0.0078	0.0151	-0.0369	35.2714
ULS: 5a. D + 0.6W_Wind downforce Case B only	-3.5707	8.9294	0.0078	0.0151	-0.0369	35.2714
ULS: 5a. D + 0.6W_Wind uplift Case A only	3.0465	-2.5891	-0.0082	-0.0185	0.0332	-28.8484
ULS: 5a. D + 0.6W_Wind uplift Case B only	2.5226	-1.6900	-0.0165	-0.0393	0.0571	-36.2930
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.6821	7.8419	0.0050	0.0090	-0.0262	26.4964
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.6821	7.8419	0.0050	0.0090	-0.0262	26.4964
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.2808	-0.7970	-0.0069	-0.0162	0.0264	-21.5935
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.8879	-0.1226	-0.0131	-0.0318	0.0443	-27.1769
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.6802	7.3791	0.0054	0.0101	-0.0269	26.4800
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.6802	7.3791	0.0054	0.0101	-0.0269	26.4800
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.2827	-1.2598	-0.0066	-0.0151	0.0257	-21.6098
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.8898	-0.5854	-0.0128	-0.0307	0.0436	-27.1933
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.5672	7.8381	0.0084	0.0171	-0.0382	35.2290
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-3.5672	7.8381	0.0084	0.0171	-0.0382	35.2290
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	3.0500	-3.6804	-0.0076	-0.0165	0.0319	-28.8907
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	2.5261	-2.7813	-0.0158	-0.0373	0.0558	-36.3354

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
Axial	13.9169
Shear X	-5.9475
Shear Z	-0.0276
Moment X	-0.0652
Moment Z	61.0778

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
Axial	8.9294
Shear X	-3.5707
Shear Z	-0.0165
Moment X	-0.0393
Moment Z	36.3354

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	-0.0006	2.7113	0.0000	0.0000	0.0000	0.0457
ULS: 2. D + L	-0.0006	2.7113	0.0000	0.0000	0.0000	0.0457
ULS: 3. D + (S or Lr or R)	-0.0008	3.3235	0.0000	0.0000	0.0000	0.0502
ULS: 3. D + (S or Lr or R)	-0.0006	2.7113	0.0000	0.0000	0.0000	0.0457
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0007	3.1705	0.0000	0.0000	0.0000	0.0491
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0006	2.7113	0.0000	0.0000	0.0000	0.0457
ULS: 5b. D + 0.7E	-0.0006	2.7113	0.0000	0.0000	0.0000	0.0457
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0007	3.1705	0.0000	0.0000	0.0000	0.0491
ULS: 8. 0.6D + 0.7E	-0.0004	1.6268	0.0000	0.0000	0.0000	0.0274
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.5658	8.8922	0.0000	0.0000	0.0000	35.4626
ULS: 5a. D + 0.6W_Wind downforce Case B only	-3.5658	8.8922	0.0000	0.0000	0.0000	35.4626
ULS: 5a. D + 0.6W_Wind uplift Case A only	3.0549	-2.5852	0.0000	0.0000	0.0000	-29.0814
ULS: 5a. D + 0.6W_Wind uplift Case B only	2.5464	-1.7107	0.0000	0.0000	0.0000	-36.8117
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.6746	7.8062	0.0000	0.0000	0.0000	26.6118
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.6746	7.8062	0.0000	0.0000	0.0000	26.6118
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.2909	-0.8019	0.0000	0.0000	0.0000	-21.7962
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.9095	-0.1460	0.0000	0.0000	0.0000	-27.5939
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.6745	7.3470	0.0000	0.0000	0.0000	26.6084
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.6745	7.3470	0.0000	0.0000	0.0000	26.6084

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 uplift Case A only	2.2910	-1.2611	0.0000	0.0000	0.0000	-21.7996
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.9097	-0.6052	0.0000	0.0000	0.0000	-27.5973
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.5655	7.8077	0.0000	0.0000	0.0000	35.4443
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-3.5655	7.8077	0.0000	0.0000	0.0000	35.4443
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	3.0551	-3.6697	0.0000	0.0000	0.0000	-29.0997
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	2.5467	-2.7952	0.0000	0.0000	0.0000	-36.8300

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
Axial	13.8619
Shear X	-5.9429
Shear Z	-0.0000
Moment X	0.0002
Moment Z	61.9416

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
Axial	8.8922
Shear X	-3.5658
Shear Z	0.0000
Moment X	0.0000
Moment Z	36.8300

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	-0.0088	2.7282	0.0017	0.0050	-0.0031	0.1059
ULS: 2. D + L	-0.0088	2.7282	0.0017	0.0050	-0.0031	0.1059
ULS: 3. D + (S or Lr or R)	-0.0113	3.3453	0.0021	0.0064	-0.0041	0.1277
ULS: 3. D + (S or Lr or R)	-0.0088	2.7282	0.0017	0.0050	-0.0031	0.1059
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0106	3.1910	0.0020	0.0060	-0.0038	0.1222
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0088	2.7282	0.0017	0.0050	-0.0031	0.1059
ULS: 5b. D + 0.7E	-0.0088	2.7282	0.0017	0.0050	-0.0031	0.1059
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0106	3.1910	0.0020	0.0060	-0.0038	0.1222
ULS: 8. 0.6D + 0.7E	-0.0053	1.6369	0.0010	0.0030	-0.0019	0.0635
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.5707	8.9294	-0.0078	-0.0151	0.0369	35.2714
ULS: 5a. D + 0.6W_Wind downforce Case B only	-3.5707	8.9294	-0.0078	-0.0151	0.0369	35.2714
ULS: 5a. D + 0.6W_Wind uplift Case A only	3.0465	-2.5891	0.0082	0.0185	-0.0332	-28.8484
ULS: 5a. D + 0.6W_Wind uplift Case B only	2.5226	-1.6900	0.0165	0.0393	-0.0571	-36.2930
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.6821	7.8419	-0.0050	-0.0090	0.0262	26.4964
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.6821	7.8419	-0.0050	-0.0090	0.0262	26.4964
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.2808	-0.7970	0.0069	0.0162	-0.0264	-21.5935
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.8879	-0.1226	0.0131	0.0318	-0.0443	-27.1769
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.6802	7.3791	-0.0054	-0.0101	0.0269	26.4800
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.6802	7.3791	-0.0054	-0.0101	0.0269	26.4800
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.2827	-1.2598	0.0066	0.0151	-0.0257	-21.6098
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.8898	-0.5854	0.0128	0.0307	-0.0436	-27.1933
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.5672	7.8381	-0.0084	-0.0171	0.0382	35.2290
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-3.5672	7.8381	-0.0084	-0.0171	0.0382	35.2290
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	3.0500	-3.6804	0.0076	0.0165	-0.0319	-28.8907
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	2.5261	-2.7813	0.0158	0.0373	-0.0558	-36.3354

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.

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
Axial	13.9169
Shear X	-5.9475
Shear Z	0.0276
Moment X	0.0656
Moment Z	61.0778

Result	Value
Axial	8.9294
Shear X	-3.5707
Shear Z	0.0165
Moment X	0.0393
Moment Z	36.3354

Reaction Forces for Foundation 5 (Node ID#401), (kip, kip-ft)

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	0.0091	2.4337	-0.0327	-0.0896	-0.0010	-0.0524
ULS: 2. D + L	0.0091	2.4337	-0.0327	-0.0896	-0.0010	-0.0524
ULS: 3. D + (S or Lr or R)	0.0117	2.9673	-0.0420	-0.1151	-0.0012	-0.0757
ULS: 3. D + (S or Lr or R)	0.0091	2.4337	-0.0327	-0.0896	-0.0010	-0.0524
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0110	2.8339	-0.0397	-0.1087	-0.0012	-0.0699
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0091	2.4337	-0.0327	-0.0896	-0.0010	-0.0524
ULS: 5b. D + 0.7E	0.0091	2.4337	-0.0327	-0.0896	-0.0010	-0.0524
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0110	2.8339	-0.0397	-0.1087	-0.0012	-0.0699
ULS: 8. 0.6D + 0.7E	0.0054	1.4602	-0.0196	-0.0538	-0.0006	-0.0315
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.1094	7.8005	-0.1546	-0.3989	0.2735	30.9223
ULS: 5a. D + 0.6W_Wind downforce Case B only	-3.1094	7.8005	-0.1546	-0.3989	0.2735	30.9223
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.6801	-2.1651	0.0689	0.1678	-0.2301	-25.6402
ULS: 5a. D + 0.6W_Wind uplift Case B only	2.2492	-1.4074	0.0674	0.1632	-0.2328	-32.5385
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.3279	6.8590	-0.1311	-0.3407	0.2047	23.1611
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.3279	6.8590	-0.1311	-0.3407	0.2047	23.1611
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.0143	-0.6152	0.0365	0.0843	-0.1730	-19.2607
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.6911	-0.0469	0.0354	0.0809	-0.1750	-24.4344
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.3298	6.4588	-0.1241	-0.3216	0.2049	23.1786
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.3298	6.4588	-0.1241	-0.3216	0.2049	23.1786
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	2.0124	-1.0154	0.0435	0.1034	-0.1728	-19.2433
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.6892	-0.4471	0.0424	0.1000	-0.1749	-24.4170
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.1131	6.8270	-0.1415	-0.3631	0.2740	30.9433
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-3.1131	6.8270	-0.1415	-0.3631	0.2740	30.9433
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.6765	-3.1386	0.0820	0.2036	-0.2297	-25.6192
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	2.2456	-2.3809	0.0805	0.1991	-0.2324	-32.5175

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
Axial	12.1324
Shear X	-5.1975
Shear Z	-0.2481
Moment X	-0.6386
Moment Z	54.6766

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
Axial	7.8005
Shear X	-3.1131
Shear Z	-0.1546
Moment X	-0.3989
Moment Z	32.5385

Project Details

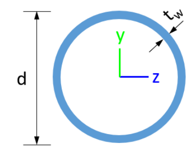
Design Code:	AISC 360-16 LRFD
Provision:	LRFD
Country:	United States
User Name:	sales@mtsolar.us
Unit System:	imperial

Design Input Information

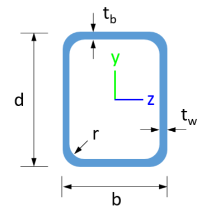
Design Factors			
Φ_t	Φ_c	Φ_b	Φ_v
0.9	0.9	0.9	0.9

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

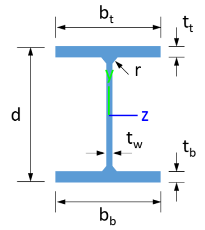
Section Dimensions



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

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	62.42	3.77	5.38
20	W10x12	3.54	0.05	2.18	53.80	50.90	1.74	12.60

Member Properties								
Member ID	Section ID	K_zL (ft)	K_yL (ft)	L_b(ft)	C_b	LST	LSC	LD
1	9	20.37	20.37	9.70	-	300	200	1
2	6	1.30	1.30	2.00	-	300	200	1
3	17	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.16,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.17	300	200	1
4	17	2.44	2.44	3.75	1.69,1.69,1.69,1.68,1.69,1.69,1.67,1.67,1.66,1.19,1.67,1.67,1.66,1.53,1.67,1.67,1.64,1.69,1.67,1.67,1.65,1.72,1.67,1.67,1.66,1.63	300	200	1
5	17	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.65,1.66,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66	300	200	1
6	17	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18	300	200	1
7	17	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.67	300	200	1
8	20	1.33	1.33	2.05	1.67,1.67,1.67,1.67,1.67,1.67,1.64,1.64,1.63,1.03,1.64,1.64,1.64,1.13,1.65,1.65,1.61,2.06,1.65,1.65,1.62,2.12,1.64,1.64,1.64,1.26	300	200	1
9	3	2.60	2.60	4.00	-	300	200	1
10	17	2.44	2.44	3.75	1.69,1.69,1.69,1.68,1.69,1.69,1.67,1.67,1.66,1.53,1.67,1.67,1.66,1.59,1.67,1.67,1.64,1.69,1.67,1.67,1.65,1.72,1.67,1.67,1.66,1.64	300	200	1
11	20	1.33	1.33	2.05	1.69,1.69,1.69,1.69,1.69,1.69,1.75,1.75,1.77,1.86,1.75,1.75,1.77,1.85,1.73,1.73,1.87,1.96,1.74,1.74,1.81,1.90,1.75,1.75,1.76,1.84	300	200	1
12	6	1.30	1.30	2.00	-	300	200	1
13	20	1.14	1.14	1.75	1.63,1.63,1.63,1.63,1.63,1.63,1.60,1.60,1.59,1.56,1.60,1.60,1.59,1.56,1.61,1.61,1.55,1.53,1.61,1.61,1.57,1.54,1.60,1.60,1.59,1.56	300	200	1
14	20	1.14	1.14	1.75	1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30	300	200	1
15	20	7.88	7.88	3.75	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	1
16	20	7.88	7.88	3.75	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	1
17	20	2.60	2.60	4.00	1.17,1.17,1.17,1.17,1.17,1.17,1.16,1.16,1.16,1.17,1.16,1.16,1.16,1.17,1.16,1.16,1.15,1.18,1.16,1.16,1.16,1.18,1.16,1.16,1.16,1.17	300	200	1
18	20	1.14	1.14	1.75	1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30	300	200	1
19	20	2.60	2.60	4.00	1.16,1.16,1.16,1.17,1.16,1.16,1.17,1.17,1.17,1.19,1.17,1.17,1.17,1.15,1.17,1.17,1.17,1.26,1.17,1.17,1.17,1.38,1.17,1.17,1.17,1.11	300	200	1
20	20	1.14	1.14	1.75	1.65,1.65,1.65,1.65,1.65,1.65,1.66,1.66,1.67,1.09,1.66,1.66,1.67,1.33,1.66,1.66,1.70,1.50,1.66,1.66,1.68,1.42,1.66,1.66,1.67,2.12	300	200	1
21	20	2.60	2.60	4.00	1.09,1.09,1.09,1.09,1.09,1.09,1.10,1.10,1.10,1.12,1.10,1.10,1.10,1.12,1.10,1.10,1.12,1.14,1.10,1.10,1.11,1.13,1.10,1.10,1.10,1.12	300	200	1
22	20	1.14	1.14	1.75	1.50,1.50,1.50,1.50,1.50,1.50,1.55,1.55,1.58,1.61,1.55,1.55,1.58,1.60,1.54,1.54,1.71,1.68,1.54,1.54,1.62,1.64,1.56,1.56,1.57,1.60	300	200	1
23	20	2.60	2.60	4.00	1.08,1.08,1.08,1.09,1.08,1.08,1.09,1.09,1.09,1.04,1.09,1.09,1.09,1.05,1.09,1.09,1.10,1.12,1.09,1.09,1.09,1.29,1.09,1.09,1.09,1.06	300	200	1

24	20	1.14	1.14	1.75	1.46,1.46,1.46,1.46,1.46,1.46,1.46,1.46,1.46,1.29,1.46,1.46,1.46,1.34,1.46,1.46,1.46,1.48,1.46,1.46,1.46,1.52,1.46,1.46,1.46,1.39	300	200	1
25	20	2.60	2.60	4.00	1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.09,1.08,1.08,1.08,1.09,1.08,1.08,1.08,1.09,1.08,1.08,1.08,1.09,1.08,1.08,1.08,1.09	300	200	1
26	20	1.14	1.14	1.75	1.46,1.46,1.46,1.45,1.46,1.46,1.47,1.47,1.48,1.47,1.47,1.47,1.48,1.47,1.47,1.47,1.50,1.48,1.47,1.47,1.49,1.48,1.47,1.47,1.48,1.47	300	200	1
27	20	2.60	2.60	4.00	1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.02,1.08,1.08,1.08,1.03,1.08,1.08,1.08,1.11,1.08,1.08,1.08,1.16,1.08,1.08,1.08,1.05	300	200	1
28	20	1.14	1.14	1.75	1.46,1.46,1.46,1.46,1.46,1.46,1.45,1.45,1.45,1.46,1.45,1.45,1.45,1.46,1.45,1.45,1.44,1.46,1.45,1.45,1.45,1.46,1.45,1.45,1.45,1.46	300	200	1
29	20	2.60	2.60	4.00	1.09,1.09,1.09,1.09,1.09,1.09,1.10,1.10,1.10,1.12,1.10,1.10,1.10,1.12,1.10,1.10,1.12,1.14,1.10,1.10,1.11,1.13,1.10,1.10,1.10,1.12	300	200	1
30	20	1.14	1.14	1.75	1.46,1.46,1.46,1.46,1.46,1.46,1.49,1.49,1.51,1.52,1.50,1.50,1.51,1.52,1.49,1.49,1.57,1.55,1.49,1.49,1.53,1.53,1.50,1.50,1.51,1.51	300	200	1
31	20	2.60	2.60	4.00	1.08,1.08,1.08,1.09,1.08,1.08,1.09,1.09,1.09,1.04,1.09,1.09,1.09,1.05,1.09,1.09,1.10,1.12,1.09,1.09,1.09,1.28,1.09,1.09,1.09,1.06	300	200	1
32	20	1.14	1.14	1.75	1.49,1.49,1.49,1.49,1.49,1.49,1.49,1.49,1.24,1.49,1.49,1.49,1.29,1.49,1.49,1.49,1.57,1.49,1.49,1.49,1.71,1.49,1.49,1.49,1.36	300	200	1
33	20	2.60	2.60	4.00	1.17,1.17,1.17,1.17,1.17,1.17,1.16,1.16,1.16,1.17,1.16,1.16,1.16,1.17,1.16,1.16,1.15,1.18,1.16,1.16,1.16,1.17,1.16,1.16,1.16,1.17	300	200	1
34	20	1.14	1.14	1.75	1.63,1.63,1.63,1.63,1.63,1.63,1.60,1.60,1.59,1.56,1.60,1.60,1.59,1.56,1.61,1.61,1.55,1.53,1.61,1.61,1.57,1.54,1.60,1.60,1.59,1.56	300	200	1
35	20	2.60	2.60	4.00	1.16,1.16,1.16,1.17,1.16,1.16,1.17,1.17,1.17,1.18,1.17,1.17,1.17,1.15,1.17,1.17,1.17,1.25,1.17,1.17,1.17,1.38,1.17,1.17,1.17,1.11	300	200	1
36	20	1.14	1.14	1.75	1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30	300	200	1
101	9	20.37	20.37	9.70	-	300	200	1
102	6	1.30	1.30	2.00	-	300	200	1
103	17	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18	300	200	1
104	17	2.44	2.44	3.75	1.69,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.66,1.55,1.67,1.67,1.66,1.60,1.67,1.67,1.65,1.69,1.67,1.67,1.65,1.72,1.67,1.67,1.66,1.64	300	200	1
105	17	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.67	300	200	1
106	17	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18	300	200	1
107	17	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.67	300	200	1
108	20	1.33	1.33	2.05	2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,1.75,2.08,2.08,2.08,2.24,2.08,2.08,2.08,2.07,2.08,2.08,2.08,2.01,2.08,2.08,2.08,2.35	300	200	1
109	3	2.60	2.60	4.00	-	300	200	1
110	17	2.44	2.44	3.75	1.69,1.68,1.69,1.68,1.68,1.68,1.67,1.67,1.66,1.55,1.67,1.67,1.66,1.60,1.67,1.67,1.65,1.69,1.67,1.67,1.65,1.72,1.67,1.67,1.66,1.64	300	200	1
111	20	1.33	1.33	2.05	2.08,2.08,2.08,2.08,2.08,2.08,2.06,2.06,2.05,2.01,2.06,2.06,2.06,2.02,2.07,2.07,1.82,1.87,2.06,2.06,1.95,1.94,2.06,2.06,2.06,2.04	300	200	1
112	6	1.30	1.30	2.00	-	300	200	1
113	20	1.14	1.14	1.75	1.46,1.46,1.46,1.46,1.46,1.46,1.49,1.49,1.51,1.52,1.50,1.50,1.51,1.52,1.49,1.49,1.57,1.55,1.49,1.49,1.53,1.53,1.50,1.50,1.51,1.51	300	200	1

114	20	1.14	1.14	1.75	1.49,1.49,1.49,1.49,1.49,1.49,1.49,1.49,1.49,1.24,1.49,1.49,1.49,1.29,1.49,1.49,1.49,1.57,1.49,1.49,1.49,1.70,1.49,1.49,1.49,1.36	300	200	1
115	20	6.63	6.63	10.20	1.15,1.15,1.15,1.15,1.15,1.15,1.14,1.14,1.13,1.13,1.14,1.14,1.13,1.13,1.14,1.14,1.11,1.12,1.14,1.14,1.12,1.12,1.14,1.14,1.13,1.13	300	200	1
116	20	6.63	6.63	10.20	1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.64,1.15,1.15,1.15,1.35,1.15,1.15,1.15,1.13,1.15,1.15,1.15,1.11,1.15,1.15,1.15,1.24	300	200	1
201	9	20.37	20.37	9.70	-	300	200	1
202	6	1.30	1.30	2.00	-	300	200	1
203	17	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18	300	200	1
204	17	2.44	2.44	3.75	1.69,1.68,1.69,1.68,1.68,1.69,1.67,1.67,1.66,1.52,1.67,1.67,1.66,1.59,1.67,1.67,1.65,1.69,1.67,1.67,1.65,1.71,1.67,1.67,1.66,1.64	300	200	1
205	17	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.67	300	200	1
206	17	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18	300	200	1
207	17	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.67	300	200	1
208	20	1.33	1.33	2.05	2.08,2.08,2.08,2.08,2.08,2.08,2.09,2.09,2.09,2.07,2.09,2.09,2.09,2.08,2.08,2.08,2.10,2.08,2.09,2.09,2.09,2.08,2.09,2.09,2.09,2.08	300	200	1
209	3	2.60	2.60	4.00	-	300	200	1
210	17	2.44	2.44	3.75	1.69,1.68,1.69,1.68,1.68,1.69,1.67,1.67,1.66,1.52,1.67,1.67,1.66,1.59,1.67,1.67,1.65,1.69,1.67,1.67,1.65,1.71,1.67,1.67,1.66,1.64	300	200	1
211	20	1.33	1.33	2.05	2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.07,2.07,2.08,2.08,2.07,2.07,2.08,2.08,2.06,2.07,2.08,2.08,2.07,2.07,2.07,2.07,2.07,2.07	300	200	1
212	6	1.30	1.30	2.00	-	300	200	1
213	20	1.14	1.14	1.75	1.46,1.46,1.46,1.45,1.46,1.46,1.47,1.47,1.48,1.47,1.47,1.47,1.48,1.47,1.47,1.47,1.50,1.48,1.47,1.47,1.49,1.48,1.47,1.47,1.48,1.47	300	200	1
214	20	1.14	1.14	1.75	1.46,1.46,1.46,1.46,1.46,1.46,1.45,1.45,1.45,1.47,1.45,1.45,1.45,1.46,1.45,1.45,1.44,1.46,1.45,1.45,1.45,1.46,1.45,1.45,1.45,1.46	300	200	1
215	20	6.63	6.63	10.20	1.16,1.16,1.16,1.16,1.16,1.16,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15	300	200	1
216	20	6.63	6.63	10.20	1.15,1.15,1.15,1.15,1.15,1.15,1.16,1.16,1.16,1.16,1.16,1.16,1.16,1.14,1.16,1.16,1.16,1.16,1.16,1.16,1.16,1.16,1.16,1.16,1.16,1.15	300	200	1
301	9	20.37	20.37	9.70	-	300	200	1
302	6	1.30	1.30	2.00	-	300	200	1
303	17	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18	300	200	1
304	17	2.44	2.44	3.75	1.69,1.68,1.69,1.68,1.68,1.68,1.67,1.67,1.66,1.55,1.67,1.67,1.66,1.60,1.67,1.67,1.65,1.69,1.67,1.67,1.65,1.72,1.67,1.67,1.66,1.64	300	200	1
305	17	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.67	300	200	1
306	17	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.18,1.18	300	200	1
307	17	1.52	1.52	2.33	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.67	300	200	1

308	20	1.33	1.33	2.05	2.07,2.07,2.07,2.07,2.07,2.07,2.07,2.07,1.54,2.07,2.07,2.07,1.89,2.07,2.07,1.82,2.07,2.07,2.07,1.59,2.07,2.07,2.07,2.27	300	200	1
309	3	2.60	2.60	4.00	-	300	200	1
310	17	2.44	2.44	3.75	1.69,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.66,1.55,1.67,1.67,1.66,1.60,1.67,1.67,1.65,1.69,1.67,1.67,1.65,1.72,1.67,1.67,1.66,1.64	300	200	1
311	20	1.33	1.33	2.05	2.06,2.06,2.06,2.06,2.06,1.87,1.87,1.79,1.73,1.87,1.87,1.80,1.74,1.92,1.92,1.59,1.62,1.91,1.91,1.70,1.68,1.86,1.86,1.81,1.75	300	200	1
312	6	1.30	1.30	2.00	-	300	200	1
313	20	1.14	1.14	1.75	1.50,1.50,1.50,1.50,1.50,1.50,1.55,1.55,1.58,1.61,1.55,1.55,1.58,1.60,1.54,1.54,1.71,1.68,1.54,1.54,1.62,1.64,1.56,1.56,1.57,1.60	300	200	1
314	20	1.14	1.14	1.75	1.46,1.46,1.46,1.46,1.46,1.46,1.46,1.46,1.29,1.46,1.46,1.46,1.34,1.46,1.46,1.46,1.48,1.46,1.46,1.46,1.52,1.46,1.46,1.46,1.39	300	200	1
315	20	6.63	6.63	10.20	1.15,1.15,1.15,1.15,1.15,1.15,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.14,1.15,1.15,1.13,1.13,1.15,1.15,1.14,1.14,1.14,1.14,1.14,1.14	300	200	1
316	20	6.63	6.63	10.20	1.16,1.16,1.16,1.16,1.16,1.16,1.16,1.16,1.16,1.36,1.16,1.16,1.16,1.22,1.16,1.16,1.15,1.15,1.16,1.16,1.16,1.14,1.16,1.16,1.16,1.19	300	200	1
401	9	20.37	20.37	9.70	-	300	200	1
402	6	1.30	1.30	2.00	-	300	200	1
403	17	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18	300	200	1
404	17	2.44	2.44	3.75	1.69,1.69,1.69,1.68,1.69,1.69,1.67,1.67,1.66,1.53,1.67,1.67,1.66,1.59,1.67,1.67,1.64,1.69,1.67,1.67,1.65,1.72,1.67,1.67,1.66,1.64	300	200	1
405	17	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.67	300	200	1
406	17	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.16,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.17	300	200	1
407	17	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.65,1.66,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66	300	200	1
408	20	7.88	7.88	3.75	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	1
409	3	2.60	2.60	4.00	-	300	200	1
410	17	2.44	2.44	3.75	1.69,1.69,1.69,1.68,1.69,1.69,1.67,1.67,1.66,1.19,1.67,1.67,1.66,1.53,1.67,1.67,1.64,1.69,1.67,1.67,1.65,1.72,1.67,1.67,1.66,1.63	300	200	1
411	20	7.88	7.88	3.75	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	1
412	6	1.30	1.30	2.00	-	300	200	1
413	20	1.14	1.14	1.75	1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30	300	200	1
414	20	1.14	1.14	1.75	1.65,1.65,1.65,1.65,1.65,1.65,1.66,1.66,1.67,1.09,1.66,1.66,1.67,1.33,1.66,1.66,1.70,1.50,1.66,1.66,1.68,1.42,1.66,1.66,1.67,2.12	300	200	1
415	20	6.63	6.63	10.20	1.12,1.12,1.12,1.12,1.12,1.12,1.13,1.13,1.13,1.14,1.13,1.13,1.13,1.13,1.13,1.13,1.14,1.14,1.13,1.13,1.13,1.14,1.13,1.13,1.13,1.13	300	200	1
416	20	6.63	6.63	10.20	1.12,1.12,1.12,1.12,1.12,1.12,1.12,1.12,1.11,1.20,1.12,1.12,1.12,1.11,1.12,1.12,1.11,1.15,1.12,1.12,1.11,1.18,1.12,1.12,1.12,1.09	300	200	1

Member Design Capacity

Member ID	Φ_tP_n (kip)	Φ_cP_n (kip)	Φ_bM_{zn} (k-ft)	Φ_bM_{yn} (k-ft)	Φ_vV_{yn} (kip)	Φ_vV_{zn} (kip)
1	377.97	227.88	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	248.88	27.16	27.16	75.30	75.30
13	159.30	143.45	46.90	6.46	56.26	44.91
14	159.30	143.45	46.90	6.46	56.26	44.91
15	159.30	55.15	46.90	6.46	56.26	44.91
16	159.30	55.15	46.90	6.46	56.26	44.91
17	159.30	132.71	46.90	6.46	56.26	44.91
18	159.30	143.45	46.90	6.46	56.26	44.91
19	159.30	132.71	46.90	6.46	56.26	44.91
20	159.30	143.45	46.90	6.46	56.26	44.91
21	159.30	132.71	46.78	6.46	56.26	44.91
22	159.30	143.45	46.90	6.46	56.26	44.91
23	159.30	132.71	44.63	6.46	56.26	44.91
24	159.30	143.45	46.90	6.46	56.26	44.91
25	159.30	132.71	46.35	6.46	56.26	44.91
26	159.30	143.45	46.90	6.46	56.26	44.91
27	159.30	132.71	43.77	6.46	56.26	44.91
28	159.30	143.45	46.90	6.46	56.26	44.91
29	159.30	132.71	46.78	6.46	56.26	44.91
30	159.30	143.45	46.90	6.46	56.26	44.91
31	159.30	132.71	44.63	6.46	56.26	44.91
32	159.30	143.45	46.90	6.46	56.26	44.91
33	159.30	132.71	46.90	6.46	56.26	44.91
34	159.30	143.45	46.90	6.46	56.26	44.91
35	159.30	132.71	46.90	6.46	56.26	44.91
36	159.30	143.45	46.90	6.46	56.26	44.91
101	377.97	227.88	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
111	159.30	142.47	46.90	6.46	56.26	44.91
112	251.01	248.88	27.16	27.16	75.30	75.30
113	159.30	143.45	46.90	6.46	56.26	44.91
114	159.30	143.45	46.90	6.46	56.26	44.91
115	159.30	75.13	21.38	6.46	56.26	44.91
116	159.30	75.13	21.38	6.46	56.26	44.91

201	377.97	227.88	83.29	83.29	113.39	113.39
202	251.01	248.88	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	143.45	46.90	6.46	56.26	44.91
214	159.30	143.45	46.90	6.46	56.26	44.91
215	159.30	75.13	22.15	6.46	56.26	44.91
216	159.30	75.13	21.96	6.46	56.26	44.91
301	377.97	227.88	83.29	83.29	113.39	113.39
302	251.01	248.88	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	142.47	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	142.47	46.90	6.46	56.26	44.91
312	251.01	248.88	27.16	27.16	75.30	75.30
313	159.30	143.45	46.90	6.46	56.26	44.91
314	159.30	143.45	46.90	6.46	56.26	44.91
315	159.30	75.13	21.76	6.46	56.26	44.91
316	159.30	75.13	21.96	6.46	56.26	44.91
401	377.97	227.88	83.29	83.29	113.39	113.39
402	251.01	248.88	27.16	27.16	75.30	75.30
403	151.65	150.70	20.17	14.14	54.12	28.95
404	151.65	145.15	20.17	14.14	54.12	28.95
405	151.65	149.10	20.17	14.14	54.12	28.95
406	151.65	150.70	20.17	14.14	54.12	28.95
407	151.65	149.10	20.17	14.14	54.12	28.95
408	159.30	55.15	46.90	6.46	56.26	44.91
409	75.10	66.32	4.25	4.25	22.53	22.53
410	151.65	145.15	20.17	14.14	54.12	28.95
411	159.30	55.15	46.90	6.46	56.26	44.91
412	251.01	248.88	27.16	27.16	75.30	75.30
413	159.30	143.45	46.90	6.46	56.26	44.91
414	159.30	143.45	46.90	6.46	56.26	44.91
415	159.30	75.13	21.57	6.46	56.26	44.91
416	159.30	75.13	20.99	6.46	56.26	44.91

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	0.053	0.656	0.021	0.046	0.002	0.664	#16	0.416	Not Required	Pass

2	0.001	0.339	0.170	0.074	0.033	0.510	#13	0.036	Not Required	Pass
3	0.003	0.558	0.013	0.055	0.001	0.566	#13	0.046	Not Required	Pass
4	0.002	0.557	0.042	0.056	0.010	0.592	#13	0.082	Not Required	Pass
5	0.002	0.346	0.038	0.055	0.010	0.350	#13	0.076	Not Required	Pass
6	0.003	0.625	0.026	0.063	0.005	0.651	#13	0.046	Not Required	Pass
7	0.003	0.388	0.055	0.062	0.014	0.400	#13	0.076	Not Required	Pass
8	0.001	0.072	0.061	0.038	0.006	0.099	#13	0.102	Not Required	Pass
9	0.004	0.061	0.042	0.002	0.001	0.104	#13	0.206	Not Required	Pass
10	0.003	0.611	0.056	0.061	0.012	0.624	#13	0.082	Not Required	Pass
11	0.001	0.069	0.061	0.039	0.006	0.093	#13	0.102	Not Required	Pass
12	0.001	0.404	0.187	0.083	0.036	0.591	#13	0.054	Not Required	Pass
13	0.001	0.106	0.149	0.050	0.008	0.223	#16	0.087	Not Required	Pass
14	0.000	0.117	0.106	0.036	0.006	0.203	#13	Not Required	Not Required	Pass
15	0.000	0.055	0.049	0.024	0.004	0.095	#13	Not Required	Not Required	Pass
16	0.000	0.055	0.049	0.024	0.004	0.095	#13	Not Required	Not Required	Pass
17	0.002	0.135	0.029	0.017	0.002	0.160	#13	0.133	Not Required	Pass
18	0.000	0.117	0.106	0.036	0.006	0.203	#13	Not Required	Not Required	Pass
19	0.002	0.133	0.038	0.017	0.003	0.151	#13	0.199	Not Required	Pass
20	0.001	0.097	0.149	0.049	0.008	0.191	#13	0.087	Not Required	Pass
21	0.002	0.135	0.029	0.014	0.002	0.158	#13	0.133	Not Required	Pass
22	0.001	0.114	0.150	0.051	0.008	0.246	#13	0.087	Not Required	Pass
23	0.003	0.148	0.032	0.014	0.002	0.172	#13	0.199	Not Required	Pass
24	0.002	0.127	0.141	0.051	0.008	0.240	#13	0.087	Not Required	Pass
25	0.002	0.143	0.027	0.013	0.002	0.166	#13	0.133	Not Required	Pass
26	0.001	0.126	0.141	0.051	0.008	0.241	#13	0.087	Not Required	Pass
27	0.003	0.148	0.030	0.013	0.002	0.174	#13	0.199	Not Required	Pass
28	0.002	0.128	0.140	0.051	0.008	0.244	#13	0.087	Not Required	Pass
29	0.002	0.135	0.029	0.014	0.002	0.158	#13	0.133	Not Required	Pass
30	0.001	0.120	0.142	0.051	0.008	0.233	#13	0.087	Not Required	Pass
31	0.003	0.148	0.032	0.014	0.002	0.172	#13	0.199	Not Required	Pass
32	0.001	0.126	0.150	0.052	0.008	0.260	#13	0.087	Not Required	Pass
33	0.002	0.135	0.029	0.017	0.002	0.160	#13	0.133	Not Required	Pass
34	0.001	0.106	0.149	0.050	0.008	0.223	#16	0.087	Not Required	Pass
35	0.002	0.133	0.038	0.017	0.003	0.151	#13	0.199	Not Required	Pass
36	0.000	0.117	0.106	0.036	0.006	0.203	#13	Not Required	Not Required	Pass
101	0.061	0.733	0.002	0.052	0.000	0.742	#13	0.416	Not Required	Pass
102	0.001	0.426	0.204	0.090	0.039	0.630	#13	0.036	Not Required	Pass
103	0.003	0.671	0.021	0.067	0.003	0.690	#13	0.046	Not Required	Pass
104	0.003	0.681	0.054	0.068	0.012	0.714	#13	0.082	Not Required	Pass
105	0.003	0.416	0.055	0.066	0.014	0.427	#13	0.076	Not Required	Pass
106	0.003	0.679	0.021	0.068	0.004	0.696	#13	0.046	Not Required	Pass
107	0.003	0.422	0.052	0.067	0.013	0.433	#13	0.076	Not Required	Pass
108	0.002	0.048	0.055	0.040	0.006	0.076	#13	0.102	Not Required	Pass
109	0.005	0.062	0.037	0.001	0.000	0.100	#13	0.206	Not Required	Pass
110	0.003	0.680	0.051	0.068	0.011	0.708	#13	0.082	Not Required	Pass
111	0.001	0.055	0.056	0.039	0.006	0.072	#21	0.102	Not Required	Pass
112	0.001	0.430	0.207	0.090	0.040	0.637	#13	0.036	Not Required	Pass
113	0.001	0.120	0.142	0.051	0.008	0.233	#13	0.087	Not Required	Pass
114	0.001	0.126	0.150	0.052	0.008	0.259	#13	0.087	Not Required	Pass
115	0.002	0.277	0.077	0.040	0.006	0.343	#13	0.507	Not Required	Pass
116	0.002	0.273	0.078	0.041	0.006	0.338	#13	0.507	Not Required	Pass
201	0.061	0.744	0.000	0.052	0.000	0.749	#16	0.416	Not Required	Pass
202	0.001	0.427	0.205	0.090	0.039	0.632	#13	0.036	Not Required	Pass
203	0.003	0.678	0.020	0.068	0.003	0.696	#13	0.046	Not Required	Pass

204	0.003	0.673	0.050	0.067	0.011	0.703	#13	0.082	Not Required	Pass
205	0.003	0.420	0.052	0.067	0.013	0.431	#13	0.076	Not Required	Pass
206	0.003	0.678	0.020	0.068	0.003	0.696	#13	0.046	Not Required	Pass
207	0.003	0.420	0.052	0.067	0.013	0.431	#13	0.076	Not Required	Pass
208	0.002	0.048	0.054	0.040	0.006	0.079	#13	0.102	Not Required	Pass
209	0.004	0.060	0.037	0.001	0.000	0.099	#13	0.206	Not Required	Pass
210	0.003	0.673	0.050	0.067	0.011	0.703	#13	0.082	Not Required	Pass
211	0.001	0.052	0.055	0.040	0.006	0.076	#13	0.102	Not Required	Pass
212	0.001	0.427	0.205	0.090	0.039	0.632	#13	0.036	Not Required	Pass
213	0.001	0.126	0.141	0.051	0.008	0.241	#13	0.087	Not Required	Pass
214	0.002	0.128	0.140	0.051	0.008	0.244	#13	0.087	Not Required	Pass
215	0.002	0.246	0.077	0.040	0.006	0.311	#13	0.507	Not Required	Pass
216	0.003	0.238	0.078	0.040	0.006	0.300	#13	0.507	Not Required	Pass
301	0.061	0.733	0.002	0.052	0.000	0.742	#13	0.416	Not Required	Pass
302	0.001	0.430	0.207	0.090	0.040	0.637	#13	0.036	Not Required	Pass
303	0.003	0.679	0.021	0.068	0.004	0.696	#13	0.046	Not Required	Pass
304	0.003	0.680	0.051	0.068	0.011	0.708	#13	0.082	Not Required	Pass
305	0.003	0.421	0.052	0.067	0.013	0.433	#13	0.076	Not Required	Pass
306	0.003	0.671	0.021	0.067	0.003	0.690	#13	0.046	Not Required	Pass
307	0.003	0.416	0.055	0.066	0.014	0.428	#13	0.076	Not Required	Pass
308	0.001	0.057	0.062	0.041	0.006	0.087	#13	0.102	Not Required	Pass
309	0.005	0.062	0.037	0.001	0.000	0.100	#13	0.206	Not Required	Pass
310	0.003	0.681	0.054	0.068	0.012	0.714	#13	0.082	Not Required	Pass
311	0.001	0.064	0.062	0.040	0.006	0.081	#16	0.102	Not Required	Pass
312	0.001	0.426	0.204	0.090	0.039	0.630	#13	0.036	Not Required	Pass
313	0.001	0.114	0.150	0.051	0.008	0.246	#13	0.087	Not Required	Pass
314	0.002	0.127	0.141	0.051	0.008	0.240	#13	0.087	Not Required	Pass
315	0.002	0.248	0.077	0.039	0.006	0.313	#13	0.507	Not Required	Pass
316	0.003	0.236	0.078	0.040	0.006	0.300	#13	0.507	Not Required	Pass
401	0.053	0.656	0.021	0.046	0.002	0.664	#16	0.416	Not Required	Pass
402	0.001	0.404	0.187	0.083	0.036	0.591	#13	0.054	Not Required	Pass
403	0.003	0.625	0.026	0.063	0.005	0.651	#13	0.046	Not Required	Pass
404	0.003	0.611	0.056	0.061	0.012	0.624	#13	0.082	Not Required	Pass
405	0.003	0.388	0.055	0.062	0.014	0.400	#13	0.076	Not Required	Pass
406	0.003	0.558	0.013	0.055	0.001	0.566	#13	0.046	Not Required	Pass
407	0.002	0.346	0.038	0.055	0.010	0.350	#13	0.076	Not Required	Pass
408	0.000	0.055	0.049	0.024	0.004	0.095	#13	Not Required	Not Required	Pass
409	0.004	0.061	0.042	0.002	0.001	0.104	#13	0.206	Not Required	Pass
410	0.002	0.557	0.042	0.056	0.010	0.592	#13	0.082	Not Required	Pass
411	0.000	0.055	0.049	0.024	0.004	0.095	#13	Not Required	Not Required	Pass
412	0.001	0.339	0.170	0.074	0.033	0.510	#13	0.036	Not Required	Pass
413	0.000	0.117	0.106	0.036	0.006	0.203	#13	Not Required	Not Required	Pass
414	0.001	0.097	0.149	0.049	0.008	0.191	#13	0.087	Not Required	Pass
415	0.002	0.284	0.077	0.039	0.006	0.343	#13	0.507	Not Required	Pass
416	0.002	0.279	0.078	0.038	0.006	0.342	#13	0.507	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/comresssion)
M_n	Nominal flexural strength (about Z/Y axis)
V_n	Nominal shear strength (along Z/Y axis)
P	Design ratio in case of axial force
M_z	Design ratio in case of bending about Z axis
M_y	Design ratio in case of bending about Y axis
V_y	Design ratio in case of shear along Y axis
V_z	Design ratio in case of shear along Z axis
(P,M_z,M_y)	Design ratio in case of axial force and bending action
KL/r	Design ratio in case of section slenderness
δ	Design ratio in case of member deflection
OK	Capacity is provided
NG	Capacity is not provided

REFERENCES	CALCULATIONS	RESULTS

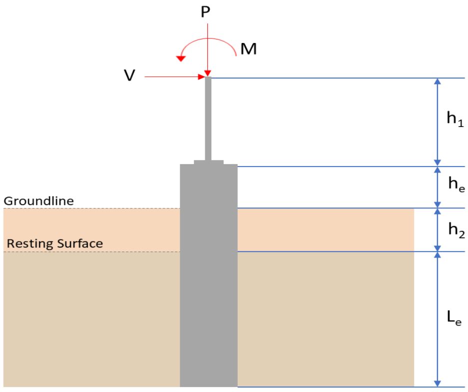
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: rectangular
$b = 48$ in - Pile width
$D = 48$ in - Pile depth
$L = 6.75$ ft - Total pile length
$h_1 = 0$ ft - Lateral load height from the top of the pile,
$h_2 = 0$ ft - Depth to resisting surface
$h_e = 0$ 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)	7.801	12.132
V_x (kip)	-3.113	-5.198
V_z (kip)	0.155	0.248
M_x (kipft)	0.399	0.639
M_z (kipft)	32.538	54.676

Material Properties

$f'_{ck} = 3$ ksi - Concrete strength,

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

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

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

Considering x-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-3.113 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.4957 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(32.538\ \text{kipft}) + ((-3.113\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 5.1812\ \text{kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:
$L_{e,x} = 6.1428\ \text{ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.155\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = 0.024682\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.399\ \text{kipft}) + ((0.155\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 0.063535\ \text{kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:
$L_{e,z} = 2.0042\ \text{ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(6.1428\ \text{ft}), (2.0042\ \text{ft})]$$

$$L_{e,req} = 6.143\ \text{ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (6.75\ \text{ft}) - (0\ \text{ft}) - (0\ \text{ft})$$

$$L_e = 6.75\ \text{ft}$$

$Ratio$ - Embedded depth

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

$$Ratio = \frac{(6.143\ \text{ft})}{(6.75\ \text{ft})}$$

$$Ratio = 0.91007$$

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

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = b\, D$$

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

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

q - End-bearing pressure

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

$$q = \frac{(7.801\ \text{kip})}{(16\ \text{ft}^2)}$$

$$q = 0.48756\ \text{kip/ft}^2$$

$$q = 0.48756\ \mathrm{kip/ft}$$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{\left(0.48756\ \mathrm{kip/ft^2}\right)}{\left(2000\ \mathrm{psf}\right)}$$

$$Ratio = 0.24378$$

Status: **PASS**
Ratio: **0.240**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(6.75\ \mathrm{ft})}{(48\ \mathrm{in})}$$

$$L/D = 1.6875$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.4957\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 5.1812\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.1812\ \mathrm{kipft/ft}) \times (6.75\ \mathrm{ft})) + \left(3 \times (-0.4957\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft})^2\right)}{(6 \times (5.1812\ \mathrm{kipft/ft})) + (4 \times (-0.4957\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft}))}$$

$$a = 4.6693\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (5.1812\ \mathrm{kipft/ft})) + (3 \times (-0.4957\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft}))]^2}{(6.75\ \mathrm{ft})^2 \times [(3 \times (5.1812\ \mathrm{kipft/ft})) + (2 \times (-0.4957\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft}))]}$$

$$p = 0.21239\ \mathrm{kip/ft^2}$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (5.1812\ \mathrm{kipft/ft})) + ((-0.4957\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft}))]}{(6.75\ \mathrm{ft})^2}$$

$$s = 0.92398\ \mathrm{kip/ft^2}$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \mathrm{psf/ft}) \times \frac{(4.6693\ \mathrm{ft})}{2}$$

$$p_a = 0.3502\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.21239\ \mathrm{kip/ft^2}\right)}{\left(0.3502\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.60649$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\, L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (6.75\ \mathrm{ft})$$

$$p_s = 1.0125\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.92398\ \mathrm{kip/ft^2}\right)}{\left(1.0125\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.91257$$

Status: PASS
Ratio: 0.910

Considering z-direction:

$H_o = 0.024682\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 0.063535\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.063535\ \mathrm{kipft/ft}) \times (6.75\ \mathrm{ft})) + \left(3 \times (0.024682\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft})^2\right)}{(6 \times (0.063535\ \mathrm{kipft/ft})) + (4 \times (0.024682\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft}))}$$

$$a = 4.8578\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.063535\ \mathrm{kipft/ft})) + (3 \times (0.024682\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft}))]^{\ 2}}{(6.75\ \mathrm{ft})^2 \times [(3 \times (0.063535\ \mathrm{kipft/ft})) + (2 \times (0.024682\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft}))]}$$

$$p = 0.017863\ \mathrm{kip/ft^2}$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (0.063535\ \mathrm{kipft/ft})) + ((0.024682\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft}))]}{(6.75\ \mathrm{ft})^2}$$

$$s = 0.038673\ \mathrm{kip/ft^2}$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \mathrm{psf/ft}) \times \frac{(4.8578\ \mathrm{ft})}{2}$$

$$p_a = 0.36434\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.017863\ \mathrm{kip/ft^2}\right)}{\left(0.36434\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.049029$$

Status: PASS
Ratio: 0.050

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\, L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (6.75\ \mathrm{ft})$$

$$p_s = 1.0125\ \mathrm{kip/ft^2}$$

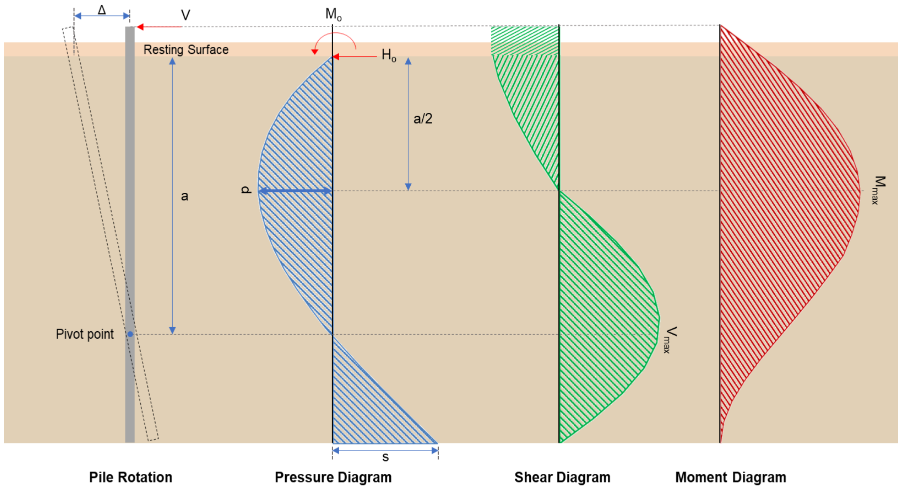
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.038673\ \text{kip/ft}^2)}{(1.0125\ \text{kip/ft}^2)}$$

$$Ratio = 0.038195$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-5.198\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = -0.82771\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(54.676\ \text{kipft}) + ((-5.198\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 8.7064\ \text{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(8.7064\ \text{kipft/ft})}{(-0.82771\ \text{kip/ft})}$$

$$E = 10.519\ \text{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (8.7064\ \text{kipft/ft}) \times (6.75\ \text{ft})) + \left(3 \times (-0.82771\ \text{kip/ft}) \times (6.75\ \text{ft})^2\right)}{(6 \times (8.7064\ \text{kipft/ft})) + (4 \times (-0.82771\ \text{kip/ft}) \times (6.75\ \text{ft}))}$$

$$a = 4.6685\ \text{ft}$$

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

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

$$V_{max} = ((-0.82771\ \text{kip/ft}) \times (48\ \text{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (10.519\ \text{ft})}{(6.75\ \text{ft})} + 3\right) \times \left(\frac{(4.6685\ \text{ft})}{(6.75\ \text{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (10.519\ \text{ft})}{(6.75\ \text{ft})} + 2\right) \times \left(\frac{(4.6685\ \text{ft})}{(6.75\ \text{ft})}\right)^3\right]\right]$$

$$V_{max} = 11.313\ \text{kip}$$

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

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

$$M_{max} = ((-0.82771\ \text{kip/ft}) \times (48\ \text{in}) \times (6.75\ \text{ft})) \times \left[\left(\frac{(10.519\ \text{ft})}{(6.75\ \text{ft})} + \frac{(4.6685\ \text{ft})}{2 \times (6.75\ \text{ft})}\right) - \left[\left(\frac{4 \times (10.519\ \text{ft})}{(6.75\ \text{ft})} + 3\right) \times \left(\frac{(4.6685\ \text{ft})}{2 \times (6.75\ \text{ft})}\right)^3\right] + \left[\left(\frac{3 \times (10.519\ \text{ft})}{(6.75\ \text{ft})} + 2\right) \times \left(\frac{(4.6685\ \text{ft})}{2 \times (6.75\ \text{ft})}\right)^4\right]\right]$$

$$M_{max} = 36.154\ \text{kipft}$$

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

H_o - Lateral force per length of pile,

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

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

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

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.639\ \text{kipft}) + ((0.248\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 0.10175\ \text{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.10175\ \text{kipft/ft})}{(0.03949\ \text{kip/ft})}$$

$$E = 2.5766\ \text{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.10175\ \text{kipft/ft}) \times (6.75\ \text{ft})) + \left(3 \times (0.03949\ \text{kip/ft}) \times (6.75\ \text{ft})^2\right)}{(6 \times (0.10175\ \text{kipft/ft})) + (4 \times (0.03949\ \text{kip/ft}) \times (6.75\ \text{ft}))}$$

$$a = 4.8577\ \text{ft}$$

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

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

$$V_{max} = ((0.03949\ \text{kip/ft}) \times (48\ \text{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (2.5766\ \text{ft})}{(6.75\ \text{ft})} + 3\right) \times \left(\frac{(4.8577\ \text{ft})}{(6.75\ \text{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (2.5766\ \text{ft})}{(6.75\ \text{ft})} + 2\right) \times \left(\frac{(4.8577\ \text{ft})}{(6.75\ \text{ft})}\right)^3\right]\right]$$

$$V_{max} = 0.21238\ \text{kip}$$

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

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

$$M_{max} = ((0.03949\ \text{kip/ft}) \times (48\ \text{in}) \times (6.75\ \text{ft})) \times \left[\left(\frac{(2.5766\ \text{ft})}{(6.75\ \text{ft})} + \frac{(4.8577\ \text{ft})}{2 \times (6.75\ \text{ft})}\right) - \left[\left(\frac{4 \times (2.5766\ \text{ft})}{(6.75\ \text{ft})} + 3\right) \times \left(\frac{(4.8577\ \text{ft})}{2 \times (6.75\ \text{ft})}\right)^3\right] + \left[\left(\frac{3 \times (2.5766\ \text{ft})}{(6.75\ \text{ft})} + 2\right) \times \left(\frac{(4.8577\ \text{ft})}{2 \times (6.75\ \text{ft})}\right)^4\right]\right]$$

$$M_{max} = 0.62201 \text{ kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

$f'_{ck} = 3 \text{ ksi}$ - 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 $A_{st,required}$

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

$$A_{st,required} = Min\left[\frac{\frac{(12.132 \text{ kip})}{(0.65)\times(0.8)} - \left(0.85 \times (3 \text{ ksi}) \times \left(2304 \text{ in}^2\right)\right)}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, \left(0.08 \times \left(2304 \text{ in}^2\right)\right)\right]$$

$$A_{st,required} = -101.86 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[\left(-101.86 \text{ in}^2\right), \left(0.0018 \times \left(2304 \text{ in}^2\right)\right)\right]$$

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

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

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

$$\phi P_N = (0.65) \times 0.80 \times \left[\left(0.85 \times (3\text{ ksi}) \times \left[\left(2304\text{ in}^2\right) - \left(4.2951\text{ in}^2\right)\right]\right) + \left((60\text{ ksi}) \times \left(4.2951\text{ in}^2\right)\right)\right]$$

$$\phi P_N = 3183.4\text{ kip}$$

$Ratio$ - Capacity

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

$$Ratio = \frac{(12.132\text{ kip})}{(3183.4\text{ kip})}$$

$$Ratio = 0.003811$$

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 $f'_{ck} = 3\text{ ksi} \rightarrow 3000\text{ psi}$,

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

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

$$V_{c,max} = 5 \times (0.64282) \times \sqrt{(3000\text{ psi})} \times (48\text{ in}) \times (38.4\text{ in})$$

$$V_{c,max} = 324.49\text{ kip}$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\text{ ksi} \rightarrow 3000\text{ psi}$, $P = 12.132\text{ kip} \rightarrow 12132\text{ lbf}$,

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

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000\text{ psi})} + \frac{(12132\text{ lbf})}{6 \times (2304\text{ in}^2)}\right] \times (48\text{ in}) \times (38.4\text{ in})$$

$$V_{c,a} = 131.41\text{ kip}$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\text{ ksi} \rightarrow 3000\text{ psi}$,

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

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

$$V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(3000\text{ psi})} + (0.05 \times (3000\text{ psi}))\right] \times (48\text{ in}) \times (38.4\text{ in})$$

$$V_{c,b} = 406.27\text{ kip}$$

V_c - Governing shear strength of concrete

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

$$V_c = Min\left[(324.49\text{ kip}), (131.41\text{ kip}), (406.27\text{ kip})\right]$$

$$V_c = 131.41\text{ kip}$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\ \text{ksi} \rightarrow 3000\ \text{psi}$,

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

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

$$V_{s,a} = 8 \times \sqrt{(3000\ \text{psi})} \times (48\ \text{in}) \times (38.4\ \text{in})$$

$$V_{s,a} = 807.65\ \text{kip}$$

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

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

$$V_s = MIN\left[(807.65\ \text{kip}), (50.894\ \text{kip})\right]$$

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

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((131.41\ \text{kip}) + (50.894\ \text{kip}))$$

$$\phi V_n = 118.5\ \text{kip}$$

Considering x-direction:

$V_{max} = 11.313\ \text{kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(11.313\ \text{kip})}{(118.5\ \text{kip})}$$

$$Ratio = 0.095466$$

Status: **PASS**
Ratio: **0.100**

Considering z-direction:

$V_{max} = 0.21238\ \text{kip}$ - Maximum shear force in the z-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(0.21238\ \text{kip})}{(118.5\ \text{kip})}$$

$$Ratio = 0.0017923$$

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: $\phi M_{n,1}$ $$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f_c')} \times S_m$$ $$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(3ksi)} \times 18432.001 in^3$$ $$\phi M_{n,1} = 273.423 kipft$$	
14.5.2.1b	$\phi M_{n,2}$ $$\phi M_{n,2} = \phi\, 0.85\, f'_{ck}\, S_m$$ $$\phi M_{n,2} = (0.65) \times 0.85 \times (3 \text{ ksi}) \times \left(18432 \text{ in}^3\right)$$ $$\phi M_{n,2} = 2545.9 \text{ kipft}$$ Therefore, ϕM_n - Allowable flexural strength, $$\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$$ $$\phi M_n = MIN[(273.42 \text{ kipft}), (2545.9 \text{ kipft})]$$ $$\phi M_n = 273.42 \text{ kipft}$$ **Considering x-direction:** $M_{max} = 36.154 \text{ kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(36.154 \text{ kipft})}{(273.42 \text{ kipft})}$$ $$Ratio = 0.13223$$	Status: **PASS** Ratio: **0.130**
	Considering z-direction: $M_{max} = 0.62201 \text{ kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(0.62201 \text{ kipft})}{(273.42 \text{ kipft})}$$ $$Ratio = 0.0022749$$	Status: **PASS** Ratio: **0.000**

REFERENCES	CALCULATIONS	RESULTS

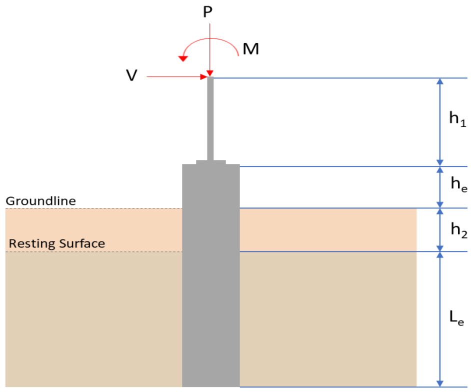
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: rectangular
$b = 48$ in - Pile width
$D = 48$ in - Pile depth
$L = 6.75$ ft - Total pile length
$h_1 = 0$ ft - Lateral load height from the top of the pile,
$h_2 = 0$ ft - Depth to resisting surface
$h_e = 0$ 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)	7.801	12.132
V_x (kip)	-3.113	-5.198
V_z (kip)	-0.155	-0.248
M_x (kipft)	-0.399	-0.639
M_z (kipft)	32.538	54.677

Material Properties

$f'_{ck} = 3$ ksi - Concrete strength,

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

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

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

Considering x-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-3.113 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.4957 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(32.538\ \text{kipft}) + ((-3.113\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 5.1812\ \text{kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:
$L_{e,x} = 6.1428\ \text{ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.155\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = -0.024682\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.399\ \text{kipft}) + ((-0.155\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 0.063535\ \text{kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:
$L_{e,z} = 1.4354\ \text{ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(6.1428\ \text{ft}), (1.4354\ \text{ft})]$$

$$L_{e,req} = 6.143\ \text{ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (6.75\ \text{ft}) - (0\ \text{ft}) - (0\ \text{ft})$$

$$L_e = 6.75\ \text{ft}$$

$Ratio$ - Embedded depth

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

$$Ratio = \frac{(6.143\ \text{ft})}{(6.75\ \text{ft})}$$

$$Ratio = 0.91007$$

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

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = b\,D$$

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

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

q - End-bearing pressure

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

$$q = \frac{(7.801\ \text{kip})}{(16\ \text{ft}^2)}$$

$$q = 0.48756\ \text{kip/ft}^2$$

$q = 0.48756\ \mathrm{kip/ft^2}$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{(0.48756\ \mathrm{kip/ft^2})}{(2000\ \mathrm{psf})}$$

$$Ratio = 0.24378$$

Status: **PASS**
Ratio: **0.240**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(6.75\ \mathrm{ft})}{(48\ \mathrm{in})}$$

$$L/D = 1.6875$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.4957\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 5.1812\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.1812\ \mathrm{kipft/ft}) \times (6.75\ \mathrm{ft})) + \left(3 \times (-0.4957\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft})^2\right)}{(6 \times (5.1812\ \mathrm{kipft/ft})) + (4 \times (-0.4957\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft}))}$$

$$a = 4.6693\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (5.1812\ \mathrm{kipft/ft})) + (3 \times (-0.4957\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft}))]^2}{(6.75\ \mathrm{ft})^2 \times [(3 \times (5.1812\ \mathrm{kipft/ft})) + (2 \times (-0.4957\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft}))]}$$

$$p = 0.21239\ \mathrm{kip/ft^2}$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (5.1812\ \mathrm{kipft/ft})) + ((-0.4957\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft}))]}{(6.75\ \mathrm{ft})^2}$$

$$s = 0.92398\ \mathrm{kip/ft^2}$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \mathrm{psf/ft}) \times \frac{(4.6693\ \mathrm{ft})}{2}$$

$$p_a = 0.3502\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.21239\ \mathrm{kip/ft^2})}{(0.3502\ \mathrm{kip/ft^2})}$$

$$Ratio = 0.60649$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\text{ psf/ft}) \times (6.75\text{ ft})$$

$$p_s = 1.0125\text{ kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.92398\text{ kip/ft}^2\right)}{\left(1.0125\text{ kip/ft}^2\right)}$$

$$Ratio = 0.91257$$

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

Considering z-direction:

$H_o = -0.024682\text{ kip/ft}$ - Lateral force per length of pile,
$M_o = 0.063535\text{ kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.063535\text{ kipft/ft}) \times (6.75\text{ ft})) + \left(3 \times (-0.024682\text{ kip/ft}) \times (6.75\text{ ft})^2\right)}{(6 \times (0.063535\text{ kipft/ft})) + (4 \times (-0.024682\text{ kip/ft}) \times (6.75\text{ ft}))}$$

$$a = 4.8578\text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.063535\text{ kipft/ft})) + (3 \times (-0.024682\text{ kip/ft}) \times (6.75\text{ ft}))]^2}{(6.75\text{ ft})^2 \times [(3 \times (0.063535\text{ kipft/ft})) + (2 \times (-0.024682\text{ kip/ft}) \times (6.75\text{ ft}))]}$$

$$p = -0.0069666\text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (0.063535\text{ kipft/ft})) + ((-0.024682\text{ kip/ft}) \times (6.75\text{ ft}))]}{(6.75\text{ ft})^2}$$

$$s = -0.0052056\text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\text{ psf/ft}) \times \frac{(4.8578\text{ ft})}{2}$$

$$p_a = 0.36434\text{ kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(-0.0069666\text{ kip/ft}^2\right)}{\left(0.36434\text{ kip/ft}^2\right)}$$

$$Ratio = -0.019121$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\text{ psf/ft}) \times (6.75\text{ ft})$$

$$p_s = 1.0125\text{ kip/ft}^2$$

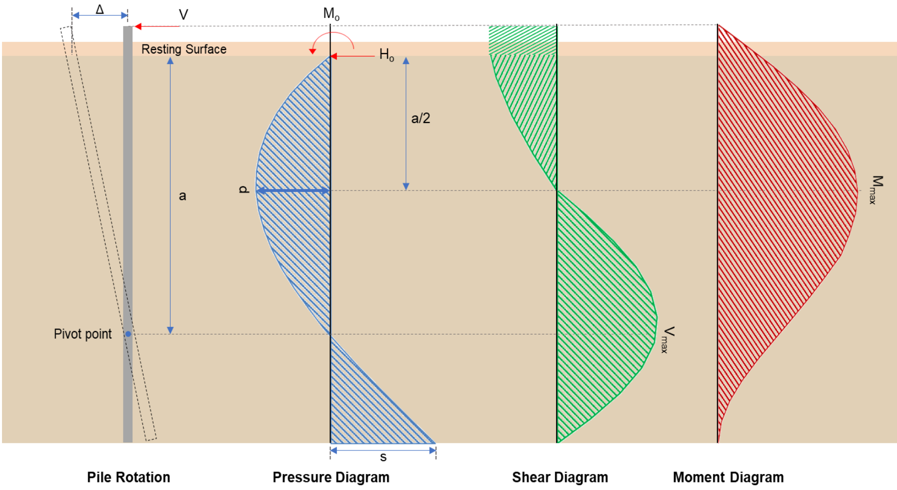
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(-0.0052056\ \text{kip/ft}^2)}{(1.0125\ \text{kip/ft}^2)}$$

$$Ratio = -0.0051414$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-5.198\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = -0.82771\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(54.677\ \text{kipft}) + ((-5.198\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 8.7065\ \text{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(8.7065\ \text{kipft/ft})}{(-0.82771\ \text{kip/ft})}$$

$$E = 10.519\ \text{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (8.7065\ \text{kipft/ft}) \times (6.75\ \text{ft})) + \left(3 \times (-0.82771\ \text{kip/ft}) \times (6.75\ \text{ft})^2\right)}{(6 \times (8.7065\ \text{kipft/ft})) + (4 \times (-0.82771\ \text{kip/ft}) \times (6.75\ \text{ft}))}$$

$$a = 4.6685\ \text{ft}$$

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

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

$$V_{max} = ((-0.82771\ \text{kip/ft}) \times (48\ \text{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (10.519\ \text{ft})}{(6.75\ \text{ft})} + 3\right) \times \left(\frac{(4.6685\ \text{ft})}{(6.75\ \text{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (10.519\ \text{ft})}{(6.75\ \text{ft})} + 2\right) \times \left(\frac{(4.6685\ \text{ft})}{(6.75\ \text{ft})}\right)^3\right]\right]$$

$$V_{max} = 11.313\ \text{kip}$$

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

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

$$M_{max} = ((-0.82771\text{ kip/ft}) \times (48\text{ in}) \times (6.75\text{ ft})) \times \left[\left(\frac{(10.519\text{ ft})}{(6.75\text{ ft})} + \frac{(4.6685\text{ ft})}{2 \times (6.75\text{ ft})}\right) - \left[\left(\frac{4 \times (10.519\text{ ft})}{(6.75\text{ ft})} + 3\right) \times \left(\frac{(4.6685\text{ ft})}{2 \times (6.75\text{ ft})}\right)^3\right] + \left[\left(\frac{3 \times (10.519\text{ ft})}{(6.75\text{ ft})} + 2\right) \times \left(\frac{(4.6685\text{ ft})}{2 \times (6.75\text{ ft})}\right)^4\right]\right]$$

$$M_{max} = 36.154\text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

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

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

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.639\text{ kipft}) + ((-0.248\text{ kip}) \times (0\text{ ft}))}{1.57 \times (48\text{ in})}$$

$$M_o = 0.10175\text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.10175\text{ kipft/ft})}{(-0.03949\text{ kip/ft})}$$

$$E = 2.5766\text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.10175\text{ kipft/ft}) \times (6.75\text{ ft})) + \left(3 \times (-0.03949\text{ kip/ft}) \times (6.75\text{ ft})^2\right)}{(6 \times (0.10175\text{ kipft/ft})) + (4 \times (-0.03949\text{ kip/ft}) \times (6.75\text{ ft}))}$$

$$a = 4.8577\text{ ft}$$

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

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

$$V_{max} = ((-0.03949\text{ kip/ft}) \times (48\text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (2.5766\text{ ft})}{(6.75\text{ ft})} + 3\right) \times \left(\frac{(4.8577\text{ ft})}{(6.75\text{ ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (2.5766\text{ ft})}{(6.75\text{ ft})} + 2\right) \times \left(\frac{(4.8577\text{ ft})}{(6.75\text{ ft})}\right)^3\right]\right]$$

$$V_{max} = 0.21238\text{ kip}$$

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

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

$$M_{max} = ((-0.03949\text{ kip/ft}) \times (48\text{ in}) \times (6.75\text{ ft})) \times \left[\left(\frac{(2.5766\text{ ft})}{(6.75\text{ ft})} + \frac{(4.8577\text{ ft})}{2 \times (6.75\text{ ft})}\right) - \left[\left(\frac{4 \times (2.5766\text{ ft})}{(6.75\text{ ft})} + 3\right) \times \left(\frac{(4.8577\text{ ft})}{2 \times (6.75\text{ ft})}\right)^3\right] + \left[\left(\frac{3 \times (2.5766\text{ ft})}{(6.75\text{ ft})} + 2\right) \times \left(\frac{(4.8577\text{ ft})}{2 \times (6.75\text{ ft})}\right)^4\right]\right]$$

	$$M_{max} = 0.62201 \text{ kipft}$$		

Minimum Reinforcement Check (LRFD)

Parameters:

$f'_{ck} = 3 \text{ ksi}$ - 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 $A_{st,required}$

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

$$A_{st,required} = Min\left[\frac{\frac{(12.132 \text{ kip})}{(0.65)\times(0.8)} - \left(0.85 \times (3 \text{ ksi}) \times \left(2304 \text{ in}^2\right)\right)}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, \left(0.08 \times \left(2304 \text{ in}^2\right)\right)\right]$$

$$A_{st,required} = -101.86 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[\left(-101.86 \text{ in}^2\right), \left(0.0018 \times \left(2304 \text{ in}^2\right)\right)\right]$$

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

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

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

$$\phi P_N = (0.65) \times 0.80 \times \left[\left(0.85 \times (3\ \text{ksi}) \times \left[\left(2304\ \text{in}^2\right) - \left(4.2951\ \text{in}^2\right)\right]\right) + \left((60\ \text{ksi}) \times \left(4.2951\ \text{in}^2\right)\right)\right]$$

$$\phi P_N = 3183.4\ \text{kip}$$

$Ratio$ - Capacity

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

$$Ratio = \frac{(12.132\ \text{kip})}{(3183.4\ \text{kip})}$$

$$Ratio = 0.003811$$

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 $f'_{ck} = 3\ \text{ksi} \rightarrow 3000\ \text{psi}$,

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

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

$$V_{c,max} = 5 \times (0.64282) \times \sqrt{(3000\ \text{psi})} \times (48\ \text{in}) \times (38.4\ \text{in})$$

$$V_{c,max} = 324.49\ \text{kip}$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\ \text{ksi} \rightarrow 3000\ \text{psi}$, $P = 12.132\ \text{kip} \rightarrow 12132\ \text{lbf}$,

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

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000\ \text{psi})} + \frac{(12132\ \text{lbf})}{6 \times (2304\ \text{in}^2)}\right] \times (48\ \text{in}) \times (38.4\ \text{in})$$

$$V_{c,a} = 131.41\ \text{kip}$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\ \text{ksi} \rightarrow 3000\ \text{psi}$,

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

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

$$V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(3000\ \text{psi})} + (0.05 \times (3000\ \text{psi}))\right] \times (48\ \text{in}) \times (38.4\ \text{in})$$

$$V_{c,b} = 406.27\ \text{kip}$$

V_c - Governing shear strength of concrete

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

$$V_c = Min\left[(324.49\ \text{kip}), (131.41\ \text{kip}), (406.27\ \text{kip})\right]$$

$$V_c = 131.41\ \text{kip}$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\text{ ksi} \rightarrow 3000\text{ psi}$,

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

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

$$V_{s,a} = 8 \times \sqrt{(3000\text{ psi})} \times (48\text{ in}) \times (38.4\text{ in})$$

$$V_{s,a} = 807.65\text{ kip}$$

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

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

$$V_s = MIN\left[(807.65\text{ kip}), (50.894\text{ kip})\right]$$

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

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((131.41\text{ kip}) + (50.894\text{ kip}))$$

$$\phi V_n = 118.5\text{ kip}$$

Considering x-direction:

$V_{max} = 11.313\text{ kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(11.313\text{ kip})}{(118.5\text{ kip})}$$

$$Ratio = 0.095467$$

Status: **PASS**
Ratio: **0.100**

Considering z-direction:

$V_{max} = 0.21238\text{ kip}$ - Maximum shear force in the z-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(0.21238\text{ kip})}{(118.5\text{ kip})}$$

$$Ratio = 0.0017923$$

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: $\phi M_{n,1}$ $$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f_c')} \times S_m$$ $$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(3ksi)} \times 18432.001in^3$$ $$\phi M_{n,1} = 273.423kipft$$	
14.5.2.1b	$\phi M_{n,2}$ $$\phi M_{n,2} = \phi\, 0.85\, f'_{ck}\, S_m$$ $$\phi M_{n,2} = (0.65) \times 0.85 \times (3 \text{ ksi}) \times \left(18432 \text{ in}^3\right)$$ $$\phi M_{n,2} = 2545.9 \text{ kipft}$$ Therefore, ϕM_n - Allowable flexural strength, $$\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$$ $$\phi M_n = MIN[(273.42 \text{ kipft}), (2545.9 \text{ kipft})]$$ $$\phi M_n = 273.42 \text{ kipft}$$ **Considering x-direction:** $M_{max} = 36.154 \text{ kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(36.154 \text{ kipft})}{(273.42 \text{ kipft})}$$ $$Ratio = 0.13223$$	Status: **PASS** Ratio: **0.130**
	Considering z-direction: $M_{max} = 0.62201 \text{ kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(0.62201 \text{ kipft})}{(273.42 \text{ kipft})}$$ $$Ratio = 0.0022749$$	Status: **PASS** Ratio: **0.000**

REFERENCES	CALCULATIONS	RESULTS

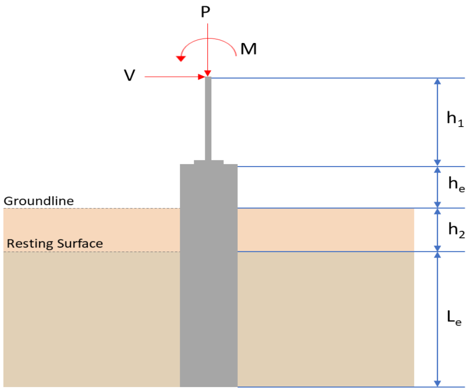
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: rectangular
$b = 48\ \mathrm{in}$ - Pile width
$D = 48\ \mathrm{in}$ - Pile depth
$L = 7\ \mathrm{ft}$ - Total pile length
$h_1 = 0\ \mathrm{ft}$ - Lateral load height from the top of the pile,
$h_2 = 0\ \mathrm{ft}$ - Depth to resisting surface
$h_e = 0\ \mathrm{ft}$ - Length of pile above the ground

Tabulation of Soil Parameters

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

Tabulation of Loads

Load Component	ASD	LRFD
P (kip)	8.929	13.917
V_x (kip)	-3.571	-5.948
V_z (kip)	-0.016	-0.028
M_x (kipft)	-0.039	-0.065
M_z (kipft)	36.335	61.078

Material Properties

$f'_{ck} = 3\ \mathrm{ksi}$ - Concrete strength,

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

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

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

Considering x-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-3.571\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.56863\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(36.335\ \mathrm{kipft}) + ((-3.571\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 5.7858\ \mathrm{kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:
$L_{e,x} = 6.2861\ \mathrm{ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.016\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.0025478\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.039\ \mathrm{kipft}) + ((-0.016\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 0.0062102\ \mathrm{kipft/ft}$$

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:
$L_{e,z} = 0.72776\ \mathrm{ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(6.2861\ \mathrm{ft}), (0.72776\ \mathrm{ft})]$$

$$L_{e,req} = 6.286\ \mathrm{ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (7\ \mathrm{ft}) - (0\ \mathrm{ft}) - (0\ \mathrm{ft})$$

$$L_e = 7\ \mathrm{ft}$$

$Ratio$ - Embedded depth

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

$$Ratio = \frac{(6.286\ \mathrm{ft})}{(7\ \mathrm{ft})}$$

$$Ratio = 0.898$$

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

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

$$q = \frac{(8.929\ \mathrm{kip})}{(16\ \mathrm{ft}^2)}$$

$$q = 0.55806\ \mathrm{kip/ft}^2$$

$$q = 0.55806\ \text{kip/ft}^2$$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{(0.55806\ \text{kip/ft}^2)}{(2000\ \text{psf})}$$

$$Ratio = 0.27903$$

Status: **PASS**
Ratio: **0.280**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(7\ \text{ft})}{(48\ \text{in})}$$

$$L/D = 1.75$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.56863\ \text{kip/ft}$ - Lateral force per length of pile,
$M_o = 5.7858\ \text{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.7858\ \text{kipft/ft}) \times (7\ \text{ft})) + \left(3 \times (-0.56863\ \text{kip/ft}) \times (7\ \text{ft})^2\right)}{(6 \times (5.7858\ \text{kipft/ft})) + (4 \times (-0.56863\ \text{kip/ft}) \times (7\ \text{ft}))}$$

$$a = 4.8501\ \text{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (5.7858\ \text{kipft/ft})) + (3 \times (-0.56863\ \text{kip/ft}) \times (7\ \text{ft}))]^{\ 2}}{(7\ \text{ft})^2 \times [(3 \times (5.7858\ \text{kipft/ft})) + (2 \times (-0.56863\ \text{kip/ft}) \times (7\ \text{ft}))]}$$

$$p = 0.2044\ \text{kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (5.7858\ \text{kipft/ft})) + ((-0.56863\ \text{kip/ft}) \times (7\ \text{ft}))]}{(7\ \text{ft})^2}$$

$$s = 0.92954\ \text{kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \text{psf/ft}) \times \frac{(4.8501\ \text{ft})}{2}$$

$$p_a = 0.36376\ \text{kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.2044\ \text{kip/ft}^2)}{(0.36376\ \text{kip/ft}^2)}$$

$$Ratio = 0.56192$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (7\ \mathrm{ft})$$

$$p_s = 1.05\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.92954\ \mathrm{kip/ft^2}\right)}{\left(1.05\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.88528$$

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

Considering z-direction:

$H_o = -0.0025478\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 0.0062102\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.0062102\ \mathrm{kipft/ft}) \times (7\ \mathrm{ft})) + \left(3 \times (-0.0025478\ \mathrm{kip/ft}) \times (7\ \mathrm{ft})^2\right)}{(6 \times (0.0062102\ \mathrm{kipft/ft})) + (4 \times (-0.0025478\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))}$$

$$a = 5.0499\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.0062102\ \mathrm{kipft/ft})) + (3 \times (-0.0025478\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))]^2}{(7\ \mathrm{ft})^2 \times [(3 \times (0.0062102\ \mathrm{kipft/ft})) + (2 \times (-0.0025478\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))]}$$

$$p = -0.00073802\ \mathrm{kip/ft^2}$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (0.0062102\ \mathrm{kipft/ft})) + ((-0.0025478\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))]}{(7\ \mathrm{ft})^2}$$

$$s = -0.00066294\ \mathrm{kip/ft^2}$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \mathrm{psf/ft}) \times \frac{(5.0499\ \mathrm{ft})}{2}$$

$$p_a = 0.37874\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(-0.00073802\ \mathrm{kip/ft^2}\right)}{\left(0.37874\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = -0.0019486$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (7\ \mathrm{ft})$$

$$p_s = 1.05\ \mathrm{kip/ft^2}$$

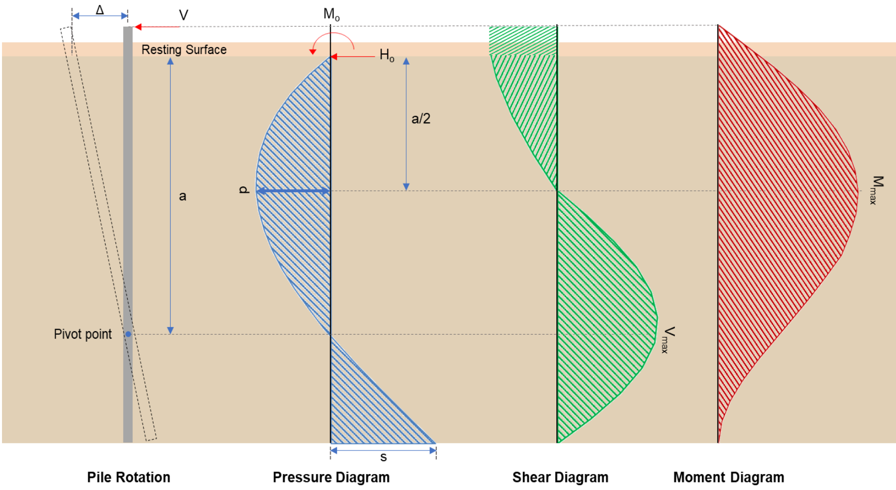
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(-0.00066294\ \mathrm{kip/ft^2})}{(1.05\ \mathrm{kip/ft^2})}$$

$$Ratio = -0.00063137$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-5.948\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.94713\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(61.078\ \mathrm{kipft}) + ((-5.948\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 9.7258\ \mathrm{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(9.7258\ \mathrm{kipft/ft})}{(-0.94713\ \mathrm{kip/ft})}$$

$$E = 10.269\ \mathrm{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (9.7258\ \mathrm{kipft/ft}) \times (7\ \mathrm{ft})) + \left(3 \times (-0.94713\ \mathrm{kip/ft}) \times (7\ \mathrm{ft})^2\right)}{(6 \times (9.7258\ \mathrm{kipft/ft})) + (4 \times (-0.94713\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))}$$

$$a = 4.8489\ \mathrm{ft}$$

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

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

$$V_{max} = ((-0.94713\ \mathrm{kip/ft}) \times (48\ \mathrm{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (10.269\ \mathrm{ft})}{(7\ \mathrm{ft})} + 3\right) \times \left(\frac{(4.8489\ \mathrm{ft})}{(7\ \mathrm{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (10.269\ \mathrm{ft})}{(7\ \mathrm{ft})} + 2\right) \times \left(\frac{(4.8489\ \mathrm{ft})}{(7\ \mathrm{ft})}\right)^3\right]\right]$$

$$V_{max} = 12.332\ \mathrm{kip}$$

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

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

$$M_{max} = ((-0.94713 \text{ kip/ft}) \times (48 \text{ in}) \times (7 \text{ ft})) \times \left[\left(\frac{(10.269 \text{ ft})}{(7 \text{ ft})} + \frac{(4.8489 \text{ ft})}{2 \times (7 \text{ ft})} \right) - \left[\left(\frac{4 \times (10.269 \text{ ft})}{(7 \text{ ft})} + 3 \right) \times \left(\frac{(4.8489 \text{ ft})}{2 \times (7 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (10.269 \text{ ft})}{(7 \text{ ft})} + 2 \right) \times \left(\frac{(4.8489 \text{ ft})}{2 \times (7 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 40.76 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.028 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.0044586 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.065 \text{ kipft}) + ((-0.028 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.01035 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.01035 \text{ kipft/ft})}{(-0.0044586 \text{ kip/ft})}$$

$$E = 2.3214 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.01035 \text{ kipft/ft}) \times (7 \text{ ft})) + \left(3 \times (-0.0044586 \text{ kip/ft}) \times (7 \text{ ft})^2\right)}{(6 \times (0.01035 \text{ kipft/ft})) + (4 \times (-0.0044586 \text{ kip/ft}) \times (7 \text{ ft}))}$$

$$a = 5.0562 \text{ ft}$$

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

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

$$V_{max} = ((-0.0044586 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (2.3214 \text{ ft})}{(7 \text{ ft})} + 3 \right) \times \left(\frac{(5.0562 \text{ ft})}{(7 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (2.3214 \text{ ft})}{(7 \text{ ft})} + 2 \right) \times \left(\frac{(5.0562 \text{ ft})}{(7 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.022424 \text{ kip}$$

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

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

$$M_{max} = ((-0.0044586 \text{ kip/ft}) \times (48 \text{ in}) \times (7 \text{ ft})) \times \left[\left(\frac{(2.3214 \text{ ft})}{(7 \text{ ft})} + \frac{(5.0562 \text{ ft})}{2 \times (7 \text{ ft})} \right) - \left[\left(\frac{4 \times (2.3214 \text{ ft})}{(7 \text{ ft})} + 3 \right) \times \left(\frac{(5.0562 \text{ ft})}{2 \times (7 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (2.3214 \text{ ft})}{(7 \text{ ft})} + 2 \right) \times \left(\frac{(5.0562 \text{ ft})}{2 \times (7 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.067405 \text{ kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

$f'_{ck} = 3 \text{ ksi}$ - Concrete strength,
$f_{yk} = 60 \text{ ksi}$ - Longitudinal reinforcement strength,
$\phi = 0.65$ - Reduction factor for axial strength,
Table 22.4.2.1 $\alpha = 0.8$ - Alpha factor for axial strength,
$A_g = 2304 \text{ in}^2$ - Gross area of concrete,

Longitudinal reinforcement:

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

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

$$A_{st,required} = Min\left[\frac{\frac{(13.917 \text{ kip})}{(0.65)\times(0.8)} - \left(0.85 \times (3 \text{ ksi}) \times \left(2304 \text{ in}^2\right)\right)}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, \left(0.08 \times \left(2304 \text{ in}^2\right)\right)\right]$$

$$A_{st,required} = -101.8 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[\left(-101.8 \text{ in}^2\right), \left(0.0018 \times \left(2304 \text{ in}^2\right)\right)\right]$$

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

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 $$\phi P_N = \phi\, 0.80\, \left[\left(0.85\, f'_{ck}\, \left[A_g - A_{st}\right]\right) + \left(f_{yk}\, A_{st}\right)\right]$$ $$\phi P_N = (0.65) \times 0.80 \times \left[\left(0.85 \times (3\text{ ksi}) \times \left[\left(2304\text{ in}^2\right) - \left(4.2951\text{ in}^2\right)\right]\right) + \left((60\text{ ksi}) \times \left(4.2951\text{ in}^2\right)\right)\right]$$ $$\phi P_N = 3183.4\text{ kip}$$ $Ratio$ - Capacity $$Ratio = \frac{P}{\phi P_N}$$ $$Ratio = \frac{(13.917\text{ kip})}{(3183.4\text{ kip})}$$ $$Ratio = 0.0043717$$	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 $f'_{ck} = 3\text{ ksi} \rightarrow 3000\text{ psi}$,	
22.5.5.1.1	$V_{c,max}$ - Max shear strength of concrete $$V_{c,max} = 5\, \lambda_s\, \sqrt{f'_{ck}}\, b_w\, d$$ $$V_{c,max} = 5 \times (0.64282) \times \sqrt{(3000\text{ psi})} \times (48\text{ in}) \times (38.4\text{ in})$$ $$V_{c,max} = 324.49\text{ kip}$$ The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\text{ ksi} \rightarrow 3000\text{ psi}$, $P = 13.917\text{ kip} \rightarrow 13917\text{ lbf}$,	
22.5.5.1.1(a)	$V_{c,a}$ - Shear strength of concrete (a) $$V_{c,a} = \left[2\, \lambda_s\, \sqrt{f'_{ck}} + \frac{P}{6\, A_g}\right]\, b_w\, d$$ $$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000\text{ psi})} + \frac{(13917\text{ lbf})}{6 \times \left(2304\text{ in}^2\right)}\right] \times (48\text{ in}) \times (38.4\text{ in})$$ $$V_{c,a} = 131.65\text{ kip}$$ The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\text{ ksi} \rightarrow 3000\text{ psi}$,	
22.5.5.1.2	$V_{c,b}$ - Shear strength of concrete (b) $$V_{c,b} = \left[2\, \lambda_s\, \sqrt{f'_{ck}} + \left(0.05\, f'_{ck}\right)\right]\, b_w\, d$$ $$V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(3000\text{ psi})} + (0.05 \times (3000\text{ psi}))\right] \times (48\text{ in}) \times (38.4\text{ in})$$ $$V_{c,b} = 406.27\text{ kip}$$ V_c - Governing shear strength of concrete $$V_c = Min\left[V_{c,max}, V_{c,a}, V_{c,b}\right]$$ $$V_c = Min\left[(324.49\text{ kip}), (131.65\text{ kip}), (406.27\text{ kip})\right]$$ $$V_c = 131.65\text{ kip}$$	

The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\ \text{ksi} \rightarrow 3000\ \text{psi}$,

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

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

$$V_{s,a} = 8 \times \sqrt{(3000\ \text{psi})} \times (48\ \text{in}) \times (38.4\ \text{in})$$

$$V_{s,a} = 807.65\ \text{kip}$$

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

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

$$V_s = MIN\left[(807.65\ \text{kip}), (50.894\ \text{kip})\right]$$

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

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((131.65\ \text{kip}) + (50.894\ \text{kip}))$$

$$\phi V_n = 118.65\ \text{kip}$$

Considering x-direction:

$V_{max} = 12.332\ \text{kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(12.332\ \text{kip})}{(118.65\ \text{kip})}$$

$$Ratio = 0.10393$$

Status: **PASS**
Ratio: **0.100**

Considering z-direction:

$V_{max} = 0.022424\ \text{kip}$ - Maximum shear force in the z-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(0.022424\ \text{kip})}{(118.65\ \text{kip})}$$

$$Ratio = 0.00018899$$

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: $\phi M_{n,1}$ $$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f_c')} \times S_m$$ $$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(3ksi)} \times 18432.001 in^3$$ $$\phi M_{n,1} = 273.423 kipft$$	
14.5.2.1b	$\phi M_{n,2}$ $$\phi M_{n,2} = \phi\, 0.85\, f'_{ck}\, S_m$$ $$\phi M_{n,2} = (0.65) \times 0.85 \times (3\ \mathrm{ksi}) \times \left(18432\ \mathrm{in}^3\right)$$ $$\phi M_{n,2} = 2545.9\ \mathrm{kipft}$$ Therefore, ϕM_n - Allowable flexural strength, $$\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$$ $$\phi M_n = MIN[(273.42\ \mathrm{kipft}), (2545.9\ \mathrm{kipft})]$$ $$\phi M_n = 273.42\ \mathrm{kipft}$$ **Considering x-direction:** $M_{max} = 40.76\ \mathrm{kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(40.76\ \mathrm{kipft})}{(273.42\ \mathrm{kipft})}$$ $$Ratio = 0.14907$$	Status: **PASS** Ratio: **0.150**
	Considering z-direction: $M_{max} = 0.067405\ \mathrm{kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(0.067405\ \mathrm{kipft})}{(273.42\ \mathrm{kipft})}$$ $$Ratio = 0.00024652$$	Status: **PASS** Ratio: **0.000**

REFERENCES	CALCULATIONS	RESULTS

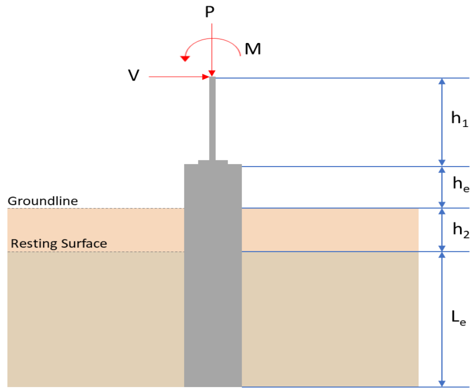
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: rectangular
$b = 48\ \mathrm{in}$ - Pile width
$D = 48\ \mathrm{in}$ - Pile depth
$L = 7\ \mathrm{ft}$ - Total pile length
$h_1 = 0\ \mathrm{ft}$ - Lateral load height from the top of the pile,
$h_2 = 0\ \mathrm{ft}$ - Depth to resisting surface
$h_e = 0\ \mathrm{ft}$ - Length of pile above the ground

Tabulation of Soil Parameters

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

Tabulation of Loads

Load Component	ASD	LRFD
P (kip)	8.892	13.862
V_x (kip)	-3.566	-5.943
V_z (kip)	0.000	0.000
M_x (kipft)	0.000	0.000
M_z (kipft)	36.830	61.942

Material Properties

$f'_{ck} = 3\ \mathrm{ksi}$ - Concrete strength,

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

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

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

Considering x-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-3.566\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.56783\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(36.83 \text{ kipft}) + ((-3.566 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 5.8646 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:
$L_{e,x} = 6.3292 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

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

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(6.3292 \text{ ft}), (0 \text{ ft})]$$

$$L_{e,req} = 6.329 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (7 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$$

$$L_e = 7 \text{ ft}$$

$Ratio$ - Embedded depth

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

$$Ratio = \frac{(6.329 \text{ ft})}{(7 \text{ ft})}$$

$$Ratio = 0.90414$$

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

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

$$q = \frac{(8.892 \text{ kip})}{(16 \text{ ft}^2)}$$

$$q = 0.55575 \text{ kip/ft}^2$$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{(0.55575 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$Ratio = 0.27788$$

Status: **PASS**
Ratio: **0.280**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(7 \text{ ft})}{(48 \text{ in})}$$

$$L/D = 1.75$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.56783\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 5.8646\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.8646\ \mathrm{kipft/ft}) \times (7\ \mathrm{ft})) + \left(3 \times (-0.56783\ \mathrm{kip/ft}) \times (7\ \mathrm{ft})^2\right)}{(6 \times (5.8646\ \mathrm{kipft/ft})) + (4 \times (-0.56783\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))}$$

$$a = 4.8482\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (5.8646\ \mathrm{kipft/ft})) + (3 \times (-0.56783\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))]^{\,2}}{(7\ \mathrm{ft})^2 \times [(3 \times (5.8646\ \mathrm{kipft/ft})) + (2 \times (-0.56783\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))]}$$

$$p = 0.21114\ \mathrm{kip/ft^2}$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (5.8646\ \mathrm{kipft/ft})) + ((-0.56783\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))]}{(7\ \mathrm{ft})^2}$$

$$s = 0.94953\ \mathrm{kip/ft^2}$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \mathrm{psf/ft}) \times \frac{(4.8482\ \mathrm{ft})}{2}$$

$$p_a = 0.36362\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.21114\ \mathrm{kip/ft^2}\right)}{\left(0.36362\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.58066$$

Status: **PASS**
Ratio: **0.580**

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (150\ \mathrm{psf/ft}) \times (7\ \mathrm{ft})$$

$$p_s = 1.05\ \mathrm{kip/ft^2}$$

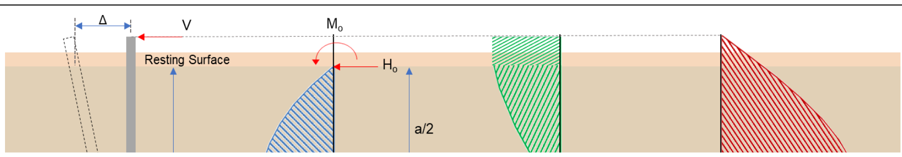
$Ratio$ - Lateral soil capacity

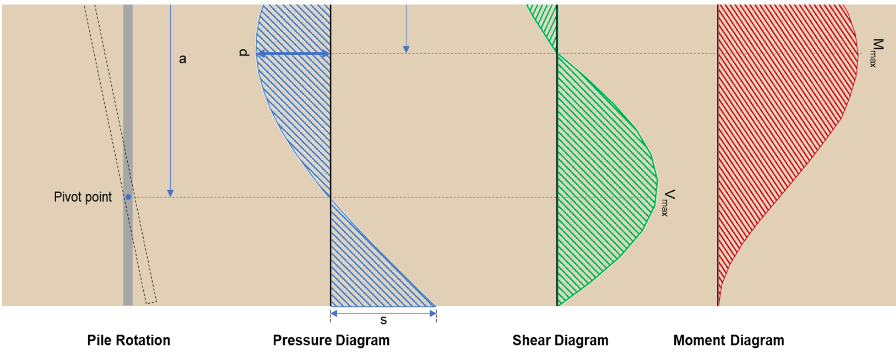
$$Ratio = \frac{s}{p_s}$$

$$Ratio = \frac{\left(0.94953\ \mathrm{kip/ft^2}\right)}{\left(1.05\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.90431$$

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





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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-5.943\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = -0.94634\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(61.942\ \text{kipft}) + ((-5.943\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 9.8634\ \text{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(9.8634\ \text{kipft/ft})}{(-0.94634\ \text{kip/ft})}$$

$$E = 10.423\ \text{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (9.8634\ \text{kipft/ft}) \times (7\ \text{ft})) + \left(3 \times (-0.94634\ \text{kip/ft}) \times (7\ \text{ft})^2\right)}{(6 \times (9.8634\ \text{kipft/ft})) + (4 \times (-0.94634\ \text{kip/ft}) \times (7\ \text{ft}))}$$

$$a = 4.8471\ \text{ft}$$

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

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

$$V_{max} = ((-0.94634\ \text{kip/ft}) \times (48\ \text{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (10.423\ \text{ft})}{(7\ \text{ft})} + 3\right) \times \left(\frac{(4.8471\ \text{ft})}{(7\ \text{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (10.423\ \text{ft})}{(7\ \text{ft})} + 2\right) \times \left(\frac{(4.8471\ \text{ft})}{(7\ \text{ft})}\right)^3\right]\right]$$

$$V_{max} = 12.469\ \text{kip}$$

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

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

$$M_{max} = ((-0.94634\ \text{kip/ft}) \times (48\ \text{in}) \times (7\ \text{ft})) \times \left[\left(\frac{(10.423\ \text{ft})}{(7\ \text{ft})} + \frac{(4.8471\ \text{ft})}{2 \times (7\ \text{ft})}\right) - \left[\left(\frac{4 \times (10.423\ \text{ft})}{(7\ \text{ft})} + 3\right) \times \left(\frac{(4.8471\ \text{ft})}{2 \times (7\ \text{ft})}\right)^3\right] + \left[\left(\frac{3 \times (10.423\ \text{ft})}{(7\ \text{ft})} + 2\right) \times \left(\frac{(4.8471\ \text{ft})}{2 \times (7\ \text{ft})}\right)^4\right]\right]$$

	$M_{max} = 41.241 \text{ kipft}$		

Minimum Reinforcement Check (LRFD)

Parameters:

$f'_{ck} = 3 \text{ ksi}$ - 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 $A_{st,required}$

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

$$A_{st,required} = Min\left[\frac{\frac{(13.862 \text{ kip})}{(0.65)\times(0.8)} - \left(0.85 \times (3 \text{ ksi}) \times \left(2304 \text{ in}^2\right)\right)}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, \left(0.08 \times \left(2304 \text{ in}^2\right)\right)\right]$$

$$A_{st,required} = -101.8 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[\left(-101.8 \text{ in}^2\right), \left(0.0018 \times \left(2304 \text{ in}^2\right)\right)\right]$$

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

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**	
22.4.2.2	**Axial Compression Strength (ACI 318-19, LRFD)** ϕP_N - Allowable axial compressive strength $$\phi P_N = \phi\, 0.80\, \left[\left(0.85\, f'_{ck}\, [A_g - A_{st}]\right) + \left(f_{yk}\, A_{st}\right)\right]$$ $$\phi P_N = (0.65) \times 0.80 \times \left[\left(0.85 \times (3\ \text{ksi}) \times \left[\left(2304\ \text{in}^2\right) - \left(4.2951\ \text{in}^2\right)\right]\right) + \left((60\ \text{ksi}) \times \left(4.2951\ \text{in}^2\right)\right)\right]$$ $$\phi P_N = 3183.4\ \text{kip}$$ $Ratio$ - Capacity $$Ratio = \frac{P}{\phi P_N}$$ $$Ratio = \frac{(13.862\ \text{kip})}{(3183.4\ \text{kip})}$$ $$Ratio = 0.0043544$$	Status: **PASS** Ratio: **0.000**
  22.5.2.2 22.5.5.1.3 22.5.5.1.1 22.5.5.1.1(a) 22.5.5.1.2	**Shear Strength (ACI 318-19, LRFD)** **Parameters:** $b_w = 48\ \text{in}$ - Effective width, d - Effective depth $$d = 0.80\, D$$ $$d = 0.80 \times (48\ \text{in})$$ $$d = 38.4\ \text{in}$$ 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 $f'_{ck} = 3\ \text{ksi} \rightarrow 3000\ \text{psi}$, $V_{c,max}$ - Max shear strength of concrete $$V_{c,max} = 5\, \lambda_s\, \sqrt{f'_{ck}}\, b_w\, d$$ $$V_{c,max} = 5 \times (0.64282) \times \sqrt{(3000\ \text{psi})} \times (48\ \text{in}) \times (38.4\ \text{in})$$ $$V_{c,max} = 324.49\ \text{kip}$$ The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\ \text{ksi} \rightarrow 3000\ \text{psi}$, $P = 13.862\ \text{kip} \rightarrow 13862\ \text{lbf}$, $V_{c,a}$ - Shear strength of concrete (a) $$V_{c,a} = \left[2\, \lambda_s\, \sqrt{f'_{ck}} + \frac{P}{6\, A_g}\right]\, b_w\, d$$ $$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000\ \text{psi})} + \frac{(13862\ \text{lbf})}{6 \times \left(2304\ \text{in}^2\right)}\right] \times (48\ \text{in}) \times (38.4\ \text{in})$$ $$V_{c,a} = 131.64\ \text{kip}$$ The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\ \text{ksi} \rightarrow 3000\ \text{psi}$, $V_{c,b}$ - Shear strength of concrete (b) $$V_{c,b} = \left[2\, \lambda_s\, \sqrt{f'_{ck}} + \left(0.05\, f'_{ck}\right)\right]\, b_w\, d$$ $$V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(3000\ \text{psi})} + (0.05 \times (3000\ \text{psi}))\right] \times (48\ \text{in}) \times (38.4\ \text{in})$$ $$V_{c,b} = 406.27\ \text{kip}$$ V_c - Governing shear strength of concrete $$V_c = Min\left[V_{c,max}, V_{c,a}, V_{c,b}\right]$$ $$V_c = Min\left[(324.49\ \text{kip}), (131.64\ \text{kip}), (406.27\ \text{kip})\right]$$ $$V_c = 131.64\ \text{kip}$$	

	The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\text{ ksi} \to 3000\text{ psi}$,	
22.5.1.2	$V_{s,a}$ - Shear strength of steel (a) $$V_{s,a} = 8\sqrt{f'_{ck}}\,b_w\,d$$ $$V_{s,a} = 8 \times \sqrt{(3000\text{ psi})} \times (48\text{ in}) \times (38.4\text{ in})$$ $$V_{s,a} = 807.65\text{ kip}$$ 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 $$V_s = MIN\left[V_{s,a}, V_{s,b}\right]$$ $$V_s = MIN\left[(807.65\text{ kip}), (50.894\text{ kip})\right]$$ $$V_s = 50.894\text{ kip}$$	
22.5.1.1	ϕV_n - Allowable shear strength $$\phi V_n = \phi\,(V_c + V_s)$$ $$\phi V_n = (0.65) \times ((131.64\text{ kip}) + (50.894\text{ kip}))$$ $$\phi V_n = 118.65\text{ kip}$$ **Considering x-direction:** $V_{max} = 12.469\text{ kip}$ - Maximum shear force in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{V_{max}}{\phi V_n}$$ $$Ratio = \frac{(12.469\text{ kip})}{(118.65\text{ kip})}$$ $$Ratio = 0.10509$$	Status: **PASS** Ratio: **0.110**
	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: $\phi M_{n,1}$ $$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f'_c)} \times S_m$$ $$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(3ksi)} \times 18432.001in^3$$ $$\phi M_{n,1} = 273.423kipft$$	
14.5.2.1b	$\phi M_{n,2}$ $$\phi M_{n,2} = \phi\,0.85\,f'_c\,S_m$$	

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

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

$$\phi M_{n,2} = 2545.9\ \mathrm{kipft}$$

Therefore,
ϕM_n - Allowable flexural strength,

$$\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$$

$$\phi M_n = MIN[(273.42\ \mathrm{kipft}), (2545.9\ \mathrm{kipft})]$$

$$\phi M_n = 273.42\ \mathrm{kipft}$$

Considering x-direction:

$M_{max} = 41.241\ \mathrm{kipft}$ - Maximum moment in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(41.241\ \mathrm{kipft})}{(273.42\ \mathrm{kipft})}$$

$$Ratio = 0.15083$$

Status: **PASS**
Ratio: **0.150**

REFERENCES	CALCULATIONS	RESULTS

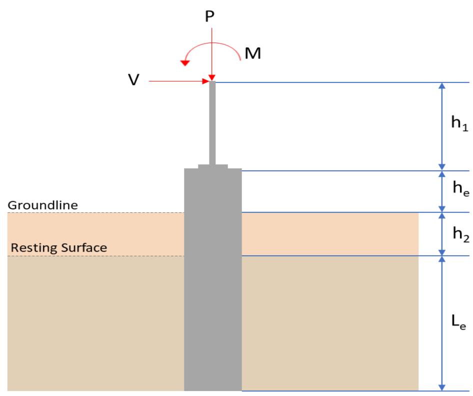
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: rectangular
$b = 48\ \mathrm{in}$ - Pile width
$D = 48\ \mathrm{in}$ - Pile depth
$L = 7\ \mathrm{ft}$ - Total pile length
$h_1 = 0\ \mathrm{ft}$ - Lateral load height from the top of the pile,
$h_2 = 0\ \mathrm{ft}$ - Depth to resisting surface
$h_e = 0\ \mathrm{ft}$ - Length of pile above the ground

Tabulation of Soil Parameters

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

Tabulation of Loads

Load Component	ASD	LRFD
P (kip)	8.929	13.917
V_x (kip)	-3.571	-5.948
V_z (kip)	0.016	0.028
M_x (kipft)	0.039	0.066
M_z (kipft)	36.335	61.078

Material Properties

$f'_{ck} = 3\ \mathrm{ksi}$ - Concrete strength,

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

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

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

Considering x-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-3.571\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.56863\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

SkyCiv

$$M_o = \frac{(36.335\ \text{kipft}) + ((-3.571\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 5.7858\ \text{kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:
$L_{e,x} = 6.2861\ \text{ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.016\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = 0.0025478\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.039\ \text{kipft}) + ((0.016\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 0.0062102\ \text{kipft/ft}$$

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:
$L_{e,z} = 0.85627\ \text{ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(6.2861\ \text{ft}), (0.85627\ \text{ft})]$$

$$L_{e,req} = 6.286\ \text{ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (7\ \text{ft}) - (0\ \text{ft}) - (0\ \text{ft})$$

$$L_e = 7\ \text{ft}$$

$Ratio$ - Embedded depth

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

$$Ratio = \frac{(6.286\ \text{ft})}{(7\ \text{ft})}$$

$$Ratio = 0.898$$

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

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

$$q = \frac{(8.929\ \text{kip})}{(16\ \text{ft}^2)}$$

$$q = 0.55806\ \text{kip/ft}^2$$

$q = 0.55806\ \mathrm{kip/ft}$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{(0.55806\ \mathrm{kip/ft^2})}{(2000\ \mathrm{psf})}$$

$$Ratio = 0.27903$$

Status: **PASS**
Ratio: **0.280**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(7\ \mathrm{ft})}{(48\ \mathrm{in})}$$

$$L/D = 1.75$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.56863\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 5.7858\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.7858\ \mathrm{kipft/ft}) \times (7\ \mathrm{ft})) + \left(3 \times (-0.56863\ \mathrm{kip/ft}) \times (7\ \mathrm{ft})^2\right)}{(6 \times (5.7858\ \mathrm{kipft/ft})) + (4 \times (-0.56863\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))}$$

$$a = 4.8501\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (5.7858\ \mathrm{kipft/ft})) + (3 \times (-0.56863\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))]^2}{(7\ \mathrm{ft})^2 \times [(3 \times (5.7858\ \mathrm{kipft/ft})) + (2 \times (-0.56863\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))]}$$

$$p = 0.2044\ \mathrm{kip/ft^2}$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (5.7858\ \mathrm{kipft/ft})) + ((-0.56863\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))]}{(7\ \mathrm{ft})^2}$$

$$s = 0.92954\ \mathrm{kip/ft^2}$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150\ \mathrm{psf/ft}) \times \frac{(4.8501\ \mathrm{ft})}{2}$$

$$p_a = 0.36376\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.2044\ \mathrm{kip/ft^2})}{(0.36376\ \mathrm{kip/ft^2})}$$

$$Ratio = 0.56192$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\, L_e$$

$$p_s = (150 \text{ psf/ft}) \times (7 \text{ ft})$$

$$p_s = 1.05 \text{ kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.92954 \text{ kip/ft}^2\right)}{\left(1.05 \text{ kip/ft}^2\right)}$$

$$Ratio = 0.88528$$

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

Considering z-direction:

$H_o = 0.0025478 \text{ kip/ft}$ - Lateral force per length of pile,
$M_o = 0.0062102 \text{ kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.0062102 \text{ kipft/ft}) \times (7 \text{ ft})) + \left(3 \times (0.0025478 \text{ kip/ft}) \times (7 \text{ ft})^2\right)}{(6 \times (0.0062102 \text{ kipft/ft})) + (4 \times (0.0025478 \text{ kip/ft}) \times (7 \text{ ft}))}$$

$$a = 5.0499 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.0062102 \text{ kipft/ft})) + (3 \times (0.0025478 \text{ kip/ft}) \times (7 \text{ ft}))]^{\,2}}{(7 \text{ ft})^2 \times [(3 \times (0.0062102 \text{ kipft/ft})) + (2 \times (0.0025478 \text{ kip/ft}) \times (7 \text{ ft}))]}$$

$$p = 0.0017301 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (0.0062102 \text{ kipft/ft})) + ((0.0025478 \text{ kip/ft}) \times (7 \text{ ft}))]}{(7 \text{ ft})^2}$$

$$s = 0.0037047 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(5.0499 \text{ ft})}{2}$$

$$p_a = 0.37874 \text{ kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.0017301 \text{ kip/ft}^2\right)}{\left(0.37874 \text{ kip/ft}^2\right)}$$

$$Ratio = 0.0045682$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\, L_e$$

$$p_s = (150 \text{ psf/ft}) \times (7 \text{ ft})$$

$$p_s = 1.05 \text{ kip/ft}^2$$

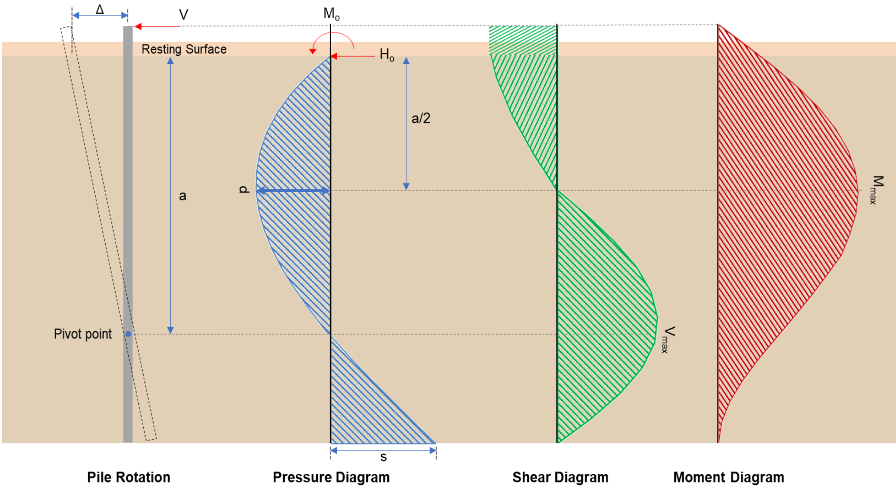
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.0037047\ \mathrm{kip/ft^2})}{(1.05\ \mathrm{kip/ft^2})}$$

$$Ratio = 0.0035283$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-5.948\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.94713\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(61.078\ \mathrm{kipft}) + ((-5.948\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 9.7258\ \mathrm{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(9.7258\ \mathrm{kipft/ft})}{(-0.94713\ \mathrm{kip/ft})}$$

$$E = 10.269\ \mathrm{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (9.7258\ \mathrm{kipft/ft}) \times (7\ \mathrm{ft})) + \left(3 \times (-0.94713\ \mathrm{kip/ft}) \times (7\ \mathrm{ft})^2\right)}{(6 \times (9.7258\ \mathrm{kipft/ft})) + (4 \times (-0.94713\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))}$$

$$a = 4.8489\ \mathrm{ft}$$

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

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

$$V_{max} = ((-0.94713\ \mathrm{kip/ft}) \times (48\ \mathrm{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (10.269\ \mathrm{ft})}{(7\ \mathrm{ft})} + 3\right) \times \left(\frac{(4.8489\ \mathrm{ft})}{(7\ \mathrm{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (10.269\ \mathrm{ft})}{(7\ \mathrm{ft})} + 2\right) \times \left(\frac{(4.8489\ \mathrm{ft})}{(7\ \mathrm{ft})}\right)^3\right]\right]$$

$$V_{max} = 12.332\ \mathrm{kip}$$

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

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

$$M_{max} = ((-0.94713 \text{ kip/ft}) \times (48 \text{ in}) \times (7 \text{ ft})) \times \left[\left(\frac{(10.269 \text{ ft})}{(7 \text{ ft})} + \frac{(4.8489 \text{ ft})}{2 \times (7 \text{ ft})} \right) - \left[\left(\frac{4 \times (10.269 \text{ ft})}{(7 \text{ ft})} + 3 \right) \times \left(\frac{(4.8489 \text{ ft})}{2 \times (7 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (10.269 \text{ ft})}{(7 \text{ ft})} + 2 \right) \times \left(\frac{(4.8489 \text{ ft})}{2 \times (7 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 40.76 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.028 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.0044586 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.066 \text{ kipft}) + ((0.028 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.01051 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.01051 \text{ kipft/ft})}{(0.0044586 \text{ kip/ft})}$$

$$E = 2.3571 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.01051 \text{ kipft/ft}) \times (7 \text{ ft})) + \left(3 \times (0.0044586 \text{ kip/ft}) \times (7 \text{ ft})^2\right)}{(6 \times (0.01051 \text{ kipft/ft})) + (4 \times (0.0044586 \text{ kip/ft}) \times (7 \text{ ft}))}$$

$$a = 5.0542 \text{ ft}$$

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

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

$$V_{max} = ((0.0044586 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (2.3571 \text{ ft})}{(7 \text{ ft})} + 3 \right) \times \left(\frac{(5.0542 \text{ ft})}{(7 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (2.3571 \text{ ft})}{(7 \text{ ft})} + 2 \right) \times \left(\frac{(5.0542 \text{ ft})}{(7 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.022582 \text{ kip}$$

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

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

$$M_{max} = ((0.0044586 \text{ kip/ft}) \times (48 \text{ in}) \times (7 \text{ ft})) \times \left[\left(\frac{(2.3571 \text{ ft})}{(7 \text{ ft})} + \frac{(5.0542 \text{ ft})}{2 \times (7 \text{ ft})} \right) - \left[\left(\frac{4 \times (2.3571 \text{ ft})}{(7 \text{ ft})} + 3 \right) \times \left(\frac{(5.0542 \text{ ft})}{2 \times (7 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (2.3571 \text{ ft})}{(7 \text{ ft})} + 2 \right) \times \left(\frac{(5.0542 \text{ ft})}{2 \times (7 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.067957 \text{ kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

$f'_{ck} = 3 \text{ ksi}$ - Concrete strength,
$f_{yk} = 60 \text{ ksi}$ - Longitudinal reinforcement strength,
$\phi = 0.65$ - Reduction factor for axial strength,
Table 22.4.2.1 $\alpha = 0.8$ - Alpha factor for axial strength,
$A_g = 2304 \text{ in}^2$ - Gross area of concrete,

Longitudinal reinforcement:

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

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

$$A_{st,required} = Min\left[\frac{\frac{(13.917 \text{ kip})}{(0.65)\times(0.8)} - \left(0.85 \times (3 \text{ ksi}) \times (2304 \text{ in}^2)\right)}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, \left(0.08 \times (2304 \text{ in}^2)\right)\right]$$

$$A_{st,required} = -101.8 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[\left(-101.8 \text{ in}^2\right), \left(0.0018 \times (2304 \text{ in}^2)\right)\right]$$

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

n_{rebar} - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

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**	

22.4.2.2	**Axial Compression Strength (ACI 318-19, LRFD)** ϕP_N - Allowable axial compressive strength $$\phi P_N = \phi\, 0.80\, \left[\left(0.85\, f'_{ck}\, \left[A_g - A_{st}\right]\right) + \left(f_{yk}\, A_{st}\right)\right]$$ $$\phi P_N = (0.65) \times 0.80 \times \left[\left(0.85 \times (3\text{ ksi}) \times \left[\left(2304\text{ in}^2\right) - \left(4.2951\text{ in}^2\right)\right]\right) + \left((60\text{ ksi}) \times \left(4.2951\text{ in}^2\right)\right)\right]$$ $$\phi P_N = 3183.4\text{ kip}$$ $Ratio$ - Capacity $$Ratio = \frac{P}{\phi P_N}$$ $$Ratio = \frac{(13.917\text{ kip})}{(3183.4\text{ kip})}$$ $$Ratio = 0.0043717$$	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 $f'_{ck} = 3\text{ ksi} \rightarrow 3000\text{ psi}$,

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

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

$$V_{c,max} = 5 \times (0.64282) \times \sqrt{(3000\text{ psi})} \times (48\text{ in}) \times (38.4\text{ in})$$

$$V_{c,max} = 324.49\text{ kip}$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\text{ ksi} \rightarrow 3000\text{ psi}$, $P = 13.917\text{ kip} \rightarrow 13917\text{ lbf}$,

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

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000\text{ psi})} + \frac{(13917\text{ lbf})}{6 \times (2304\text{ in}^2)}\right] \times (48\text{ in}) \times (38.4\text{ in})$$

$$V_{c,a} = 131.65\text{ kip}$$

The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\text{ ksi} \rightarrow 3000\text{ psi}$,

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

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

$$V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(3000\text{ psi})} + (0.05 \times (3000\text{ psi}))\right] \times (48\text{ in}) \times (38.4\text{ in})$$

$$V_{c,b} = 406.27\text{ kip}$$

V_c - Governing shear strength of concrete

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

$$V_c = Min\left[(324.49\text{ kip}), (131.65\text{ kip}), (406.27\text{ kip})\right]$$

$$V_c = 131.65\text{ kip}$$

	The following variables were converted to be consistent with empirical formula $f'_{ck} = 3\ \mathrm{ksi} \rightarrow 3000\ \mathrm{psi}$,	
22.5.1.2	$V_{s,a}$ - Shear strength of steel (a) $$V_{s,a} = 8\sqrt{f'_{ck}}\, b_w\, d$$ $$V_{s,a} = 8 \times \sqrt{(3000\ \mathrm{psi})} \times (48\ \mathrm{in}) \times (38.4\ \mathrm{in})$$ $$V_{s,a} = 807.65\ \mathrm{kip}$$ 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 $$V_s = MIN\left[V_{s,a}, V_{s,b}\right]$$ $$V_s = MIN\left[(807.65\ \mathrm{kip}), (50.894\ \mathrm{kip})\right]$$ $$V_s = 50.894\ \mathrm{kip}$$	
22.5.1.1	ϕV_n - Allowable shear strength $$\phi V_n = \phi\ (V_c + V_s)$$ $$\phi V_n = (0.65) \times ((131.65\ \mathrm{kip}) + (50.894\ \mathrm{kip}))$$ $$\phi V_n = 118.65\ \mathrm{kip}$$ **Considering x-direction:** $V_{max} = 12.332\ \mathrm{kip}$ - Maximum shear force in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{V_{max}}{\phi V_n}$$ $$Ratio = \frac{(12.332\ \mathrm{kip})}{(118.65\ \mathrm{kip})}$$ $$Ratio = 0.10393$$	Status: **PASS** Ratio: **0.100**
	Considering z-direction: $V_{max} = 0.022582\ \mathrm{kip}$ - Maximum shear force in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{V_{max}}{\phi V_n}$$ $$Ratio = \frac{(0.022582\ \mathrm{kip})}{(118.65\ \mathrm{kip})}$$ $$Ratio = 0.00019032$$	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: $\phi M_{n,1}$ $$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f_c')} \times S_m$$ $$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(3ksi)} \times 18432.001in^3$$ $$\phi M_{n,1} = 273.423kipft$$	
14.5.2.1b	$\phi M_{n,2}$ $$\phi M_{n,2} = \phi\, 0.85\, f_{ck}'\, S_m$$ $$\phi M_{n,2} = (0.65) \times 0.85 \times (3\ \mathrm{ksi}) \times \left(18432\ \mathrm{in}^3\right)$$ $$\phi M_{n,2} = 2545.9\ \mathrm{kipft}$$ Therefore, ϕM_n - Allowable flexural strength, $$\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$$ $$\phi M_n = MIN[(273.42\ \mathrm{kipft}), (2545.9\ \mathrm{kipft})]$$ $$\phi M_n = 273.42\ \mathrm{kipft}$$ **Considering x-direction:** $M_{max} = 40.76\ \mathrm{kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(40.76\ \mathrm{kipft})}{(273.42\ \mathrm{kipft})}$$ $$Ratio = 0.14907$$	Status: **PASS** Ratio: **0.150**
	Considering z-direction: $M_{max} = 0.067957\ \mathrm{kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(0.067957\ \mathrm{kipft})}{(273.42\ \mathrm{kipft})}$$ $$Ratio = 0.00024854$$	Status: **PASS** Ratio: **0.000**