Project Details

Project Name: MTSOLAR_Honeywell Aguadilla Clay 4x16 5P - V1JB

Location: FHMW+FW, Homestead Base, FL, USA

Unique ID: 5P-19.75-6TOP-XD-45-L-4Hx16W-23AG

Dealer: ______________________________

Date: Fri Mar 28 2025

Number of Modules: 64

Number of Poles: 5

Date Sold:

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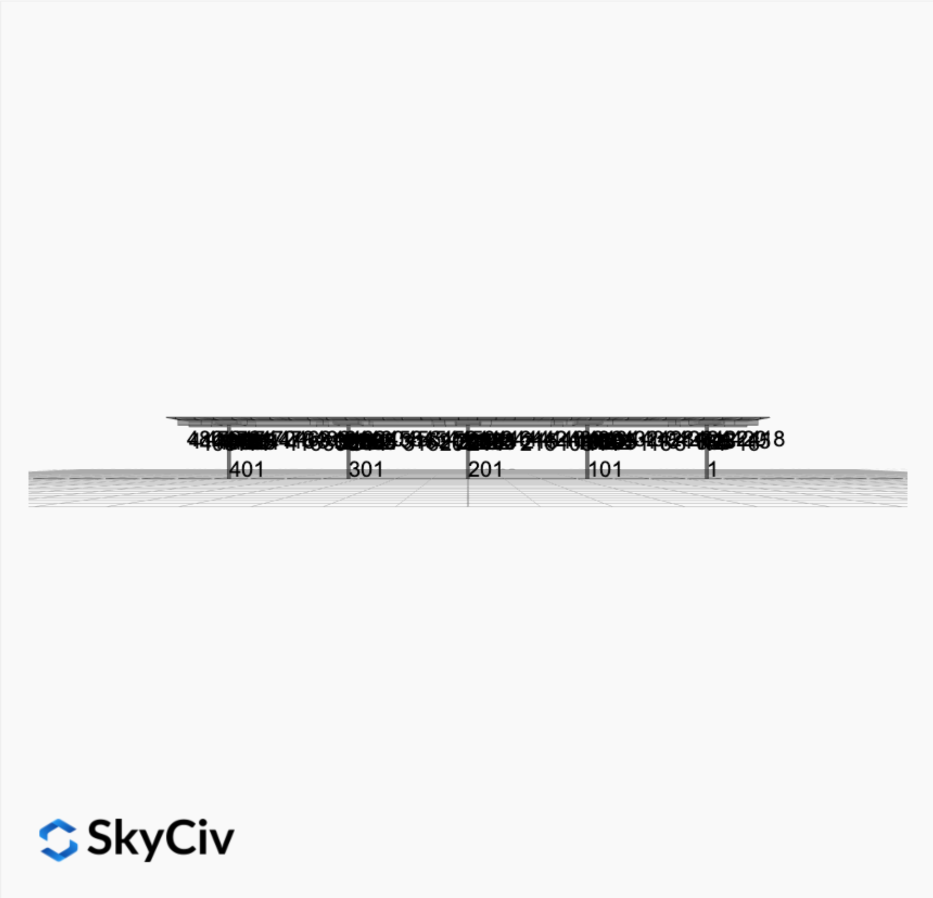


Array Dimensions N/S	15.03 ft
Array Dimensions E/W	95.87 ft
Winter Tilt Angle	1
Front Edge Clearance	9 ft

MT Solar Bill of Materials (5P-19.75-6TOP-XD-45-L-4Hx16W-23AG)

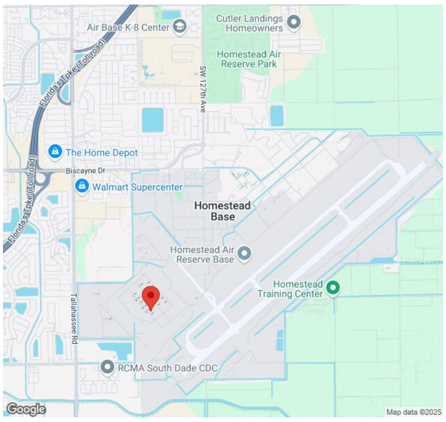
Part	Short Description	BOM Qty
MTS-PC-6	6IN Pole Cap Assembly	5
MTS-HF-XD	H-Frame Assembly-XD	5
MTS-XD-Wing-45	45IN XD Wing	4
MTS-XD-Splice-90	90IN XD Splice	8
MTS-XD-Splice-57	57IN XD Splice	8
MTS-CLAMP-HOOK-4PK	Hook Clamp	16

Rail Bill of Materials

Part	Qty
Rails (180in)	32
Rail Attachment	64

Part	Qty
Module Mid Clamp	96
Module End Clamp	64
Ground Lug	16

Site Details:



Site Address: FHMW+FW, Homestead Base, FL, USA

Array Specification

Duty Classification:	XD
Module Width:	44.60 in
Module Length:	70.90in
Number of Rows:	4
Number of Columns:	16
Total Number of Modules:	64
Winter Tilt Angle:	1
Front Edge Clearance:	9
Total Array Height at Tilt:	9.26 ft
Total Frame Length:	94.00 ft
Module Info/Notes:	
Array Dimensions N/S:	15.03 ft
Array Dimensions E/W:	95.87 ft
Rail Length:	180.40 in
Rail Spacing:	3.00 ft

Support Specifications

Pole Size:	6in Pipe Sch 40
Pole Length above Grade:	9.13 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

Site Info

Risk Category:	I
Exposure:	C
Soil Classification:	clay
Site Location:	FHMW+FW, Homestead Base, FL, USA
Wind Speed:	175 mph

Snow Load:	0 psf

Design Disclaimer

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

AutoDesigner Input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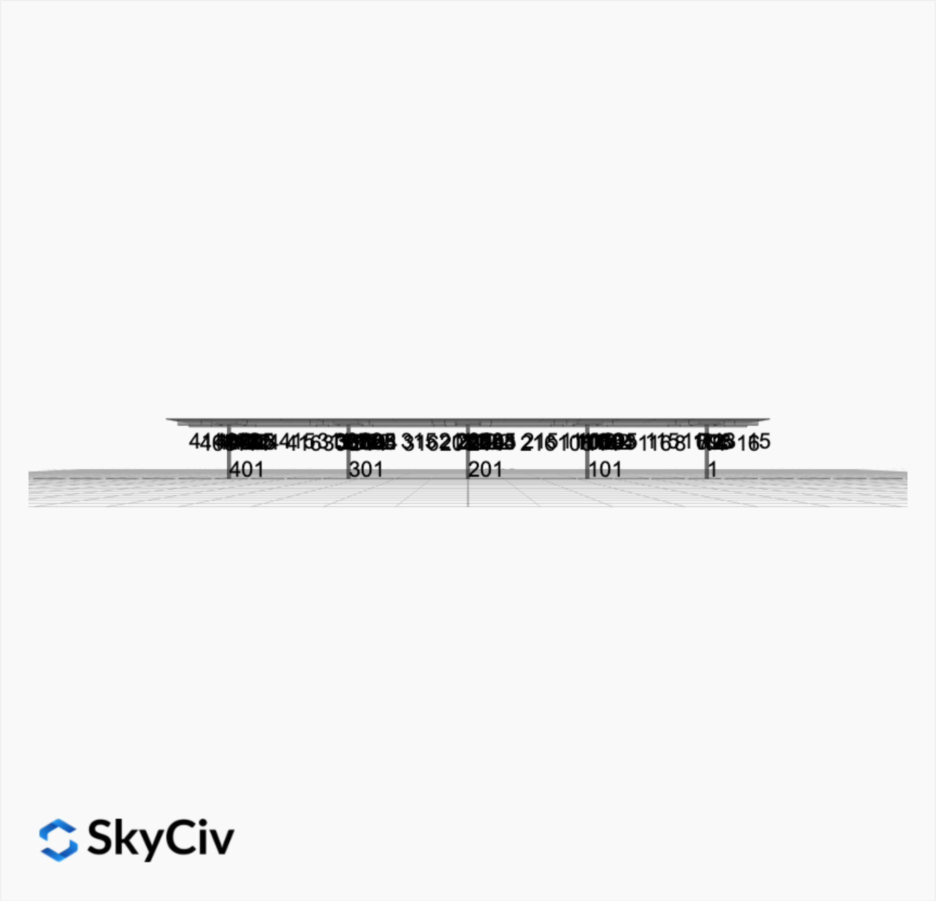
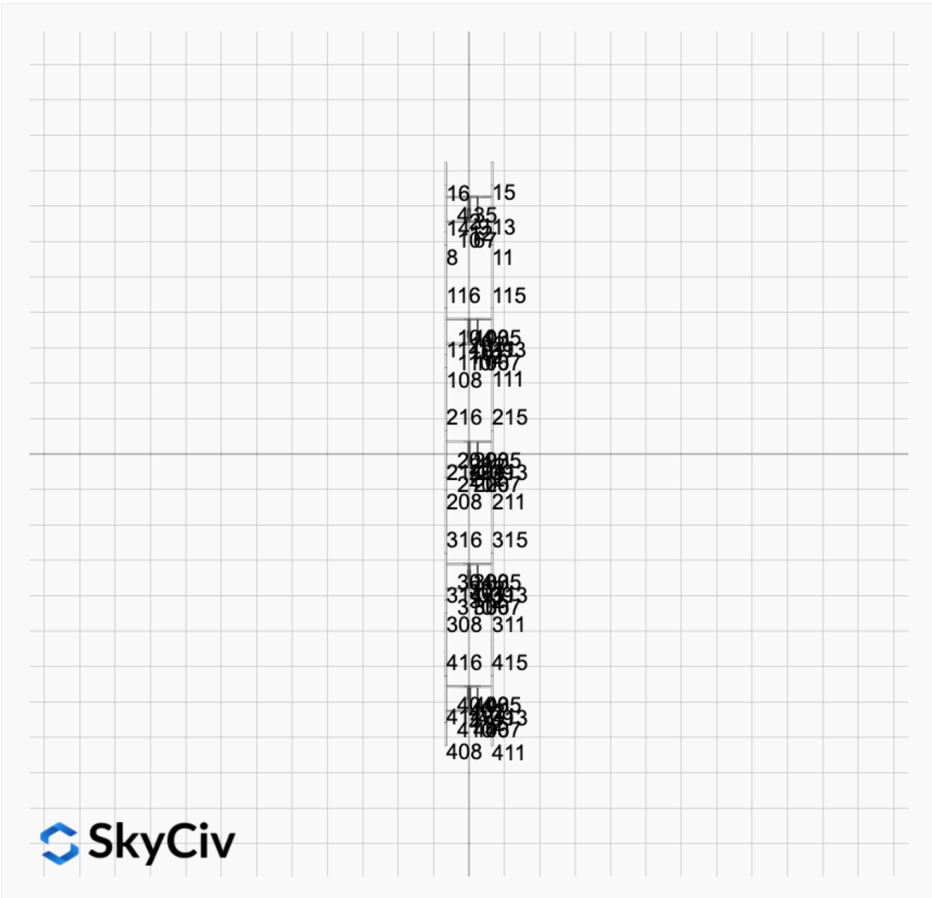
Design Notes:

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




SkyCiv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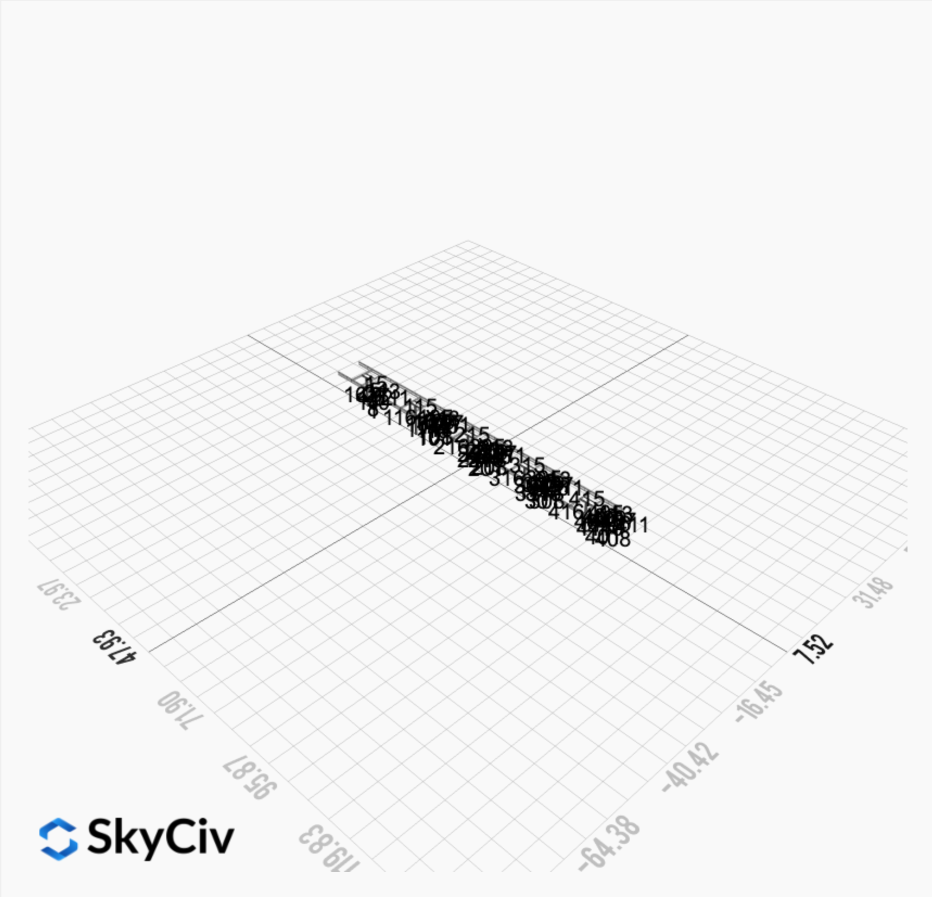
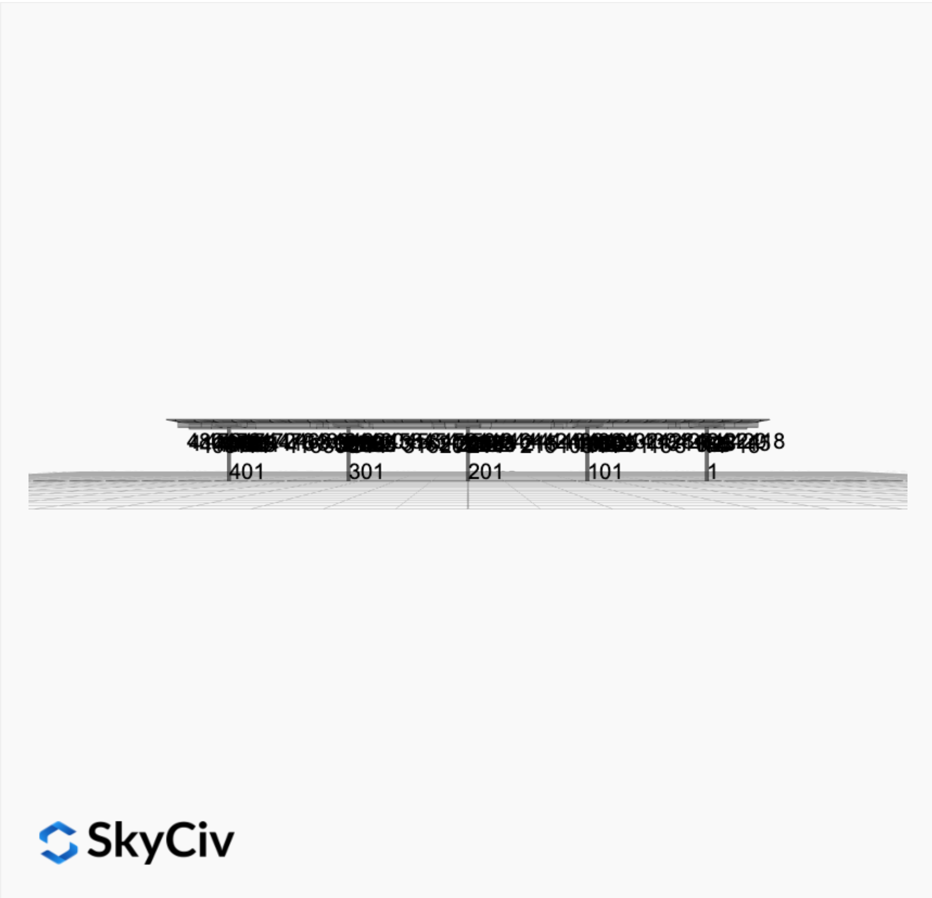


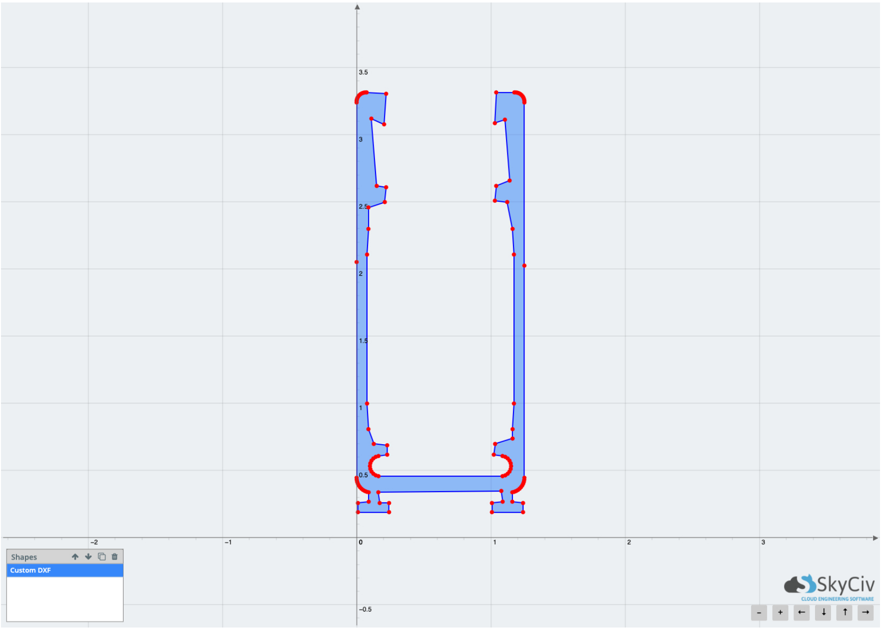
23.97
47.93
71.90
95.87
119.83
7.52
31.48
-16.45
-40.42
-64.38
SkyCiv



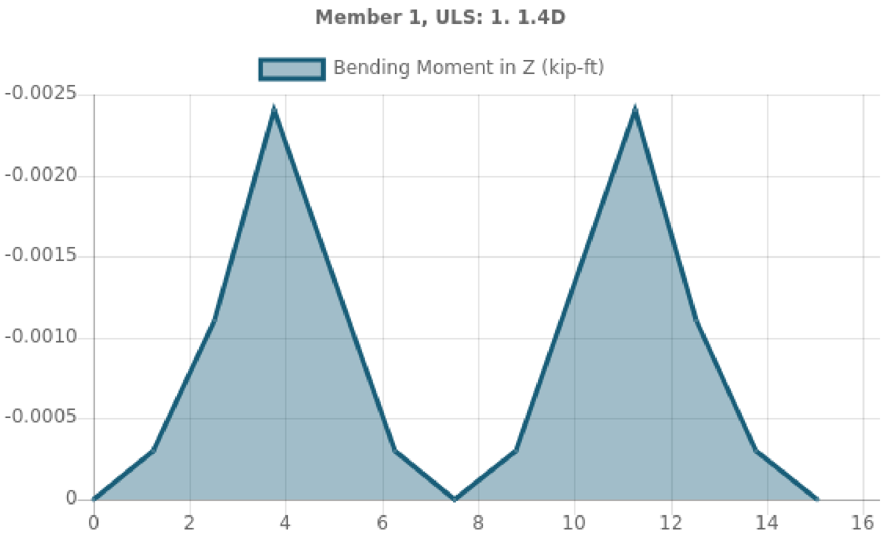
401
301
201
101
1
SkyCiv

Rail Design Check

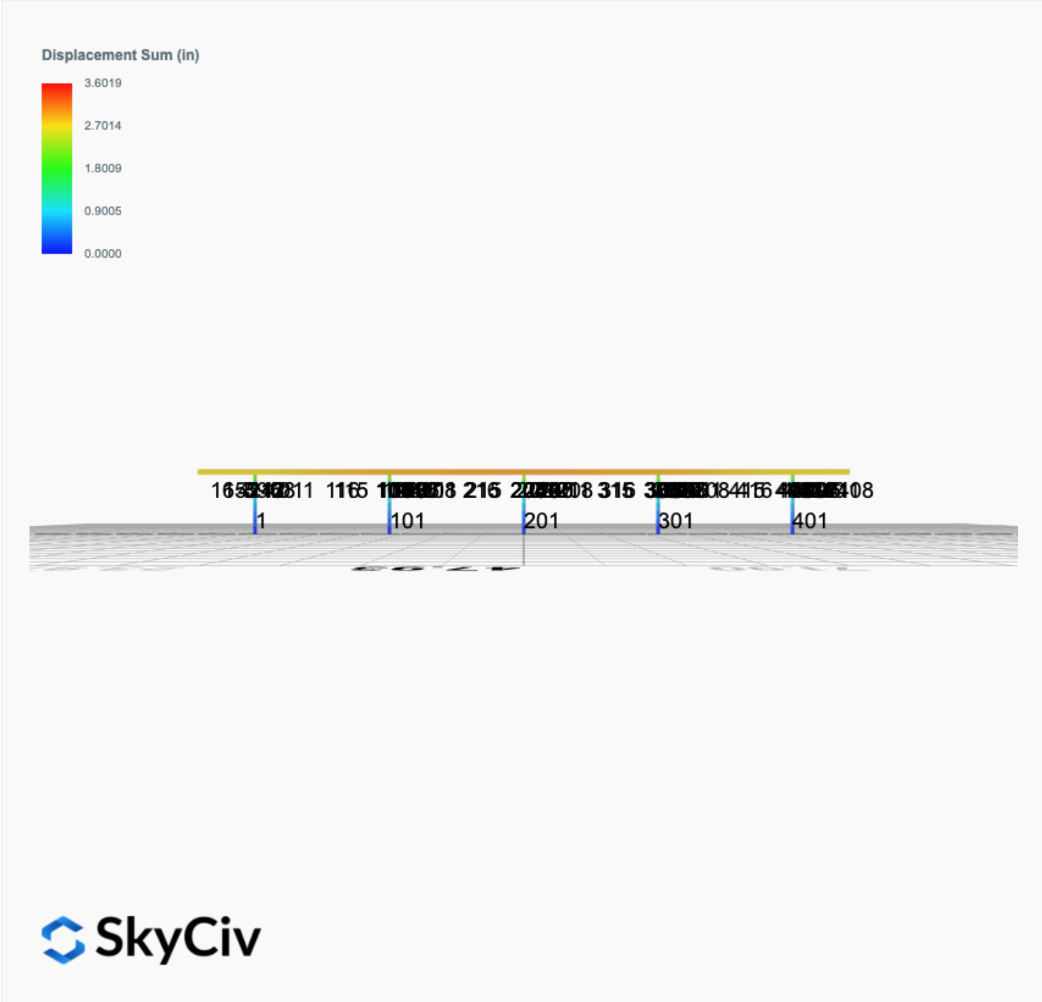
Rail Length: 15.033333333333333 ft
Additional Restraints Required: None
Tributary Width: 2.9958333333333336 ft
Material: Aluminium
Density: 169 lb/ft^3
Elasticity Modulus: 10000 ksi
Fy: 34.5 ksi
Fu: 37 ksi
Wind uplift Case A (X): 0.0000 kip/ft
Wind uplift Case A (Y): -0.0182 kip/ft
Wind uplift Case A: -0.1383 kip/ft
Wind uplift Case B: -0.1383 kip/ft
Wind uplift Case B (X): 0.0000 kip/ft
Wind uplift Case B (Y): 0.1642 kip/ft

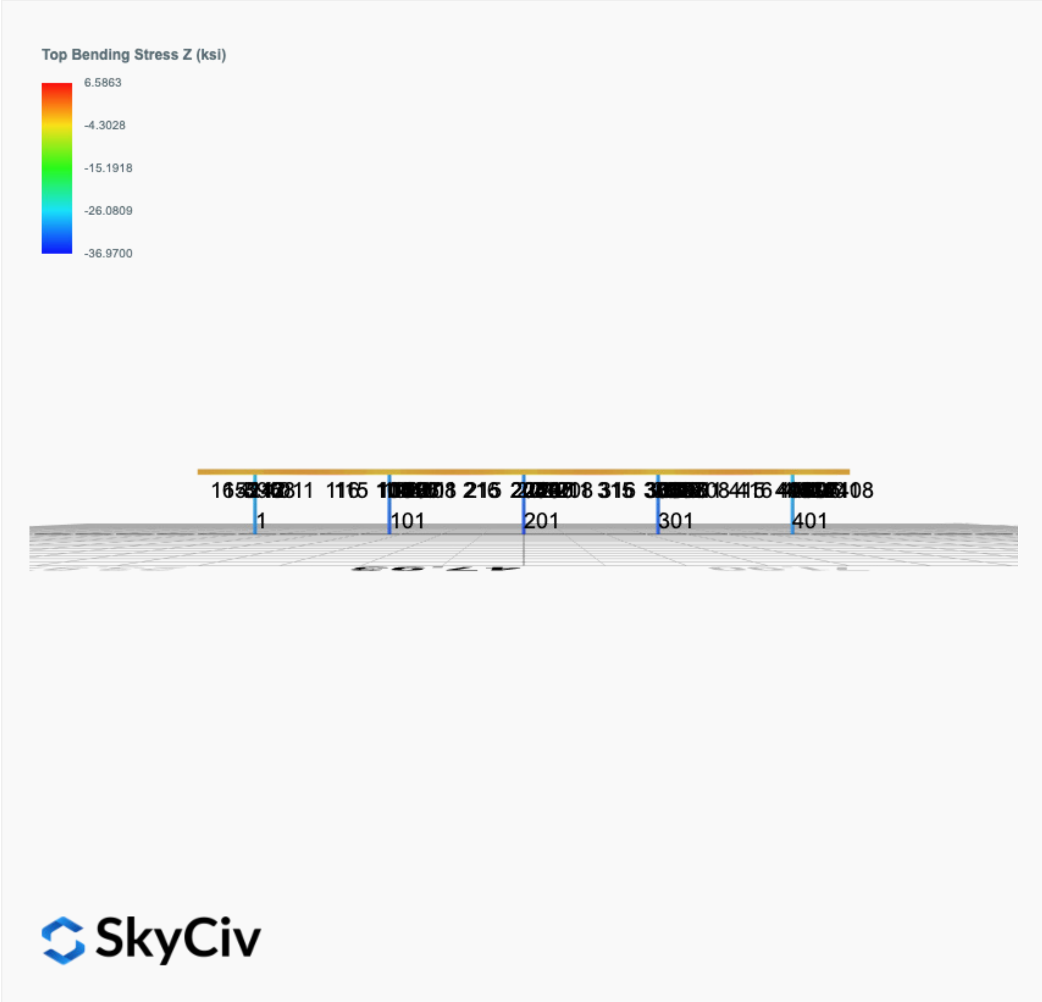


Result Check	Max Limit	Max Value	Utility	Status
Custom Stress Limit	34.5	25.49540705	0.739	PASS
Material Yield	34.5	25.49540705	0.739	PASS
Material Strength	37	25.49540705	0.689	PASS



FEM Results (Envelope Worst Case for each member)




Top Bending Stress Z (ksi)
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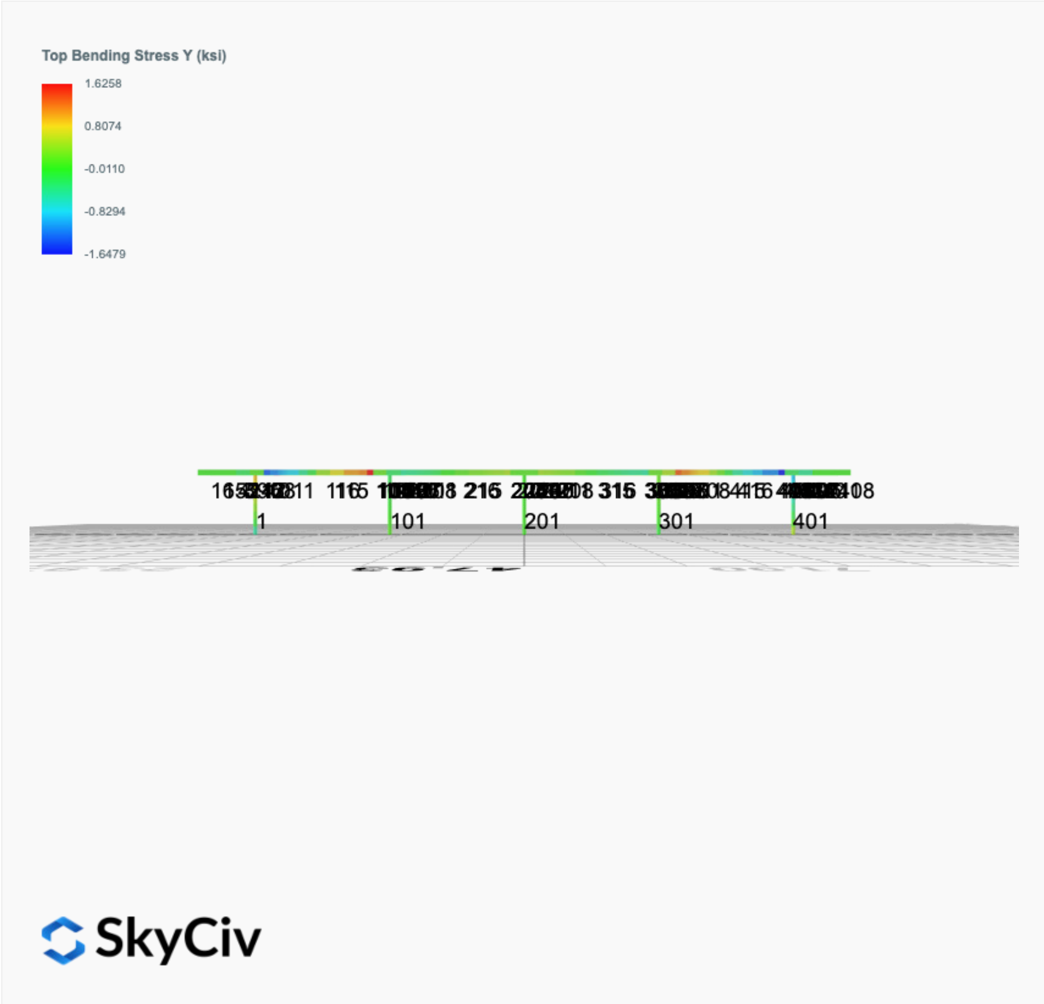
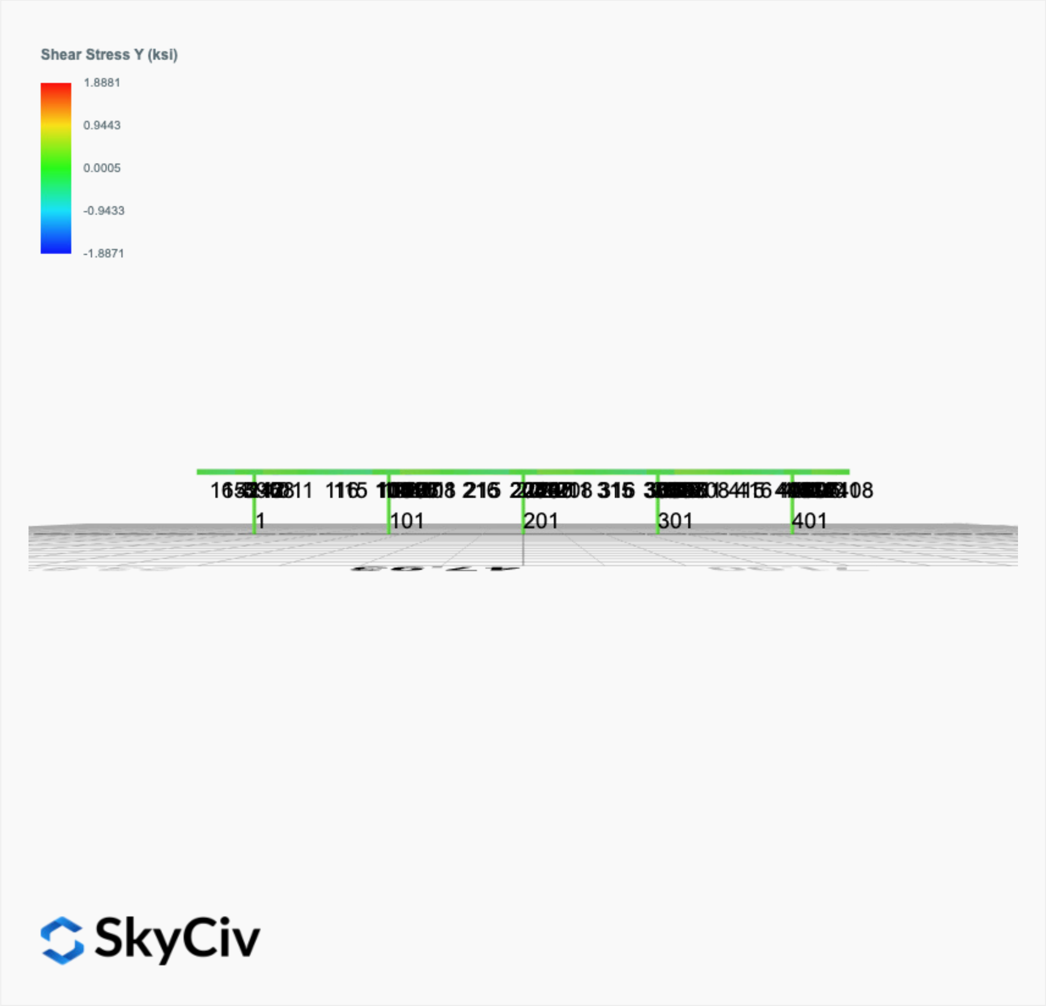
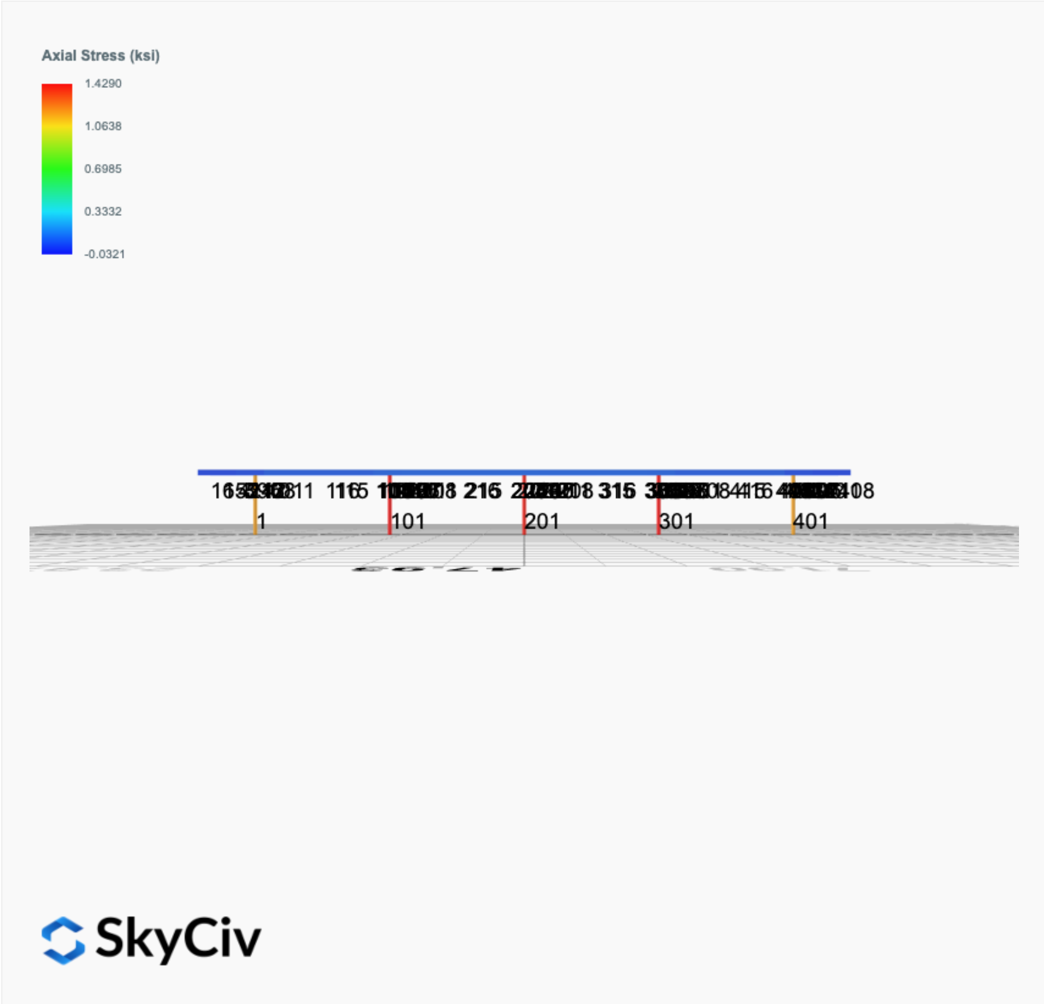
-4.3028
-15.1918
-26.0809
-36.9700
1
101
201
301
401
SkyCiv


Top Bending Stress Y (ksi)
1.6258
0.8074
-0.0110
-0.8294
-1.6479
1
101
201
301
401
SkyCiv


Shear Stress Y (ksi)
1.8881
0.9443
0.0005
-0.9433
-1.8871
1
101
201
301
401
SkyCiv


Axial Stress (ksi)
1.4290
1.0638
0.6985
0.3332
-0.0321
1
101
201
301
401
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	0.0003	2.0864	0.0248	0.0683	-0.0010	0.0297
ULS: 2. D + L	0.0003	2.0864	0.0248	0.0683	-0.0010	0.0297
ULS: 3. D + (S or Lr or R)	0.0003	2.0864	0.0248	0.0683	-0.0010	0.0297
ULS: 3. D + (S or Lr or R)	0.0003	2.0864	0.0248	0.0683	-0.0010	0.0297
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0003	2.0864	0.0248	0.0683	-0.0010	0.0297
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0003	2.0864	0.0248	0.0683	-0.0010	0.0297
ULS: 5b. D + 0.7E	0.0003	2.0864	0.0248	0.0683	-0.0010	0.0297
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0003	2.0864	0.0248	0.0683	-0.0010	0.0297
ULS: 8. 0.6D + 0.7E	0.0002	1.2518	0.0149	0.0410	-0.0006	0.0178
ULS: 5a. D + 0.6W_Wind downforce Case A only	-0.0896	8.2356	0.1164	0.3226	0.0003	-10.1364
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.0896	8.2356	0.1164	0.3226	0.0003	-10.1364
ULS: 5a. D + 0.6W_Wind uplift Case A only	-0.0941	6.2133	0.0903	0.2484	-0.0150	13.7278
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.1052	-2.5717	-0.0482	-0.1311	0.0141	-15.3990
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.0671	6.6983	0.0935	0.2590	0.0000	-7.5948
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0671	6.6983	0.0935	0.2590	0.0000	-7.5948
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	-0.0705	5.1815	0.0739	0.2034	-0.0115	10.3033
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0790	-1.4072	-0.0300	-0.0813	0.0104	-11.5418
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.0671	6.6983	0.0935	0.2590	0.0000	-7.5948
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0671	6.6983	0.0935	0.2590	0.0000	-7.5948
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	-0.0705	5.1815	0.0739	0.2034	-0.0115	10.3033
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0790	-1.4072	-0.0300	-0.0813	0.0104	-11.5418
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-0.0897	7.4010	0.1065	0.2953	0.0007	-10.1483
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.0897	7.4010	0.1065	0.2953	0.0007	-10.1483
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	-0.0943	5.3787	0.0804	0.2211	-0.0146	13.7159
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.1051	-3.4063	-0.0581	-0.1584	0.0145	-15.4109

Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	12.7522
Shear X	-0.1763
Shear Z	0.1827
Moment X	0.5073
Moment Y (Twist)	0.0251
Moment Z	26.1503

Worst Case Reactions ASD

These results are taken from the worst case values in the above table and are used in the Soil Checks in the Foundation Module.
Note: Worst case values are assumed as downforce wind load cases.

Result	Value (kip, kip-ft)
Axial	8.2356
Shear X	-0.1052
Shear Z	0.1164
Moment X	0.3226
Moment Y (Twist)	0.0150
Moment Z	15.4109

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	-0.0002	2.3491	-0.0046	-0.0131	0.0002	0.0345
ULS: 2. D + L	-0.0002	2.3491	-0.0046	-0.0131	0.0002	0.0345
ULS: 3. D + (S or Lr or R)	-0.0002	2.3491	-0.0046	-0.0131	0.0002	0.0345
ULS: 3. D + (S or Lr or R)	-0.0002	2.3491	-0.0046	-0.0131	0.0002	0.0345
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0002	2.3491	-0.0046	-0.0131	0.0002	0.0345

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0002	2.3491	-0.0046	-0.0131	0.0002	0.0345
ULS: 5b. D + 0.7E	-0.0002	2.3491	-0.0046	-0.0131	0.0002	0.0345
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0002	2.3491	-0.0046	-0.0131	0.0002	0.0345
ULS: 8. 0.6D + 0.7E	-0.0001	1.4094	-0.0027	-0.0079	0.0001	0.0207
ULS: 5a. D + 0.6W_Wind downforce Case A only	-0.1375	9.4869	-0.0227	-0.0643	0.0104	-11.0188
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.1375	9.4869	-0.0227	-0.0643	0.0104	-11.0188
ULS: 5a. D + 0.6W_Wind uplift Case A only	-0.0673	7.1346	-0.0144	-0.0428	-0.0105	14.9642
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.0768	-3.0533	0.0073	0.0221	0.0115	-16.6161
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.1032	7.7024	-0.0181	-0.0515	0.0079	-8.2554
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.1032	7.7024	-0.0181	-0.0515	0.0079	-8.2554
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	-0.0505	5.9382	-0.0119	-0.0353	-0.0078	11.2318
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0576	-1.7027	0.0043	0.0133	0.0086	-12.4534
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.1032	7.7024	-0.0181	-0.0515	0.0079	-8.2554
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.1032	7.7024	-0.0181	-0.0515	0.0079	-8.2554
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	-0.0505	5.9382	-0.0119	-0.0353	-0.0078	11.2318
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0576	-1.7027	0.0043	0.0133	0.0086	-12.4534
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-0.1374	8.5473	-0.0208	-0.0591	0.0103	-11.0326
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.1374	8.5473	-0.0208	-0.0591	0.0103	-11.0326
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	-0.0672	6.1950	-0.0126	-0.0375	-0.0106	14.9504
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.0769	-3.9929	0.0091	0.0274	0.0114	-16.6299

Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	14.7154
Shear X	-0.2296
Shear Z	-0.0357
Moment X	-0.1015
Moment Y (Twist)	0.0195
Moment Z	28.2519

Worst Case Reactions ASD

These results are taken from the worst case values in the above table and are used in the Soil Checks in the Foundation Module.
Note: Worst case values are assumed as downforce wind load cases.

Result	Value (kip, kip-ft)
Axial	9.4869
Shear X	-0.1375
Shear Z	-0.0227
Moment X	-0.0643
Moment Y (Twist)	0.0115
Moment Z	16.6299

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	-0.0001	2.3390	-0.0001	-0.0003	0.0000	0.0338
ULS: 2. D + L	-0.0001	2.3390	-0.0001	-0.0003	0.0000	0.0338
ULS: 3. D + (S or Lr or R)	-0.0001	2.3390	-0.0001	-0.0003	0.0000	0.0338
ULS: 3. D + (S or Lr or R)	-0.0001	2.3390	-0.0001	-0.0003	0.0000	0.0338
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0001	2.3390	-0.0001	-0.0003	0.0000	0.0338
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0001	2.3390	-0.0001	-0.0003	0.0000	0.0338
ULS: 5b. D + 0.7E	-0.0001	2.3390	-0.0001	-0.0003	0.0000	0.0338
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0001	2.3390	-0.0001	-0.0003	0.0000	0.0338
ULS: 8. 0.6D + 0.7E	-0.0001	1.4034	-0.0000	-0.0002	0.0000	0.0203
ULS: 5a. D + 0.6W_Wind downforce Case A only	-0.1337	9.4353	-0.0003	-0.0016	0.0002	-11.3145
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.1337	9.4353	-0.0003	-0.0016	0.0002	-11.3145
ULS: 5a. D + 0.6W_Wind uplift Case A only	-0.0713	7.0996	-0.0002	-0.0012	-0.0001	15.3202
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.0809	-3.0352	0.0001	0.0006	0.0002	-16.9914

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.1003	7.6612	-0.0002	-0.0013	0.0001	-8.4774
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.1003	7.6612	-0.0002	-0.0013	0.0001	-8.4774
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	-0.0535	5.9094	-0.0002	-0.0010	-0.0001	11.4986
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0606	-1.6917	0.0001	0.0004	0.0002	-12.7351
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.1003	7.6612	-0.0002	-0.0013	0.0001	-8.4774
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.1003	7.6612	-0.0002	-0.0013	0.0001	-8.4774
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	-0.0535	5.9094	-0.0002	-0.0010	-0.0001	11.4986
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0606	-1.6917	0.0001	0.0004	0.0002	-12.7351
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-0.1337	8.4997	-0.0002	-0.0014	0.0002	-11.3281
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.1337	8.4997	-0.0002	-0.0014	0.0002	-11.3281
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	-0.0713	6.1640	-0.0002	-0.0011	-0.0002	15.3067
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.0809	-3.9708	0.0001	0.0007	0.0002	-17.0050

Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	14.6339
Shear X	-0.2232
Shear Z	-0.0004
Moment X	-0.0025
Moment Y (Twist)	0.0003
Moment Z	28.8945

Worst Case Reactions ASD

These results are taken from the worst case values in the above table and are used in the Soil Checks in the Foundation Module.
Note: Worst case values are assumed as downforce wind load cases.

Result	Value (kip, kip-ft)
Axial	9.4353
Shear X	-0.1337
Shear Z	-0.0003
Moment X	-0.0016
Moment Y (Twist)	0.0002
Moment Z	17.0050

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	-0.0002	2.3490	0.0048	0.0133	-0.0002	0.0345
ULS: 2. D + L	-0.0002	2.3490	0.0048	0.0133	-0.0002	0.0345
ULS: 3. D + (S or Lr or R)	-0.0002	2.3490	0.0048	0.0133	-0.0002	0.0345
ULS: 3. D + (S or Lr or R)	-0.0002	2.3490	0.0048	0.0133	-0.0002	0.0345
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0002	2.3490	0.0048	0.0133	-0.0002	0.0345
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0002	2.3490	0.0048	0.0133	-0.0002	0.0345
ULS: 5b. D + 0.7E	-0.0002	2.3490	0.0048	0.0133	-0.0002	0.0345
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0002	2.3490	0.0048	0.0133	-0.0002	0.0345
ULS: 8. 0.6D + 0.7E	-0.0001	1.4094	0.0029	0.0080	-0.0001	0.0207
ULS: 5a. D + 0.6W_Wind downforce Case A only	-0.1374	9.4866	0.0236	0.0652	-0.0103	-11.0178
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.1374	9.4866	0.0236	0.0652	-0.0103	-11.0178
ULS: 5a. D + 0.6W_Wind uplift Case A only	-0.0674	7.1344	0.0151	0.0435	0.0102	14.9629
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.0769	-3.0532	-0.0077	-0.0225	-0.0111	-16.6147
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.1031	7.7022	0.0189	0.0522	-0.0078	-8.2547
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.1031	7.7022	0.0189	0.0522	-0.0078	-8.2547
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	-0.0506	5.9380	0.0125	0.0359	0.0076	11.2308
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0576	-1.7027	-0.0046	-0.0136	-0.0084	-12.4524
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.1031	7.7022	0.0189	0.0522	-0.0078	-8.2547
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.1031	7.7022	0.0189	0.0522	-0.0078	-8.2547
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	-0.0506	5.9380	0.0125	0.0359	0.0076	11.2308
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0576	-1.7027	-0.0046	-0.0136	-0.0084	-12.4524

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-0.1373	8.5470	0.0217	0.0599	-0.0102	-11.0316
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.1373	8.5470	0.0217	0.0599	-0.0102	-11.0316
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	-0.0673	6.1948	0.0132	0.0381	0.0103	14.9491
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.0770	-3.9928	-0.0096	-0.0279	-0.0110	-16.6285

Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	14.7149
Shear X	-0.2295
Shear Z	0.0372
Moment X	0.1029
Moment Y (Twist)	0.0189
Moment Z	28.2496

Worst Case Reactions ASD

These results are taken from the worst case values in the above table and are used in the Soil Checks in the Foundation Module.
Note: Worst case values are assumed as downforce wind load cases.

Result	Value (kip, kip-ft)
Axial	9.4866
Shear X	-0.1374
Shear Z	0.0236
Moment X	0.0652
Moment Y (Twist)	0.0111
Moment Z	16.6285

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	0.0003	2.0864	-0.0249	-0.0691	0.0009	0.0297
ULS: 2. D + L	0.0003	2.0864	-0.0249	-0.0691	0.0009	0.0297
ULS: 3. D + (S or Lr or R)	0.0003	2.0864	-0.0249	-0.0691	0.0009	0.0297
ULS: 3. D + (S or Lr or R)	0.0003	2.0864	-0.0249	-0.0691	0.0009	0.0297
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0003	2.0864	-0.0249	-0.0691	0.0009	0.0297
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0003	2.0864	-0.0249	-0.0691	0.0009	0.0297
ULS: 5b. D + 0.7E	0.0003	2.0864	-0.0249	-0.0691	0.0009	0.0297
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0003	2.0864	-0.0249	-0.0691	0.0009	0.0297
ULS: 8. 0.6D + 0.7E	0.0002	1.2518	-0.0149	-0.0414	0.0006	0.0178
ULS: 5a. D + 0.6W_Wind downforce Case A only	-0.0896	8.2356	-0.1171	-0.3262	-0.0003	-10.1365
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.0896	8.2356	-0.1171	-0.3262	-0.0003	-10.1365
ULS: 5a. D + 0.6W_Wind uplift Case A only	-0.0941	6.2133	-0.0908	-0.2510	0.0151	13.7281
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.1052	-2.5717	0.0485	0.1324	-0.0142	-15.3993
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.0671	6.6983	-0.0940	-0.2619	-0.0000	-7.5950
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0671	6.6983	-0.0940	-0.2619	-0.0000	-7.5950
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	-0.0705	5.1816	-0.0743	-0.2056	0.0115	10.3035
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0790	-1.4072	0.0301	0.0820	-0.0104	-11.5421
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.0671	6.6983	-0.0940	-0.2619	-0.0000	-7.5950
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0671	6.6983	-0.0940	-0.2619	-0.0000	-7.5950
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	-0.0705	5.1816	-0.0743	-0.2056	0.0115	10.3035
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0790	-1.4072	0.0301	0.0820	-0.0104	-11.5421
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-0.0897	7.4011	-0.1071	-0.2986	-0.0007	-10.1484
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.0897	7.4011	-0.1071	-0.2986	-0.0007	-10.1484
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	-0.0942	5.3787	-0.0808	-0.2234	0.0147	13.7162
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.1051	-3.4063	0.0584	0.1600	-0.0145	-15.4112

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 (kip, kip-ft)
Axial	12.7523
Shear X	-0.1762
Shear Z	-0.1838
Moment X	-0.5130
Moment Y (Twist)	0.0252
Moment Z	26.1509

Result	Value (kip, kip-ft)
Axial	8.2356
Shear X	-0.1052
Shear Z	-0.1171
Moment X	-0.3262
Moment Y (Twist)	0.0151
Moment Z	15.4112

Project Details

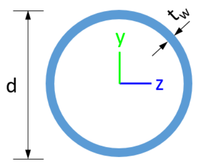
Design Code:	AISC 360-16 LRFD
Provision:	LRFD
Country:	United States
User Name:	sales@mtsolar.us
Unit System:	imperial

Design Input Information

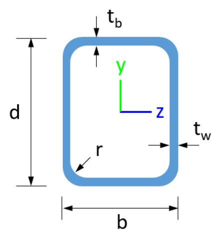
Design Factors			
Φ_t	Φ_c	Φ_b	Φ_v
0.9	0.9	0.9	0.9

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

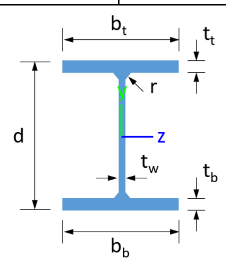
Section Dimensions



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					
7	6in Pipe Sch 40	6.63	0.28					



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
7	6in Pipe Sch 40	5.58	56.28	28.14	28.14	0.00	11.28	11.28
17	HSS5x3x1/4	3.37	11.00	4.81	10.70	0.93	3.77	5.38
20	W10x12	3.54	0.05	2.18	53.80	50.90	1.74	12.60

Member Properties								
Member ID	Section ID	K_zL (ft)	K_yL (ft)	L_b(ft)	C_b	LST	LSC	LD
1	7	19.18	19.18	9.13	-	300	200	1
2	6	1.30	1.30	2.00	-	300	200	1
3	17	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17	300	200	1
4	17	2.44	2.44	3.75	1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.67,1.68,1.71,1.67,1.67,1.68,1.71,1.67,1.67,1.68,1.70,1.67,1.67,1.68,1.70,1.67,1.67,1.68,1.74	300	200	1
5	17	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66	300	200	1
6	17	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18	300	200	1
7	17	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66	300	200	1
8	20	1.33	1.33	2.05	1.62,1.62,1.62,1.62,1.62,1.62,1.70,1.70,1.36,1.59,1.70,1.70,1.36,1.59,1.69,1.69,1.43,2.17,1.69,1.69,1.43,2.17,1.70,1.70,1.33,1.32	300	200	1
9	3	2.60	2.60	4.00	-	300	200	1
10	17	2.44	2.44	3.75	1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.67,1.68,1.71,1.67,1.67,1.68,1.71,1.67,1.67,1.68,1.70,1.67,1.67,1.68,1.70,1.67,1.67,1.68,1.72	300	200	1
11	20	1.33	1.33	2.05	1.63,1.63,1.63,1.63,1.63,1.63,1.50,1.50,1.75,1.80,1.50,1.50,1.75,1.80,1.52,1.52,1.73,1.85,1.52,1.52,1.73,1.85,1.49,1.49,1.76,1.79	300	200	1
12	6	1.30	1.30	2.00	-	300	200	1
13	20	4.88	4.00	7.50	1.13,1.13,1.13,1.13,1.13,1.13,1.12,1.12,1.13,1.13,1.12,1.12,1.13,1.13,1.12,1.12,1.13,1.14,1.12,1.12,1.13,1.14,1.12,1.12,1.13,1.13	300	200	1
14	20	4.88	4.00	7.50	1.12,1.12,1.12,1.12,1.12,1.12,1.13,1.13,1.11,2.65,1.13,1.13,1.11,2.65,1.13,1.13,1.11,1.37,1.13,1.13,1.11,1.37,1.13,1.13,1.10,4.10	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
101	7	19.18	19.18	9.13	-	300	200	1
102	6	1.30	1.30	2.00	-	300	200	1
103	17	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18	300	200	1
104	17	2.44	2.44	3.75	1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.67,1.68,1.73,1.67,1.67,1.68,1.73,1.67,1.67,1.68,1.70,1.67,1.67,1.68,1.70,1.67,1.67,1.67,1.91	300	200	1
105	17	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66	300	200	1
106	17	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18	300	200	1
107	17	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66	300	200	1
108	20	1.33	1.33	2.05	2.07,2.07,2.07,2.07,2.07,2.07,2.06,2.06,2.37,1.28,2.06,2.06,2.37,1.28,2.06,2.06,2.11,1.61,2.06,2.06,2.11,1.61,2.06,2.06,2.36,1.13	300	200	1
109	3	2.60	2.60	4.00	-	300	200	1
110	17	2.44	2.44	3.75	1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.67,1.68,1.71,1.67,1.67,1.68,1.71,1.67,1.67,1.68,1.69,1.67,1.67,1.68,1.69,1.67,1.67,1.68,1.74	300	200	1
111	20	1.33	1.33	2.05	2.07,2.07,2.07,2.07,2.07,2.07,2.09,2.09,2.06,2.04,2.09,2.09,2.06,2.04,2.09,2.09,2.06,2.00,2.09,2.09,2.06,2.00,2.09,2.09,2.06,2.05	300	200	1
112	6	4.20	4.20	2.00	-	300	200	1

113	20	4.88	4.00	7.50	1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.05,1.05,1.04,1.04,1.05,1.05,1.04,1.04,1.05,1.08,1.04,1.04,1.05,1.08,1.04,1.04,1.05,1.05	300	200	1
114	20	4.88	4.00	7.50	1.04,1.04,1.04,1.04,1.04,1.04,1.05,1.05,1.03,1.05,1.05,1.05,1.03,1.05,1.05,1.05,1.03,1.78,1.05,1.05,1.03,1.78,1.05,1.05,1.03,1.02	300	200	1
115	20	10.20	10.20	10.20	1.16,1.16,1.16,1.16,1.16,1.16,1.18,1.18,1.15,1.14,1.18,1.18,1.15,1.14,1.17,1.17,1.15,1.14,1.17,1.17,1.15,1.14,1.18,1.18,1.14,1.14	300	200	1
116	20	10.20	10.20	10.20	1.16,1.16,1.16,1.16,1.16,1.16,1.15,1.15,1.21,1.14,1.15,1.15,1.21,1.14,1.15,1.15,1.19,1.09,1.15,1.15,1.19,1.09,1.15,1.15,1.22,1.55	300	200	1
201	7	19.18	19.18	9.13	-	300	200	1
202	6	1.30	1.30	2.00	-	300	200	1
203	17	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18	300	200	1
204	17	2.44	2.44	3.75	1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.67,1.68,1.71,1.67,1.67,1.68,1.71,1.67,1.67,1.68,1.69,1.67,1.67,1.68,1.69,1.67,1.67,1.68,1.74	300	200	1
205	17	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66	300	200	1
206	17	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18	300	200	1
207	17	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66	300	200	1
208	20	1.33	1.33	2.05	2.08,2.08,2.08,2.08,2.08,2.08,2.07,2.07,2.19,1.47,2.07,2.07,2.19,1.47,2.07,2.07,2.10,1.83,2.07,2.07,2.10,1.83,2.07,2.07,2.31,1.27	300	200	1
209	3	2.60	2.60	4.00	-	300	200	1
210	17	2.44	2.44	3.75	1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.67,1.68,1.71,1.67,1.67,1.68,1.71,1.67,1.67,1.68,1.69,1.67,1.67,1.68,1.69,1.67,1.67,1.68,1.74	300	200	1
211	20	1.33	1.33	2.05	2.08,2.08,2.08,2.08,2.08,2.08,2.10,2.10,2.07,2.07,2.10,2.10,2.07,2.07,2.09,2.09,2.07,2.07,2.09,2.09,2.07,2.07,2.10,2.10,2.07,2.07	300	200	1
212	6	1.30	1.30	2.00	-	300	200	1
213	20	4.88	4.00	7.50	1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.05,1.05,1.04,1.04,1.05,1.05,1.04,1.04,1.04,1.05,1.04,1.04,1.04,1.05,1.04,1.04,1.05,1.05	300	200	1
214	20	4.88	4.00	7.50	1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.03,1.27,1.04,1.04,1.03,1.27,1.04,1.04,1.03,1.36,1.04,1.04,1.03,1.36,1.04,1.04,1.03,1.02	300	200	1
215	20	10.20	10.20	10.20	1.18,1.18,1.18,1.18,1.18,1.18,1.19,1.19,1.18,1.18,1.19,1.19,1.18,1.18,1.19,1.19,1.18,1.18,1.19,1.19,1.18,1.18,1.19,1.19,1.18,1.18	300	200	1
216	20	10.20	10.20	10.20	1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.21,1.13,1.18,1.18,1.21,1.13,1.18,1.18,1.20,1.16,1.18,1.18,1.20,1.16,1.18,1.18,1.21,1.10	300	200	1
301	7	19.18	19.18	9.13	-	300	200	1
302	6	4.20	4.20	2.00	-	300	200	1
303	17	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18	300	200	1
304	17	2.44	2.44	3.75	1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.67,1.68,1.71,1.67,1.67,1.68,1.71,1.67,1.67,1.68,1.69,1.67,1.67,1.68,1.69,1.67,1.67,1.68,1.74	300	200	1
305	17	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66	300	200	1
306	17	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18	300	200	1
307	17	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66	300	200	1
308	20	1.33	1.33	2.05	2.03,2.03,2.03,2.03,2.03,2.03,1.90,1.90,2.35,1.09,1.90,1.90,2.35,1.09,1.91,1.91,2.12,1.39,1.91,1.91,2.12,1.39,1.89,1.89,2.32,1.02	300	200	1
309	3	2.60	2.60	4.00	-	300	200	1
310	17	2.44	2.44	3.75	1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.67,1.68,1.73,1.67,1.67,1.68,1.73,1.67,1.67,1.68,1.70,1.67,1.67,1.68,1.70,1.67,1.67,1.67,1.91	300	200	1
311	20	1.33	1.33	2.05	2.05,2.05,2.05,2.05,2.05,2.05,2.10,2.10,1.84,1.79,2.10,2.10,1.84,1.79,2.09,2.09,1.87,1.75,2.09,2.09,1.87,1.75,2.10,2.10,1.83,1.80	300	200	1
312	6	1.30	1.30	2.00	-	300	200	1
313	20	4.88	4.00	7.50	1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.05,1.05,1.04,1.04,1.05,1.05,1.04,1.04,1.05,1.08,1.04,1.04,1.05,1.08,1.04,1.04,1.05,1.05	300	200	1
314	20	4.88	4.00	7.50	1.04,1.04,1.04,1.04,1.04,1.04,1.05,1.05,1.03,1.05,1.05,1.05,1.03,1.05,1.05,1.05,1.04,1.78,1.05,1.05,1.04,1.78,1.05,1.05,1.03,1.02	300	200	1

315	20	10.20	10.20	10.20	1.16,1.16,1.16,1.16,1.16,1.16,1.17,1.17,1.15,1.15,1.17,1.17,1.15,1.15,1.17,1.17,1.15,1.15,1.17,1.17,1.15,1.15,1.17,1.17,1.15,1.15	300	200	1
316	20	10.20	10.20	10.20	1.16,1.16,1.16,1.16,1.16,1.16,1.15,1.15,1.19,1.09,1.15,1.15,1.19,1.09,1.15,1.15,1.17,1.13,1.15,1.15,1.17,1.13,1.15,1.15,1.19,1.05	300	200	1
401	7	19.18	19.18	9.13	-	300	200	1
402	6	1.30	1.30	2.00	-	300	200	1
403	17	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18	300	200	1
404	17	2.44	2.44	3.75	1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.67,1.68,1.71,1.67,1.67,1.68,1.71,1.67,1.67,1.68,1.70,1.67,1.67,1.68,1.70,1.67,1.67,1.68,1.72	300	200	1
405	17	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66	300	200	1
406	17	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17	300	200	1
407	17	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66,1.67,1.67,1.67,1.66	300	200	1
408	20	7.88	7.88	3.75	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	1
409	3	2.60	2.60	4.00	-	300	200	1
410	17	2.44	2.44	3.75	1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.67,1.68,1.71,1.67,1.67,1.68,1.71,1.67,1.67,1.68,1.70,1.67,1.67,1.68,1.70,1.67,1.67,1.68,1.74	300	200	1
411	20	7.88	7.88	3.75	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	1
412	6	1.30	1.30	2.00	-	300	200	1
413	20	4.88	4.00	7.50	1.13,1.13,1.13,1.13,1.13,1.13,1.12,1.12,1.13,1.14,1.12,1.12,1.13,1.14,1.12,1.12,1.13,1.14,1.12,1.12,1.13,1.14,1.12,1.12,1.13,1.13	300	200	1
414	20	4.88	4.00	7.50	1.12,1.12,1.12,1.12,1.12,1.12,1.13,1.13,1.11,2.65,1.13,1.13,1.11,2.65,1.13,1.13,1.11,1.37,1.13,1.13,1.11,1.37,1.13,1.13,1.10,4.09	300	200	1
415	20	10.20	10.20	10.20	1.13,1.13,1.13,1.13,1.13,1.13,1.12,1.12,1.14,1.14,1.12,1.12,1.14,1.14,1.12,1.12,1.14,1.14,1.12,1.12,1.14,1.14,1.12,1.12,1.14,1.14	300	200	1
416	20	10.20	10.20	10.20	1.13,1.13,1.13,1.13,1.13,1.13,1.14,1.14,1.11,1.54,1.14,1.14,1.11,1.54,1.14,1.14,1.12,1.20,1.14,1.14,1.12,1.20,1.14,1.14,1.10,1.99	300	200	1

Member Design Capacity

Member ID	$\Phi_t P_n$ (kip)	$\Phi_c P_n$ (kip)	$\Phi_b M_{zn}$ (k-ft)	$\Phi_b M_{yn}$ (k-ft)	$\Phi_v V_{yn}$ (kip)	$\Phi_v V_{zn}$ (kip)
1	251.16	116.55	42.30	42.30	75.35	75.35
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	140.46	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	140.46	46.90	6.46	56.26	44.91
12	251.01	248.88	27.16	27.16	75.30	75.30
13	159.30	97.43	34.34	6.46	56.26	44.91
14	159.30	97.43	33.75	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
101	251.16	116.55	42.30	42.30	75.35	75.35
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	140.46	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	140.46	46.90	6.46	56.26	44.91
112	251.01	229.64	27.16	27.16	75.30	75.30
113	159.30	97.43	31.72	6.46	56.26	44.91
114	159.30	97.43	31.21	6.46	56.26	44.91
115	159.30	32.87	21.91	6.46	56.26	44.91
116	159.30	32.87	21.01	6.46	56.26	44.91
201	251.16	116.55	42.30	42.30	75.35	75.35
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	140.46	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	140.46	46.90	6.46	56.26	44.91
212	251.01	248.88	27.16	27.16	75.30	75.30
213	159.30	97.43	31.70	6.46	56.26	44.91
214	159.30	97.43	31.19	6.46	56.26	44.91
215	159.30	32.87	22.67	6.46	56.26	44.91
216	159.30	32.87	21.22	6.46	56.26	44.91
301	251.16	116.55	42.30	42.30	75.35	75.35
302	251.01	229.64	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	140.46	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	140.46	46.90	6.46	56.26	44.91
312	251.01	248.88	27.16	27.16	75.30	75.30
313	159.30	97.43	31.73	6.46	56.26	44.91
314	159.30	97.43	31.20	6.46	56.26	44.91
315	159.30	32.87	22.13	6.46	56.26	44.91
316	159.30	32.87	20.32	6.46	56.26	44.91
401	251.16	116.55	42.30	42.30	75.35	75.35
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

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	97.43	34.33	6.46	56.26	44.91
414	159.30	97.43	33.74	6.46	56.26	44.91
415	159.30	32.87	21.60	6.46	56.26	44.91
416	159.30	32.87	21.22	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	0.109	0.618	0.027	0.002	0.002	0.635	#16	0.512	Not Required	Pass
2	0.001	0.381	0.006	0.080	0.001	0.387	#13	0.054	Not Required	Pass
3	0.000	0.641	0.008	0.064	0.003	0.644	#15	0.046	Not Required	Pass
4	0.000	0.753	0.008	0.075	0.002	0.761	#13	0.122	Not Required	Pass
5	0.000	0.396	0.004	0.064	0.001	0.400	#15	0.076	Not Required	Pass
6	0.000	0.695	0.008	0.070	0.002	0.700	#15	0.046	Not Required	Pass
7	0.000	0.432	0.012	0.069	0.004	0.434	#15	0.076	Not Required	Pass
8	0.001	0.094	0.021	0.052	0.001	0.102	#13	0.102	Not Required	Pass
9	0.001	0.063	0.009	0.001	0.001	0.072	#13	0.206	Not Required	Pass
10	0.000	0.815	0.012	0.081	0.003	0.818	#13	0.082	Not Required	Pass
11	0.001	0.077	0.020	0.044	0.001	0.089	#15	0.102	Not Required	Pass
12	0.000	0.424	0.006	0.086	0.002	0.429	#13	0.054	Not Required	Pass
13	0.001	0.200	0.027	0.057	0.001	0.209	#15	0.306	Not Required	Pass
14	0.001	0.240	0.028	0.067	0.001	0.249	#13	0.306	Not Required	Pass
15	0.000	0.062	0.001	0.027	0.000	0.063	#15	Not Required	Not Required	Pass
16	0.000	0.073	0.001	0.032	0.000	0.074	#13	Not Required	Not Required	Pass
101	0.126	0.671	0.005	0.003	0.000	0.687	#32	0.512	Not Required	Pass
102	0.000	0.472	0.008	0.097	0.002	0.480	#13	0.054	Not Required	Pass
103	0.000	0.762	0.003	0.076	0.001	0.765	#15	0.046	Not Required	Pass
104	0.000	0.901	0.009	0.090	0.002	0.906	#13	0.122	Not Required	Pass
105	0.000	0.473	0.010	0.076	0.002	0.475	#15	0.076	Not Required	Pass
106	0.000	0.761	0.004	0.076	0.002	0.764	#15	0.046	Not Required	Pass
107	0.000	0.472	0.003	0.076	0.001	0.473	#15	0.076	Not Required	Pass
108	0.001	0.074	0.006	0.052	0.000	0.076	#13	0.102	Not Required	Pass
109	0.001	0.070	0.004	0.001	0.000	0.072	#13	0.206	Not Required	Pass
110	0.000	0.895	0.004	0.089	0.001	0.899	#13	0.122	Not Required	Pass
111	0.001	0.064	0.006	0.044	0.000	0.068	#15	0.102	Not Required	Pass
112	0.000	0.464	0.007	0.095	0.001	0.471	#13	0.174	Not Required	Pass
113	0.002	0.203	0.026	0.058	0.001	0.210	#15	0.306	Not Required	Pass
114	0.002	0.252	0.027	0.069	0.001	0.252	#13	0.306	Not Required	Pass
115	0.004	0.315	0.019	0.045	0.001	0.318	#15	0.780	Not Required	Pass
116	0.004	0.372	0.020	0.054	0.001	0.374	#13	0.780	Not Required	Pass
201	0.126	0.685	0.000	0.003	0.000	0.699	#32	0.512	Not Required	Pass
202	0.000	0.464	0.007	0.096	0.001	0.471	#13	0.054	Not Required	Pass
203	0.000	0.765	0.001	0.077	0.000	0.765	#15	0.046	Not Required	Pass
204	0.000	0.900	0.003	0.090	0.001	0.900	#13	0.082	Not Required	Pass
205	0.000	0.475	0.004	0.076	0.001	0.476	#15	0.076	Not Required	Pass

206	0.000	0.765	0.001	0.077	0.000	0.765	#15	0.046	Not Required	Pass
207	0.000	0.474	0.004	0.076	0.001	0.475	#15	0.076	Not Required	Pass
208	0.001	0.070	0.006	0.053	0.000	0.073	#13	0.102	Not Required	Pass
209	0.001	0.068	0.001	0.001	0.000	0.069	#13	0.206	Not Required	Pass
210	0.000	0.899	0.003	0.090	0.001	0.899	#13	0.082	Not Required	Pass
211	0.001	0.060	0.006	0.045	0.000	0.063	#15	0.102	Not Required	Pass
212	0.000	0.464	0.007	0.096	0.001	0.471	#13	0.054	Not Required	Pass
213	0.002	0.219	0.009	0.058	0.000	0.220	#15	0.306	Not Required	Pass
214	0.002	0.267	0.009	0.068	0.000	0.267	#13	0.306	Not Required	Pass
215	0.005	0.279	0.006	0.045	0.000	0.281	#15	0.780	Not Required	Pass
216	0.005	0.326	0.006	0.053	0.000	0.327	#13	0.780	Not Required	Pass
301	0.126	0.671	0.006	0.003	0.000	0.687	#32	0.512	Not Required	Pass
302	0.000	0.464	0.007	0.095	0.001	0.471	#13	0.174	Not Required	Pass
303	0.000	0.761	0.004	0.076	0.002	0.764	#15	0.046	Not Required	Pass
304	0.000	0.895	0.004	0.089	0.001	0.899	#13	0.122	Not Required	Pass
305	0.000	0.472	0.003	0.076	0.001	0.473	#15	0.076	Not Required	Pass
306	0.000	0.761	0.003	0.076	0.001	0.765	#15	0.046	Not Required	Pass
307	0.000	0.472	0.010	0.076	0.002	0.474	#15	0.076	Not Required	Pass
308	0.001	0.086	0.020	0.054	0.001	0.096	#13	0.102	Not Required	Pass
309	0.001	0.070	0.004	0.001	0.000	0.072	#13	0.206	Not Required	Pass
310	0.000	0.901	0.009	0.090	0.002	0.905	#13	0.122	Not Required	Pass
311	0.001	0.074	0.019	0.045	0.001	0.086	#15	0.102	Not Required	Pass
312	0.000	0.473	0.008	0.097	0.002	0.481	#13	0.054	Not Required	Pass
313	0.002	0.203	0.026	0.058	0.001	0.211	#15	0.306	Not Required	Pass
314	0.002	0.252	0.027	0.069	0.001	0.252	#13	0.306	Not Required	Pass
315	0.005	0.283	0.006	0.044	0.000	0.285	#15	0.780	Not Required	Pass
316	0.005	0.330	0.006	0.052	0.000	0.332	#13	0.780	Not Required	Pass
401	0.109	0.618	0.027	0.002	0.002	0.635	#16	0.512	Not Required	Pass
402	0.000	0.424	0.006	0.086	0.002	0.429	#13	0.054	Not Required	Pass
403	0.000	0.696	0.008	0.070	0.002	0.700	#15	0.046	Not Required	Pass
404	0.000	0.815	0.012	0.081	0.003	0.819	#13	0.082	Not Required	Pass
405	0.000	0.432	0.012	0.069	0.004	0.434	#15	0.076	Not Required	Pass
406	0.000	0.641	0.008	0.064	0.003	0.644	#15	0.046	Not Required	Pass
407	0.000	0.396	0.004	0.064	0.001	0.400	#15	0.076	Not Required	Pass
408	0.000	0.073	0.001	0.032	0.000	0.074	#13	Not Required	Not Required	Pass
409	0.001	0.063	0.009	0.001	0.001	0.072	#13	0.206	Not Required	Pass
410	0.000	0.753	0.008	0.075	0.002	0.761	#13	0.122	Not Required	Pass
411	0.000	0.062	0.001	0.027	0.000	0.063	#15	Not Required	Not Required	Pass
412	0.001	0.381	0.006	0.080	0.001	0.387	#13	0.054	Not Required	Pass
413	0.001	0.200	0.027	0.057	0.001	0.209	#15	0.204	Not Required	Pass
414	0.001	0.240	0.028	0.067	0.001	0.250	#13	0.306	Not Required	Pass
415	0.004	0.317	0.020	0.044	0.001	0.319	#15	0.780	Not Required	Pass
416	0.004	0.376	0.021	0.052	0.001	0.378	#13	0.780	Not Required	Pass

Definitions

Φ_t	Safety factor for tensile
Φ_c	Safety factor for compression
Φ_b	Safety factor for flexure
Φ_v	Safety factor for shear
E	Modulus of elasticity
F_y	Specified minimum yield stress
F_u	Specified minimum tensile strength

A	Cross-sectional area
J	Torsional constant
I_{yp}	Moment of inertia about the Y axes
I_{zp}	Moment of inertia about the Z axes
I_w	Warping constant
S_{yp}	Plastic section modulus about the Y axis
S_{zp}	Plastic section modulus about the Z axis
KL	Effective length
C_b	Buckling modification factor (from all load combinations)
L_b	Length between braced points
LST	Limited slenderness for tension
LSC	Limited slenderness for compression
LD	Limited deflection
P_n	Nominal axial strength (tension/comression)
M_n	Nominal flexural strength (about Z/Y axis)
V_n	Nominal shear strength (along Z/Y axis)
P	Design ratio in case of axial force
M_z	Design ratio in case of bending about Z axis
M_y	Design ratio in case of bending about Y axis
V_y	Design ratio in case of shear along Y axis
V_z	Design ratio in case of shear along Z axis
(P,M_z,M_y)	Design ratio in case of axial force and bending action
KL/r	Design ratio in case of section slenderness
δ	Design ratio in case of member deflection
OK	Capacity is provided
NG	Capacity is not provided

REFERENCES	CALCULATIONS	RESULTS

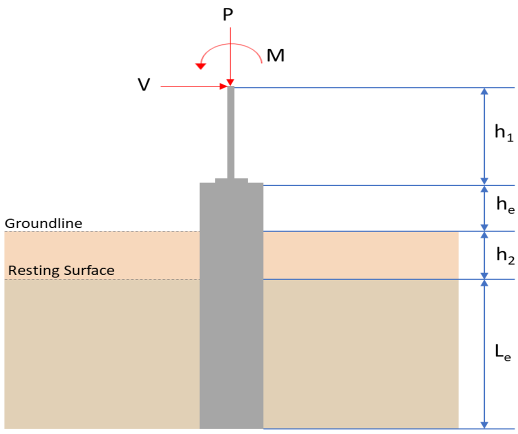
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: rectangular
$b = 48\ \mathrm{in}$ - Pile width
$D = 48\ \mathrm{in}$ - Pile depth
$L = 6.75\ \mathrm{ft}$ - Total pile length
$h_1 = 0\ \mathrm{ft}$ - Lateral load height from the top of the pile,
$h_2 = 0\ \mathrm{ft}$ - Depth to resisting surface
$h_e = 0\ \mathrm{ft}$ - Length of pile above the ground

Tabulation of Soil Parameters

Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) (psf/ft)
1	Clay, sandy clay, silty clay, clayey silt, silt and sandy silt	1500.000	100.000

Tabulation of Loads

Load Component	ASD	LRFD
P (kip)	8.236	12.752
V_x (kip)	-0.105	-0.176
V_z (kip)	0.116	0.183
M_x (kipft)	0.323	0.507
M_z (kipft)	15.411	26.150

Material Properties

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

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

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

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

Considering x-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.105\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.01672\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(15.411\text{ kipft}) + ((-0.105\text{ kip}) \times (0\text{ ft}))}{1.57 \times (48\text{ in})}$$

$$M_o = 2.454\text{ kipft/ft}$$

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:
$L_{e,x} = 6.5776\text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.116\text{ kip})}{1.57 \times (48\text{ in})}$$

$$H_o = 0.018471\text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.323\text{ kipft}) + ((0.116\text{ kip}) \times (0\text{ ft}))}{1.57 \times (48\text{ in})}$$

$$M_o = 0.051433\text{ kipft/ft}$$

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:
$L_{e,z} = 2.1341\text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(6.5776\text{ ft}), (2.1341\text{ ft})]$$

$$L_{e,req} = 6.578\text{ ft}$$

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

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

$$Ratio = \frac{(6.578\text{ ft})}{(6.75\text{ ft})}$$

$$Ratio = 0.97452$$

Status: PASS
Ratio: 0.970

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

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

$$q = \frac{(8.236\ \text{kip})}{(16\ \text{ft}^2)}$$

$$q = 0.51475\ \text{kip/ft}^2$$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{\left(0.51475\ \text{kip/ft}^2\right)}{(1500\ \text{psf})}$$

$$Ratio = 0.34317$$

Status: **PASS**
Ratio: **0.340**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

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

$$L/D = 1.6875$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.01672\ \text{kip/ft}$ - Lateral force per length of pile,
$M_o = 2.454\ \text{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (2.454\ \text{kipft/ft}) \times (6.75\ \text{ft})) + \left(3 \times (-0.01672\ \text{kip/ft}) \times (6.75\ \text{ft})^2\right)}{(6 \times (2.454\ \text{kipft/ft})) + (4 \times (-0.01672\ \text{kip/ft}) \times (6.75\ \text{ft}))}$$

$$a = 4.5167\ \text{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (2.454\ \text{kipft/ft})) + (3 \times (-0.01672\ \text{kip/ft}) \times (6.75\ \text{ft}))]^2}{(6.75\ \text{ft})^2 \times [(3 \times (2.454\ \text{kipft/ft})) + (2 \times (-0.01672\ \text{kip/ft}) \times (6.75\ \text{ft}))]}$$

$$p = 0.20719\ \text{kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (2.454\ \text{kipft/ft})) + ((-0.01672\ \text{kip/ft}) \times (6.75\ \text{ft}))]}{(6.75\ \text{ft})^2}$$

$$s = 0.63145\ \text{kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (100\ \text{psf/ft}) \times \frac{(4.5167\ \text{ft})}{2}$$

$$p_a = 0.22584\ \text{kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.20719\ \mathrm{kip/ft^2}\right)}{\left(0.22584\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.91741$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (100\ \mathrm{psf/ft}) \times (6.75\ \mathrm{ft})$$

$$p_s = 0.675\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.63145\ \mathrm{kip/ft^2}\right)}{\left(0.675\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.93549$$

Status: **PASS**
Ratio: **0.940**

Considering z-direction:

$H_o = 0.018471\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 0.051433\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.051433\ \mathrm{kipft/ft}) \times (6.75\ \mathrm{ft})) + \left(3 \times (0.018471\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft})^2\right)}{(6 \times (0.051433\ \mathrm{kipft/ft})) + (4 \times (0.018471\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft}))}$$

$$a = 4.8475\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.051433\ \mathrm{kipft/ft})) + (3 \times (0.018471\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft}))]^{\,2}}{(6.75\ \mathrm{ft})^2 \times [(3 \times (0.051433\ \mathrm{kipft/ft})) + (2 \times (0.018471\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft}))]}$$

$$p = 0.013707\ \mathrm{kip/ft^2}$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (0.051433\ \mathrm{kipft/ft})) + ((0.018471\ \mathrm{kip/ft}) \times (6.75\ \mathrm{ft}))]}{(6.75\ \mathrm{ft})^2}$$

$$s = 0.029965\ \mathrm{kip/ft^2}$$

Check lateral soil pressure capacity:

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

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

$$p_a = (100\ \mathrm{psf/ft}) \times \frac{(4.8475\ \mathrm{ft})}{2}$$

$$p_a = 0.24237\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.013707\ \mathrm{kip/ft^2}\right)}{\left(0.24237\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.056555$$

Status: **PASS**
Ratio: **0.060**

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (100\ \text{psf/ft}) \times (6.75\ \text{ft})$$

$$p_s = 0.675\ \text{kip/ft}^2$$

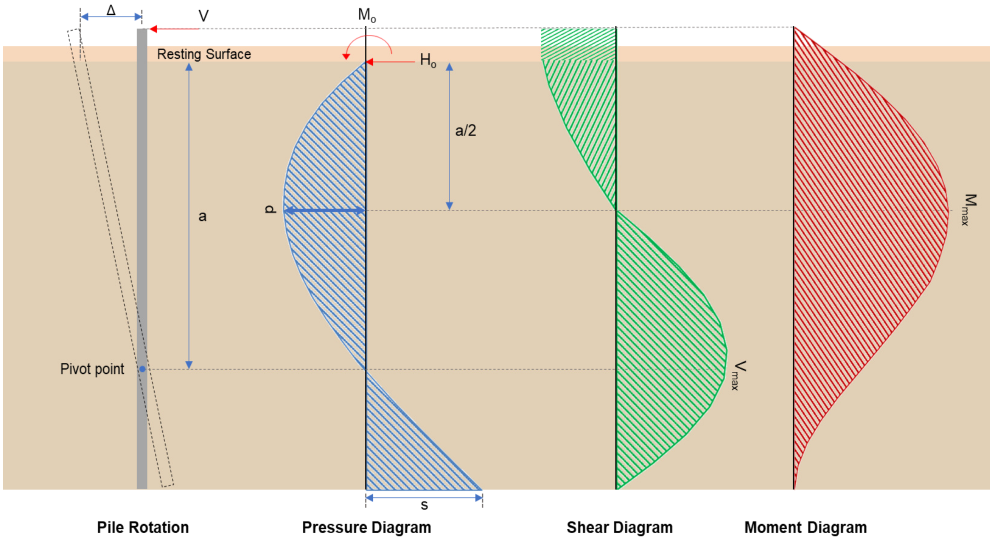
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.029965\ \text{kip/ft}^2)}{(0.675\ \text{kip/ft}^2)}$$

$$Ratio = 0.044393$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.176\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = -0.028025\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(26.15\ \text{kipft}) + ((-0.176\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 4.164\ \text{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(4.164\ \text{kipft/ft})}{(-0.028025\ \text{kip/ft})}$$

$$E = 148.58\ \text{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (4.164\ \text{kipft/ft}) \times (6.75\ \text{ft})) + \left(3 \times (-0.028025\ \text{kip/ft}) \times (6.75\ \text{ft})^2\right)}{\ldots}$$

$$a = \frac{}{(6 \times (4.164\ \text{kipft/ft})) + (4 \times (-0.028025\ \text{kip/ft}) \times (6.75\ \text{ft}))}$$

$$a = 4.5165\ \text{ft}$$

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

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

$$V_{max} = ((-0.028025\ \text{kip/ft}) \times (48\ \text{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (148.58\ \text{ft})}{(6.75\ \text{ft})} + 3\right) \times \left(\frac{(4.5165\ \text{ft})}{(6.75\ \text{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (148.58\ \text{ft})}{(6.75\ \text{ft})} + 2\right) \times \left(\frac{(4.5165\ \text{ft})}{(6.75\ \text{ft})}\right)^3\right]\right]$$

$$V_{max} = 4.4575\ \text{kip}$$

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

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

$$M_{max} = ((-0.028025\ \text{kip/ft}) \times (48\ \text{in}) \times (6.75\ \text{ft})) \times \left[\left(\frac{(148.58\ \text{ft})}{(6.75\ \text{ft})} + \frac{(4.5165\ \text{ft})}{2 \times (6.75\ \text{ft})}\right) - \left[\left(\frac{4 \times (148.58\ \text{ft})}{(6.75\ \text{ft})} + 3\right) \times \left(\frac{(4.5165\ \text{ft})}{2 \times (6.75\ \text{ft})}\right)^3\right] + \left[\left(\frac{3 \times (148.58\ \text{ft})}{(6.75\ \text{ft})} + 2\right) \times \left(\frac{(4.5165\ \text{ft})}{2 \times (6.75\ \text{ft})}\right)^4\right]\right]$$

$$M_{max} = 14.974\ \text{kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.183\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = 0.02914\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.507\ \text{kipft}) + ((0.183\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 0.080732\ \text{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.080732\ \text{kipft/ft})}{(0.02914\ \text{kip/ft})}$$

$$E = 2.7705\ \text{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.080732\ \text{kipft/ft}) \times (6.75\ \text{ft})) + \left(3 \times (0.02914\ \text{kip/ft}) \times (6.75\ \text{ft})^2\right)}{(6 \times (0.080732\ \text{kipft/ft})) + (4 \times (0.02914\ \text{kip/ft}) \times (6.75\ \text{ft}))}$$

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

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

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

$$V_{max} = ((0.02914\ \text{kip/ft}) \times (48\ \text{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (2.7705\ \text{ft})}{(6.75\ \text{ft})} + 3\right) \times \left(\frac{(4.8482\ \text{ft})}{(6.75\ \text{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (2.7705\ \text{ft})}{(6.75\ \text{ft})} + 2\right) \times \left(\frac{(4.8482\ \text{ft})}{(6.75\ \text{ft})}\right)^3\right]\right]$$

$$V_{max} = 0.16255\ \text{kip}$$

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

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

$$M_{max} = ((0.02914\ \text{kip/ft}) \times (48\ \text{in}) \times (6.75\ \text{ft})) \times \left[\left(\frac{(2.7705\ \text{ft})}{(6.75\ \text{ft})} + \frac{(4.8482\ \text{ft})}{2 \times (6.75\ \text{ft})}\right) - \left[\left(\frac{4 \times (2.7705\ \text{ft})}{(6.75\ \text{ft})} + 3\right) \times \left(\frac{(4.8482\ \text{ft})}{2 \times (6.75\ \text{ft})}\right)^3\right] + \left[\left(\frac{3 \times (2.7705\ \text{ft})}{(6.75\ \text{ft})} + 2\right) \times \left(\frac{(4.8482\ \text{ft})}{2 \times (6.75\ \text{ft})}\right)^4\right]\right]$$

$$M_{max} = 0.47862\ \text{kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

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

Longitudinal reinforcement:

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

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

$$A_{st,required} = Min\left[\frac{\frac{(12.752\ \text{kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5\ \text{ksi}) \times (2304\ \text{in}^2))}{(60\ \text{ksi}) - (0.85 \times (2.5\ \text{ksi}))}, (0.08 \times (2304\ \text{in}^2))\right]$$

$$A_{st,required} = -84.172\ \text{in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[(-84.172\ \text{in}^2), (0.0018 \times (2304\ \text{in}^2))\right]$$

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

n_{rebar} - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

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

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

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

$Ratio$ - Capacity

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

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

$$Ratio = 0.96556$$

Status: PASS
Ratio: 0.970

25.2.3 s_{rebar} - Minimum spacing of reinforcement,

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

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

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

Ties:

25.7.2.2 Since longitudinal reinforcement is $\leq$ No. 10⌀: Use #3(0.375 in)

25.7.2.1 s_{ties} - Maximum spacing of ties,

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

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

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

Summary:

Main reinforcement: **14 - #5 (0.625 in)**
Ties: **#3(0.375 in) - 10 in**

Axial Compression Strength (ACI 318-19, LRFD)

22.4.2.2 ϕP_N - Allowable axial compressive strength

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

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

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

$Ratio$ - Capacity

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

$$Ratio = \frac{(12.752\text{ kip})}{(2675.2\text{ kip})}$$

$$Ratio = 0.0047668$$

Status: PASS
Ratio: 0.000

Shear Strength (ACI 318-19, LRFD)

Parameters:

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

22.5.2.2 d - Effective depth

$$d = 0.80\, D$$

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

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

22.5.5.1.3 λ_s - size effect modification factor

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

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

$$\lambda_s = 0.64282$$

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

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

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

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

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

The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5\ \text{ksi} \rightarrow 2500\ \text{psi}$,$P = 12.752\ \text{kip} \rightarrow 12752\ \text{lbf}$,

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

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500\ \text{psi})} + \frac{(12752\ \text{lbf})}{6 \times (2304\ \text{in}^2)}\right] \times (48\ \text{in}) \times (38.4\ \text{in})$$

$$V_{c,a} = 120.19\ \text{kip}$$

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

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

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

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

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

V_c - Governing shear strength of concrete

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

$$V_c = Min\left[(296.21\ \text{kip}), (120.19\ \text{kip}), (348.89\ \text{kip})\right]$$

$$V_c = 120.19\ \text{kip}$$

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

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

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

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

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

A_v - Ties rebar area,

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

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

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

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

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

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

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

V_s - Governing shear strength of steel

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

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

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

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((120.19\ \text{kip}) + (50.894\ \text{kip}))$$

$$\phi V_n = 111.2\ \text{kip}$$

Considering x-direction:

$V_{max} = 4.4575\ \text{kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

	$$Ratio = \frac{(4.4575 \text{ kip})}{(111.2 \text{ kip})}$$ $$Ratio = 0.040085$$	Status: **PASS** Ratio: **0.040**
	Considering z-direction: $V_{max} = 0.16255 \text{ kip}$ - Maximum shear force in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{V_{max}}{\phi V_n}$$ $$Ratio = \frac{(0.16255 \text{ kip})}{(111.2 \text{ kip})}$$ $$Ratio = 0.0014618$$	Status: **PASS** Ratio: **0.000**
14.5.2.1b	**Flexural Strength (ACI 318-19, LRFD)** S_m - Section modulus $$S_m = \frac{b\,D^2}{6}$$ $$S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$$ $$S_m = 18432 \text{ in}^3$$ $\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$ $$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f'_c)} \times S_m$$ $$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5ksi)} \times 18432.001in^3$$ $$\phi M_{n,1} = 249.600kipft$$ $\phi M_{n,2}$ $$\phi M_{n,2} = \phi\, 0.85\, f'_{ck}\, S_m$$ $$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times \left(18432 \text{ in}^3\right)$$ $$\phi M_{n,2} = 2121.6 \text{ kipft}$$ Therefore, ϕM_n - Allowable flexural strength, $$\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$$ $$\phi M_n = MIN[(249.6 \text{ kipft}), (2121.6 \text{ kipft})]$$ $$\phi M_n = 249.6 \text{ kipft}$$ **Considering x-direction:** $M_{max} = 14.974 \text{ kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(14.974 \text{ kipft})}{(249.6 \text{ kipft})}$$ $$Ratio = 0.059993$$	Status: **PASS** Ratio: **0.060**
	Considering z-direction: $M_{max} = 0.47862 \text{ kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$	

	$$Ratio = \frac{(0.47862 \text{ kipft})}{(249.6 \text{ kipft})}$$ $$Ratio = 0.0019176$$	Status: **PASS** Ratio: **0.000**

REFERENCES	CALCULATIONS	RESULTS

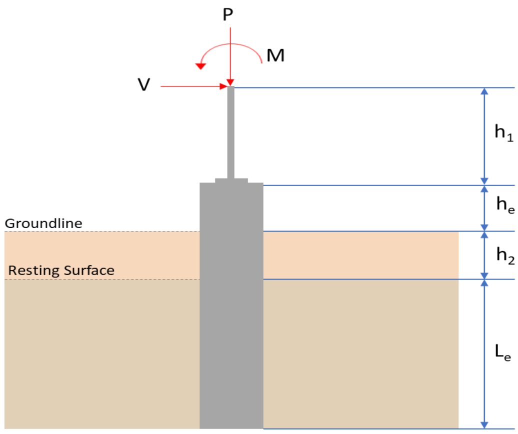
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: rectangular
$b = 48\ \text{in}$ - Pile width
$D = 48\ \text{in}$ - Pile depth
$L = 6.75\ \text{ft}$ - Total pile length
$h_1 = 0\ \text{ft}$ - Lateral load height from the top of the pile,
$h_2 = 0\ \text{ft}$ - Depth to resisting surface
$h_e = 0\ \text{ft}$ - 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	Clay, sandy clay, silty clay, clayey silt, silt and sandy silt	1500.000	100.000

Tabulation of Loads

Load Component	ASD	LRFD
P (kip)	8.236	12.752
V_x (kip)	-0.105	-0.176
V_z (kip)	-0.117	-0.184
M_x (kipft)	-0.326	-0.513
M_z (kipft)	15.411	26.151

Material Properties

$f'_{ck} = 2.5\ \text{ksi}$ - 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,

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

$$H_o = \frac{(-0.105\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = -0.01672\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(15.411 \text{ kipft}) + ((-0.105 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 2.454 \text{ kipft/ft}$$

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:
$L_{e,x} = 6.5776 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.117 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.018631 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.326 \text{ kipft}) + ((-0.117 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.051911 \text{ kipft/ft}$$

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:
$L_{e,z} = 1.5394 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(6.5776 \text{ ft}), (1.5394 \text{ ft})]$$

$$L_{e,req} = 6.578 \text{ ft}$$

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

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

$$Ratio = \frac{(6.578 \text{ ft})}{(6.75 \text{ ft})}$$

$$Ratio = 0.97452$$

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

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

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

$$q = \frac{(8.236 \text{ kip})}{(16 \text{ ft}^2)}$$

$$q = 0.51475 \text{ kip/ft}^2$$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{\left(0.51475 \text{ kip/ft}^2\right)}{(1500 \text{ psf})}$$

$$Ratio = 0.34317$$

Status: **PASS**
Ratio: **0.340**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

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

$$L/D = 1.6875$$

Since L/D $\leq$ 10,

Pile is short.

Considering x-direction:

$H_o = -0.01672 \text{ kip/ft}$ - Lateral force per length of pile,
$M_o = 2.454 \text{ kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (2.454 \text{ kipft/ft}) \times (6.75 \text{ ft})) + \left(3 \times (-0.01672 \text{ kip/ft}) \times (6.75 \text{ ft})^2\right)}{(6 \times (2.454 \text{ kipft/ft})) + (4 \times (-0.01672 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.5167 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (2.454 \text{ kipft/ft})) + (3 \times (-0.01672 \text{ kip/ft}) \times (6.75 \text{ ft}))]^2}{(6.75 \text{ ft})^2 \times [(3 \times (2.454 \text{ kipft/ft})) + (2 \times (-0.01672 \text{ kip/ft}) \times (6.75 \text{ ft}))]}$$

$$p = 0.20719 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (2.454 \text{ kipft/ft})) + ((-0.01672 \text{ kip/ft}) \times (6.75 \text{ ft}))]}{(6.75 \text{ ft})^2}$$

$$s = 0.63145 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (100 \text{ psf/ft}) \times \frac{(4.5167 \text{ ft})}{2}$$

$$p_a = 0.22584 \text{ kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.20719\ \text{kip/ft}^2\right)}{\left(0.22584\ \text{kip/ft}^2\right)}$$

$$Ratio = 0.91741$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\, L_e$$

$$p_s = (100\ \text{psf/ft}) \times (6.75\ \text{ft})$$

$$p_s = 0.675\ \text{kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.63145\ \text{kip/ft}^2\right)}{\left(0.675\ \text{kip/ft}^2\right)}$$

$$Ratio = 0.93549$$

Status: **PASS**
Ratio: **0.940**

Considering z-direction:

$H_o = -0.018631\ \text{kip/ft}$ - Lateral force per length of pile,
$M_o = 0.051911\ \text{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.051911\ \text{kipft/ft}) \times (6.75\ \text{ft})) + \left(3 \times (-0.018631\ \text{kip/ft}) \times (6.75\ \text{ft})^2\right)}{(6 \times (0.051911\ \text{kipft/ft})) + (4 \times (-0.018631\ \text{kip/ft}) \times (6.75\ \text{ft}))}$$

$$a = 4.8474\ \text{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.051911\ \text{kipft/ft})) + (3 \times (-0.018631\ \text{kip/ft}) \times (6.75\ \text{ft}))]^{\ 2}}{(6.75\ \text{ft})^2 \times [(3 \times (0.051911\ \text{kipft/ft})) + (2 \times (-0.018631\ \text{kip/ft}) \times (6.75\ \text{ft}))]}$$

$$p = -0.0049449\ \text{kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (0.051911\ \text{kipft/ft})) + ((-0.018631\ \text{kip/ft}) \times (6.75\ \text{ft}))]}{(6.75\ \text{ft})^2}$$

$$s = -0.0028885\ \text{kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (100\ \text{psf/ft}) \times \frac{(4.8474\ \text{ft})}{2}$$

$$p_a = 0.24237\ \text{kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(-0.0049449\ \text{kip/ft}^2\right)}{\left(0.24237\ \text{kip/ft}^2\right)}$$

$$Ratio = -0.020402$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (100\ \text{psf/ft}) \times (6.75\ \text{ft})$$

$$p_s = 0.675\ \text{kip/ft}^2$$

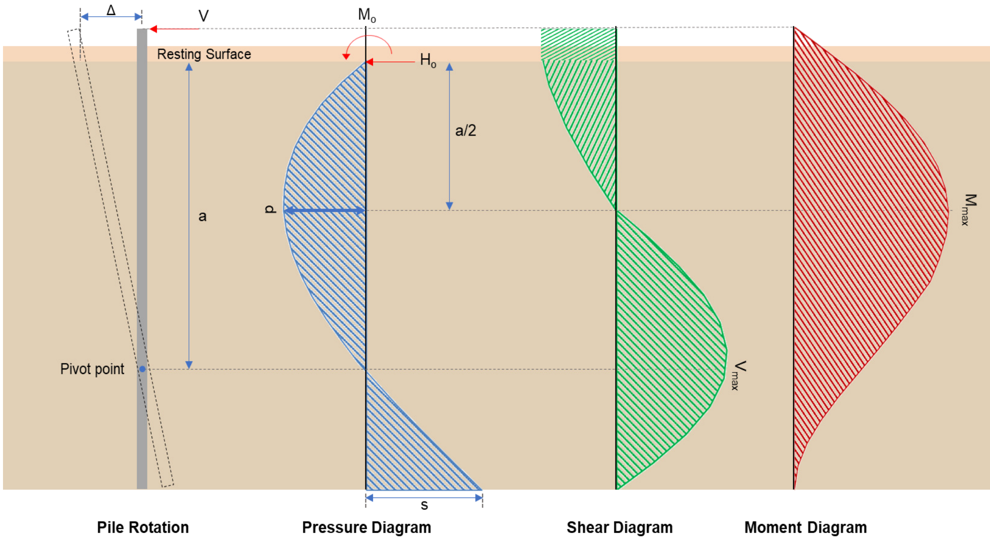
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(-0.0028885\ \text{kip/ft}^2\right)}{\left(0.675\ \text{kip/ft}^2\right)}$$

$$Ratio = -0.0042793$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.176\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = -0.028025\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(26.151\ \text{kipft}) + ((-0.176\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 4.1642\ \text{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(4.1642\ \text{kipft/ft})}{(-0.028025\ \text{kip/ft})}$$

$$E = 148.59\ \text{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (4.1642\ \text{kipft/ft}) \times (6.75\ \text{ft})) + \left(3 \times (-0.028025\ \text{kip/ft}) \times (6.75\ \text{ft})^2\right)}{}$$

$$a = \frac{}{(6 \times (4.1642\ \text{kipft/ft})) + (4 \times (-0.028025\ \text{kip/ft}) \times (6.75\ \text{ft}))}$$

$$a = 4.5165\ \text{ft}$$

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

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

$$V_{max} = ((-0.028025\ \text{kip/ft}) \times (48\ \text{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (148.59\ \text{ft})}{(6.75\ \text{ft})} + 3\right) \times \left(\frac{(4.5165\ \text{ft})}{(6.75\ \text{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (148.59\ \text{ft})}{(6.75\ \text{ft})} + 2\right) \times \left(\frac{(4.5165\ \text{ft})}{(6.75\ \text{ft})}\right)^3\right]\right]$$

$$V_{max} = 4.4577\ \text{kip}$$

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

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

$$M_{max} = ((-0.028025\ \text{kip/ft}) \times (48\ \text{in}) \times (6.75\ \text{ft})) \times \left[\left(\frac{(148.59\ \text{ft})}{(6.75\ \text{ft})} + \frac{(4.5165\ \text{ft})}{2 \times (6.75\ \text{ft})}\right) - \left[\left(\frac{4 \times (148.59\ \text{ft})}{(6.75\ \text{ft})} + 3\right) \times \left(\frac{(4.5165\ \text{ft})}{2 \times (6.75\ \text{ft})}\right)^3\right] + \left[\left(\frac{3 \times (148.59\ \text{ft})}{(6.75\ \text{ft})} + 2\right) \times \left(\frac{(4.5165\ \text{ft})}{2 \times (6.75\ \text{ft})}\right)^4\right]\right]$$

$$M_{max} = 14.975\ \text{kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.184\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = -0.0293\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.513\ \text{kipft}) + ((-0.184\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 0.081688\ \text{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.081688\ \text{kipft/ft})}{(-0.0293\ \text{kip/ft})}$$

$$E = 2.788\ \text{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.081688\ \text{kipft/ft}) \times (6.75\ \text{ft})) + \left(3 \times (-0.0293\ \text{kip/ft}) \times (6.75\ \text{ft})^2\right)}{(6 \times (0.081688\ \text{kipft/ft})) + (4 \times (-0.0293\ \text{kip/ft}) \times (6.75\ \text{ft}))}$$

$$a = 4.8473\ \text{ft}$$

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

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

$$V_{max} = ((-0.0293\ \text{kip/ft}) \times (48\ \text{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (2.788\ \text{ft})}{(6.75\ \text{ft})} + 3\right) \times \left(\frac{(4.8473\ \text{ft})}{(6.75\ \text{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (2.788\ \text{ft})}{(6.75\ \text{ft})} + 2\right) \times \left(\frac{(4.8473\ \text{ft})}{(6.75\ \text{ft})}\right)^3\right]\right]$$

$$V_{max} = 0.16397\ \text{kip}$$

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

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

$$M_{max} = ((-0.0293\ \text{kip/ft}) \times (48\ \text{in}) \times (6.75\ \text{ft})) \times \left[\left(\frac{(2.788\ \text{ft})}{(6.75\ \text{ft})} + \frac{(4.8473\ \text{ft})}{2 \times (6.75\ \text{ft})}\right) - \left[\left(\frac{4 \times (2.788\ \text{ft})}{(6.75\ \text{ft})} + 3\right) \times \left(\frac{(4.8473\ \text{ft})}{2 \times (6.75\ \text{ft})}\right)^3\right] + \left[\left(\frac{3 \times (2.788\ \text{ft})}{(6.75\ \text{ft})} + 2\right) \times \left(\frac{(4.8473\ \text{ft})}{2 \times (6.75\ \text{ft})}\right)^4\right]\right]$$

$$M_{max} = 0.48302\ \text{kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

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

Longitudinal reinforcement:

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

22.4.2.2, 10.6.1.1 $A_{st,required}$

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

$$A_{st,required} = Min\left[\frac{\frac{(12.752\ \text{kip})}{(0.65)\times(0.8)} - (0.85 \times (2.5\ \text{ksi}) \times (2304\ \text{in}^2))}{(60\ \text{ksi}) - (0.85 \times (2.5\ \text{ksi}))}, (0.08 \times (2304\ \text{in}^2))\right]$$

$$A_{st,required} = -84.172\ \text{in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max[(-84.172\ \text{in}^2), (0.0018 \times (2304\ \text{in}^2))]$$

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

n_{rebar} - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

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

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

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

$Ratio$ - Capacity

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

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

$$Ratio = 0.96556$$

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. 10⌀: 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

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

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

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

$Ratio$ - Capacity

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

$$Ratio = \frac{(12.752\ \text{kip})}{(2675.2\ \text{kip})}$$

$$Ratio = 0.0047668$$

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

Shear Strength (ACI 318-19, LRFD)

Parameters:

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

22.5.2.2 d - Effective depth

$$d = 0.80\ D$$

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

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

22.5.5.1.3 λ_s - size effect modification factor

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

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

$$\lambda_s = 0.64282$$

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

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

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

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

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

The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5\ \text{ksi} \rightarrow 2500\ \text{psi}$, $P = 12.752\ \text{kip} \rightarrow 12752\ \text{lbf}$,

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

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500\ \text{psi})} + \frac{(12752\ \text{lbf})}{6 \times (2304\ \text{in}^2)}\right] \times (48\ \text{in}) \times (38.4\ \text{in})$$

$$V_{c,a} = 120.19\ \text{kip}$$

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

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

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

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

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

V_c - Governing shear strength of concrete

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

$$V_c = Min\left[(296.21\ \text{kip}), (120.19\ \text{kip}), (348.89\ \text{kip})\right]$$

$$V_c = 120.19\ \text{kip}$$

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

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

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

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

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

A_v - Ties rebar area,

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

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

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

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

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

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

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

V_s - Governing shear strength of steel

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

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

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

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((120.19\ \text{kip}) + (50.894\ \text{kip}))$$

$$\phi V_n = 111.2\ \text{kip}$$

Considering x-direction:

$V_{max} = 4.4577\ \text{kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(4.4577 \text{ kip})}{(111.2 \text{ kip})}$$

$$Ratio = 0.040087$$

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

Considering z-direction:

$V_{max} = 0.16397 \text{ kip}$ - Maximum shear force in the z-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(0.16397 \text{ kip})}{(111.2 \text{ kip})}$$

$$Ratio = 0.0014746$$

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

Flexural Strength (ACI 318-19, LRFD)

S_m - Section modulus

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

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

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

$\lambda = 1$ - Concrete modification factor (Normal concrete),
Allowable flexural strength:
M_n shall be the lesser of:
$\phi M_{n,1}$

$$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f_c')} \times S_m$$

$$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5ksi)} \times 18432.001in^3$$

$$\phi M_{n,1} = 249.600kipft$$

14.5.2.1b $\phi M_{n,2}$

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

$$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times \left(18432 \text{ in}^3\right)$$

$$\phi M_{n,2} = 2121.6 \text{ kipft}$$

Therefore,
ϕM_n - Allowable flexural strength,

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

$$\phi M_n = MIN[(249.6 \text{ kipft}), (2121.6 \text{ kipft})]$$

$$\phi M_n = 249.6 \text{ kipft}$$

Considering x-direction:

$M_{max} = 14.975 \text{ kipft}$ - Maximum moment in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(14.975 \text{ kipft})}{(249.6 \text{ kipft})}$$

$$Ratio = 0.059995$$

Status: **PASS**
Ratio: **0.060**

Considering z-direction:

$M_{max} = 0.48302 \text{ kipft}$ - Maximum moment in the z-direction,
$Ratio$ - Capacity

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

	$$Ratio = \frac{(0.48302\ \text{kipft})}{(249.6\ \text{kipft})}$$ $$Ratio = 0.0019352$$	Status: **PASS** Ratio: **0.000**

REFERENCES	CALCULATIONS	RESULTS

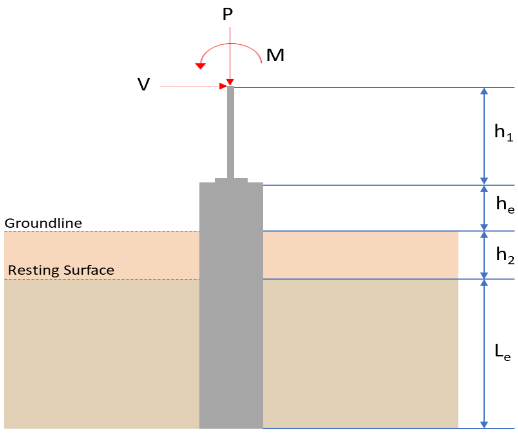
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: rectangular
$b = 48\ \text{in}$ - Pile width
$D = 48\ \text{in}$ - Pile depth
$L = 7\ \text{ft}$ - Total pile length
$h_1 = 0\ \text{ft}$ - Lateral load height from the top of the pile,
$h_2 = 0\ \text{ft}$ - Depth to resisting surface
$h_e = 0\ \text{ft}$ - 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	Clay, sandy clay, silty clay, clayey silt, silt and sandy silt	1500.000	100.000

Tabulation of Loads

Load Component	ASD	LRFD
P (kip)	9.487	14.715
V_x (kip)	-0.137	-0.230
V_z (kip)	-0.023	-0.036
M_x (kipft)	-0.064	-0.102
M_z (kipft)	16.630	28.252

Material Properties

$f'_{ck} = 2.5\ \text{ksi}$ - 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,

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

$$H_o = \frac{(-0.137\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = -0.021815\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(16.63\ \text{kipft}) + ((-0.137\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 2.6481\ \text{kipft/ft}$$

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:
$L_{e,x} = 6.7281\ \text{ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

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

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

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.064\ \text{kipft}) + ((-0.023\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 0.010191\ \text{kipft/ft}$$

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:
$L_{e,z} = 0.96701\ \text{ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(6.7281\ \text{ft}), (0.96701\ \text{ft})]$$

$$L_{e,req} = 6.728\ \text{ft}$$

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

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

$$Ratio = \frac{(6.728\ \text{ft})}{(7\ \text{ft})}$$

$$Ratio = 0.96114$$

Status: **PASS**
Ratio: **0.960**

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

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

$$q = \frac{(9.487\ \text{kip})}{(16\ \text{ft}^2)}$$

$$q = 0.59294\ \text{kip/ft}^2$$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{\left(0.59294\ \text{kip/ft}^2\right)}{(1500\ \text{psf})}$$

$$Ratio = 0.39529$$

Status: **PASS**
Ratio: **0.400**

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:

$H_o = -0.021815\ \text{kip/ft}$ - Lateral force per length of pile,
$M_o = 2.6481\ \text{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (2.6481\ \text{kipft/ft}) \times (7\ \text{ft})) + \left(3 \times (-0.021815\ \text{kip/ft}) \times (7\ \text{ft})^2\right)}{(6 \times (2.6481\ \text{kipft/ft})) + (4 \times (-0.021815\ \text{kip/ft}) \times (7\ \text{ft}))}$$

$$a = 4.6883\ \text{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (2.6481\ \text{kipft/ft})) + (3 \times (-0.021815\ \text{kip/ft}) \times (7\ \text{ft}))]^{2}}{(7\ \text{ft})^2 \times [(3 \times (2.6481\ \text{kipft/ft})) + (2 \times (-0.021815\ \text{kip/ft}) \times (7\ \text{ft}))]}$$

$$p = 0.20579\ \text{kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (2.6481\ \text{kipft/ft})) + ((-0.021815\ \text{kip/ft}) \times (7\ \text{ft}))]}{(7\ \text{ft})^2}$$

$$s = 0.62981\ \text{kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (100\ \text{psf/ft}) \times \frac{(4.6883\ \text{ft})}{2}$$

$$p_a = 0.23441\ \text{kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.20579 \text{ kip/ft}^2\right)}{\left(0.23441 \text{ kip/ft}^2\right)}$$

$$Ratio = 0.87788$$

Status: **PASS**
Ratio: **0.880**

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\, L_e$$

$$p_s = (100 \text{ psf/ft}) \times (7 \text{ ft})$$

$$p_s = 0.7 \text{ kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.62981 \text{ kip/ft}^2\right)}{\left(0.7 \text{ kip/ft}^2\right)}$$

$$Ratio = 0.89973$$

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

Considering z-direction:

$H_o = -0.0036624 \text{ kip/ft}$ - Lateral force per length of pile,
$M_o = 0.010191 \text{ kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.010191 \text{ kipft/ft}) \times (7 \text{ ft})) + \left(3 \times (-0.0036624 \text{ kip/ft}) \times (7 \text{ ft})^2\right)}{(6 \times (0.010191 \text{ kipft/ft})) + (4 \times (-0.0036624 \text{ kip/ft}) \times (7 \text{ ft}))}$$

$$a = 5.0321 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.010191 \text{ kipft/ft})) + (3 \times (-0.0036624 \text{ kip/ft}) \times (7 \text{ ft}))]^2}{(7 \text{ ft})^2 \times [(3 \times (0.010191 \text{ kipft/ft})) + (2 \times (-0.0036624 \text{ kip/ft}) \times (7 \text{ ft}))]}$$

$$p = -0.00096608 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (0.010191 \text{ kipft/ft})) + ((-0.0036624 \text{ kip/ft}) \times (7 \text{ ft}))]}{(7 \text{ ft})^2}$$

$$s = -0.00064344 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (100 \text{ psf/ft}) \times \frac{(5.0321 \text{ ft})}{2}$$

$$p_a = 0.25161 \text{ kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(-0.00096608 \text{ kip/ft}^2\right)}{\left(0.25161 \text{ kip/ft}^2\right)}$$

$$Ratio = -0.0038397$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (100\ \mathrm{psf/ft}) \times (7\ \mathrm{ft})$$

$$p_s = 0.7\ \mathrm{kip/ft^2}$$

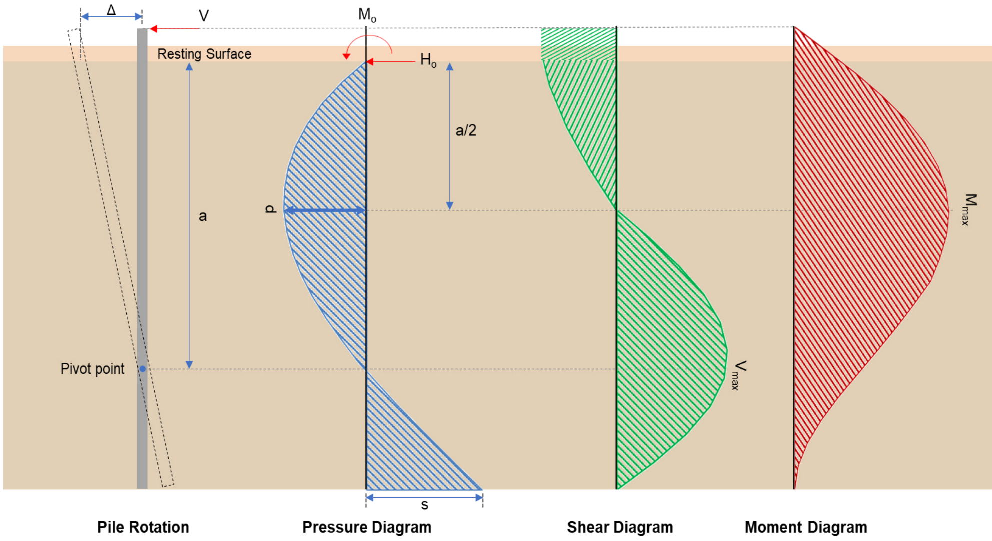
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(-0.00064344\ \mathrm{kip/ft^2})}{(0.7\ \mathrm{kip/ft^2})}$$

$$Ratio = -0.0009192$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.23\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.036624\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(28.252\ \mathrm{kipft}) + ((-0.23\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 4.4987\ \mathrm{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(4.4987\ \mathrm{kipft/ft})}{(-0.036624\ \mathrm{kip/ft})}$$

$$E = 122.83\ \mathrm{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (4.4987\ \mathrm{kipft/ft}) \times (7\ \mathrm{ft})) + \left(3 \times (-0.036624\ \mathrm{kip/ft}) \times (7\ \mathrm{ft})^2\right)}{}$$

$$a = \frac{}{(6 \times (4.4987\ \text{kipft/ft})) + (4 \times (-0.036624\ \text{kip/ft}) \times (7\ \text{ft}))}$$

$$a = 4.688\ \text{ft}$$

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

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

$$V_{max} = ((-0.036624\ \text{kip/ft}) \times (48\ \text{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (122.83\ \text{ft})}{(7\ \text{ft})} + 3\right) \times \left(\frac{(4.688\ \text{ft})}{(7\ \text{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (122.83\ \text{ft})}{(7\ \text{ft})} + 2\right) \times \left(\frac{(4.688\ \text{ft})}{(7\ \text{ft})}\right)^3\right]\right]$$

$$V_{max} = 4.6627\ \text{kip}$$

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

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

$$M_{max} = ((-0.036624\ \text{kip/ft}) \times (48\ \text{in}) \times (7\ \text{ft})) \times \left[\left(\frac{(122.83\ \text{ft})}{(7\ \text{ft})} + \frac{(4.688\ \text{ft})}{2 \times (7\ \text{ft})}\right) - \left[\left(\frac{4 \times (122.83\ \text{ft})}{(7\ \text{ft})} + 3\right) \times \left(\frac{(4.688\ \text{ft})}{2 \times (7\ \text{ft})}\right)^3\right] + \left[\left(\frac{3 \times (122.83\ \text{ft})}{(7\ \text{ft})} + 2\right) \times \left(\frac{(4.688\ \text{ft})}{2 \times (7\ \text{ft})}\right)^4\right]\right]$$

$$M_{max} = 16.225\ \text{kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.036\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = -0.0057325\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.102\ \text{kipft}) + ((-0.036\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 0.016242\ \text{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.016242\ \text{kipft/ft})}{(-0.0057325\ \text{kip/ft})}$$

$$E = 2.8333\ \text{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.016242\ \text{kipft/ft}) \times (7\ \text{ft})) + \left(3 \times (-0.0057325\ \text{kip/ft}) \times (7\ \text{ft})^2\right)}{(6 \times (0.016242\ \text{kipft/ft})) + (4 \times (-0.0057325\ \text{kip/ft}) \times (7\ \text{ft}))}$$

$$a = 5.0296\ \text{ft}$$

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

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

$$V_{max} = ((-0.0057325\ \text{kip/ft}) \times (48\ \text{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (2.8333\ \text{ft})}{(7\ \text{ft})} + 3\right) \times \left(\frac{(5.0296\ \text{ft})}{(7\ \text{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (2.8333\ \text{ft})}{(7\ \text{ft})} + 2\right) \times \left(\frac{(5.0296\ \text{ft})}{(7\ \text{ft})}\right)^3\right]\right]$$

$$V_{max} = 0.03175\ \text{kip}$$

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

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

$$M_{max} = ((-0.0057325\ \text{kip/ft}) \times (48\ \text{in}) \times (7\ \text{ft})) \times \left[\left(\frac{(2.8333\ \text{ft})}{(7\ \text{ft})} + \frac{(5.0296\ \text{ft})}{2 \times (7\ \text{ft})}\right) - \left[\left(\frac{4 \times (2.8333\ \text{ft})}{(7\ \text{ft})} + 3\right) \times \left(\frac{(5.0296\ \text{ft})}{2 \times (7\ \text{ft})}\right)^3\right] + \left[\left(\frac{3 \times (2.8333\ \text{ft})}{(7\ \text{ft})} + 2\right) \times \left(\frac{(5.0296\ \text{ft})}{2 \times (7\ \text{ft})}\right)^4\right]\right]$$

$$M_{max} = 0.096849\ \text{kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

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

Longitudinal reinforcement:

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

22.4.2.2, 10.6.1.1 $A_{st,required}$

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

$$A_{st,required} = Min\left[\frac{\frac{(14.715\ \text{kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5\ \text{ksi}) \times (2304\ \text{in}^2))}{(60\ \text{ksi}) - (0.85 \times (2.5\ \text{ksi}))}, (0.08 \times (2304\ \text{in}^2))\right]$$

$$A_{st,required} = -84.107\ \text{in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[(-84.107\ \text{in}^2), (0.0018 \times (2304\ \text{in}^2))\right]$$

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

n_{rebar} - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

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

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

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

$Ratio$ - Capacity

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

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

$$Ratio = 0.96556$$

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

25.2.3 s_{rebar} - Minimum spacing of reinforcement,

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

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

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

Ties:

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

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

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

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

Summary:

Main reinforcement: **14 - #5 (0.625 in)**
Ties: **#3(0.375 in) - 10 in**

Axial Compression Strength (ACI 318-19, LRFD)

22.4.2.2 ϕP_N - Allowable axial compressive strength

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

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

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

$Ratio$ - Capacity

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

$$Ratio = \frac{(14.715\ \text{kip})}{(2675.2\ \text{kip})}$$

$$Ratio = 0.0055006$$

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

Shear Strength (ACI 318-19, LRFD)

Parameters:

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

$$d = 0.80\, D$$

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

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

22.5.5.1.3 λ_s - size effect modification factor

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

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

$$\lambda_s = 0.64282$$

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

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

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

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

The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5\ \text{ksi} \rightarrow 2500\ \text{psi}$, $P = 14.715\ \text{kip} \rightarrow 14715\ \text{lbf}$,

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

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500\ \text{psi})} + \frac{(14715\ \text{lbf})}{6 \times (2304\ \text{in}^2)}\right] \times (48\ \text{in}) \times (38.4\ \text{in})$$

$$V_{c,a} = 120.45\ \text{kip}$$

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

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

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

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

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

V_c - Governing shear strength of concrete

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

$$V_c = Min\left[(296.21\ \text{kip}), (120.45\ \text{kip}), (348.89\ \text{kip})\right]$$

$$V_c = 120.45\ \text{kip}$$

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

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

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

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

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

A_v - Ties rebar area,

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

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

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

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

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

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

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

V_s - Governing shear strength of steel

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

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

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

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((120.45\ \text{kip}) + (50.894\ \text{kip}))$$

$$\phi V_n = 111.37\ \text{kip}$$

Considering x-direction:

$V_{max} = 4.6627\ \text{kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

	$$Ratio = \frac{(4.6627\ \text{kip})}{(111.37\ \text{kip})}$$ $$Ratio = 0.041866$$	Status: **PASS** Ratio: **0.040**
	Considering z-direction: $V_{max} = 0.03175\ \text{kip}$ - Maximum shear force in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{V_{max}}{\phi V_n}$$ $$Ratio = \frac{(0.03175\ \text{kip})}{(111.37\ \text{kip})}$$ $$Ratio = 0.00028508$$	Status: **PASS** Ratio: **0.000**
14.5.2.1b	**Flexural Strength (ACI 318-19, LRFD)** S_m - Section modulus $$S_m = \frac{b\,D^2}{6}$$ $$S_m = \frac{(48\ \text{in}) \times (48\ \text{in})^2}{6}$$ $$S_m = 18432\ \text{in}^3$$ $\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$ $$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f_c')} \times S_m$$ $$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 ksi)} \times 18432.001 in^3$$ $$\phi M_{n,1} = 249.600 kipft$$ $\phi M_{n,2}$ $$\phi M_{n,2} = \phi\ 0.85\ f_{ck}'\ S_m$$ $$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5\ \text{ksi}) \times \left(18432\ \text{in}^3\right)$$ $$\phi M_{n,2} = 2121.6\ \text{kipft}$$ Therefore, ϕM_n - Allowable flexural strength, $$\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$$ $$\phi M_n = MIN[(249.6\ \text{kipft}), (2121.6\ \text{kipft})]$$ $$\phi M_n = 249.6\ \text{kipft}$$ **Considering x-direction:** $M_{max} = 16.225\ \text{kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(16.225\ \text{kipft})}{(249.6\ \text{kipft})}$$ $$Ratio = 0.065003$$	Status: **PASS** Ratio: **0.070**
	Considering z-direction: $M_{max} = 0.096849\ \text{kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$	

	$$Ratio = \frac{(0.096849\ \text{kipft})}{(249.6\ \text{kipft})}$$ $$Ratio = 0.00038802$$	Status: **PASS** Ratio: **0.000**

REFERENCES	CALCULATIONS	RESULTS

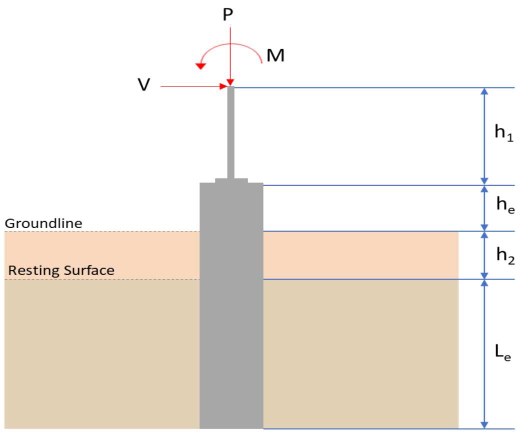
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: rectangular
$b = 48\ \text{in}$ - Pile width
$D = 48\ \text{in}$ - Pile depth
$L = 7\ \text{ft}$ - Total pile length
$h_1 = 0\ \text{ft}$ - Lateral load height from the top of the pile,
$h_2 = 0\ \text{ft}$ - Depth to resisting surface
$h_e = 0\ \text{ft}$ - 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	Clay, sandy clay, silty clay, clayey silt, silt and sandy silt	1500.000	100.000

Tabulation of Loads

Load Component	ASD	LRFD
$P\ (\text{kip})$	9.435	14.634
$V_x\ (\text{kip})$	-0.134	-0.223
$V_z\ (\text{kip})$	0.000	0.000
$M_x\ (\text{kipft})$	-0.002	-0.002
$M_z\ (\text{kipft})$	17.005	28.894

Material Properties

$f'_{ck} = 2.5\ \text{ksi}$ - 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,

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

$$H_o = \frac{(-0.134\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = -0.021338\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(17.005 \text{ kipft}) + ((-0.134 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 2.7078 \text{ kipft/ft}$$

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:
$L_{e,x} = 6.7818 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.002 \text{ kipft}) + ((0 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.00031847 \text{ kipft/ft}$$

L_e - Required depth of embedment in earth,

$$L_e = 2.29 \sqrt[3]{\frac{M_o}{R}}$$

$$L_e = 2.29 \times \sqrt[3]{\frac{(0.00031847 \text{ kipft/ft})}{(100 \text{ psf/ft})}}$$

$$L_e = 0.33692 \text{ ft}$$

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(6.7818 \text{ ft}), (0.33692 \text{ ft})]$$

$$L_{e,req} = 6.782 \text{ ft}$$

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

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

$$Ratio = \frac{(6.782 \text{ ft})}{(7 \text{ ft})}$$

$$Ratio = 0.96886$$

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

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

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

$$q = \frac{(9.435 \text{ kip})}{(16 \text{ ft}^2)}$$

$$q = 0.58969 \text{ kip/ft}^2$$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{(0.58969 \text{ kip/ft}^2)}{(1500 \text{ psf})}$$

$$Ratio = 0.39312$$

Status: **PASS**
Ratio: **0.390**

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:

$H_o = -0.021338 \text{ kip/ft}$ - Lateral force per length of pile,
$M_o = 2.7078 \text{ kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (2.7078 \text{ kipft/ft}) \times (7 \text{ ft})) + \left(3 \times (-0.021338 \text{ kip/ft}) \times (7 \text{ ft})^2\right)}{(6 \times (2.7078 \text{ kipft/ft})) + (4 \times (-0.021338 \text{ kip/ft}) \times (7 \text{ ft}))}$$

$$a = 4.6874 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (2.7078 \text{ kipft/ft})) + (3 \times (-0.021338 \text{ kip/ft}) \times (7 \text{ ft}))]^2}{(7 \text{ ft})^2 \times [(3 \times (2.7078 \text{ kipft/ft})) + (2 \times (-0.021338 \text{ kip/ft}) \times (7 \text{ ft}))]}$$

$$p = 0.21089 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (2.7078 \text{ kipft/ft})) + ((-0.021338 \text{ kip/ft}) \times (7 \text{ ft}))]}{(7 \text{ ft})^2}$$

$$s = 0.64485 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (100 \text{ psf/ft}) \times \frac{(4.6874 \text{ ft})}{2}$$

$$p_a = 0.23437 \text{ kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.21089 \text{ kip/ft}^2)}{(0.23437 \text{ kip/ft}^2)}$$

$$Ratio = 0.89982$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\, L_e$$

$$p_s = (100 \text{ psf/ft}) \times (7 \text{ ft})$$

$$p_s = 0.7 \text{ kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.64485 \text{ kip/ft}^2)}{(0.7 \text{ kip/ft}^2)}$$

$$Ratio = 0.92121$$

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

Considering z-direction:

$H_o = 0 \text{ kip/ft}$ - Lateral force per length of pile,
$M_o = 0.00031847 \text{ kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.00031847 \text{ kipft/ft}) \times (7 \text{ ft})) + \left(3 \times (0 \text{ kip/ft}) \times (7 \text{ ft})^2\right)}{(6 \times (0.00031847 \text{ kipft/ft})) + (4 \times (0 \text{ kip/ft}) \times (7 \text{ ft}))}$$

$$a = 4.6667 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.00031847 \text{ kipft/ft})) + (3 \times (0 \text{ kip/ft}) \times (7 \text{ ft}))]^2}{(7 \text{ ft})^2 \times [(3 \times (0.00031847 \text{ kipft/ft})) + (2 \times (0 \text{ kip/ft}) \times (7 \text{ ft}))]}$$

$$p = 0.000025998 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (0.00031847 \text{ kipft/ft})) + ((0 \text{ kip/ft}) \times (7 \text{ ft}))]}{(7 \text{ ft})^2}$$

$$s = 0.000077993 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (100 \text{ psf/ft}) \times \frac{(4.6667 \text{ ft})}{2}$$

$$p_a = 0.23333 \text{ kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.000025998\ \mathrm{kip/ft^2})}{(0.23333\ \mathrm{kip/ft^2})}$$

$$Ratio = 0.00011142$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (100\ \mathrm{psf/ft}) \times (7\ \mathrm{ft})$$

$$p_s = 0.7\ \mathrm{kip/ft^2}$$

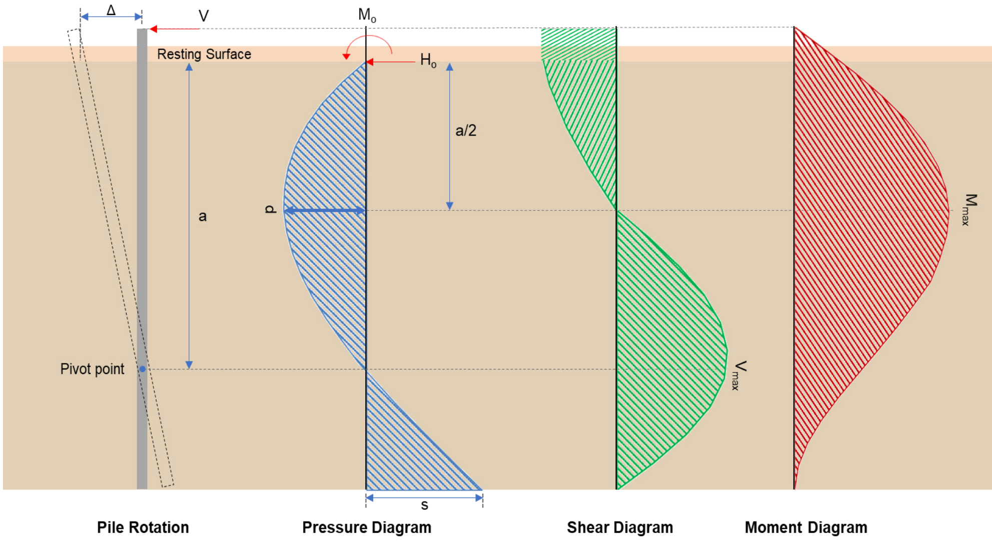
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.000077993\ \mathrm{kip/ft^2})}{(0.7\ \mathrm{kip/ft^2})}$$

$$Ratio = 0.00011142$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.223\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.03551\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(28.894\ \mathrm{kipft}) + ((-0.223\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 4.601\ \mathrm{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(4.601\ \mathrm{kipft/ft})}{(-0.03551\ \mathrm{kip/ft})}$$

$$E = 129.57\ \mathrm{ft}$$

a - Distance from resting surface to pivot point,

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

$$(6\,M_o) + (4\,H_o\,L_e)$$

$$a = \frac{(4 \times (4.601\ \text{kipft/ft}) \times (7\ \text{ft})) + \left(3 \times (-0.03551\ \text{kip/ft}) \times (7\ \text{ft})^2\right)}{(6 \times (4.601\ \text{kipft/ft})) + (4 \times (-0.03551\ \text{kip/ft}) \times (7\ \text{ft}))}$$

$$a = 4.6869\ \text{ft}$$

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

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

$$V_{max} = ((-0.03551\ \text{kip/ft}) \times (48\ \text{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (129.57\ \text{ft})}{(7\ \text{ft})} + 3\right) \times \left(\frac{(4.6869\ \text{ft})}{(7\ \text{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (129.57\ \text{ft})}{(7\ \text{ft})} + 2\right) \times \left(\frac{(4.6869\ \text{ft})}{(7\ \text{ft})}\right)^3\right]\right]$$

$$V_{max} = 4.7637\ \text{kip}$$

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

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

$$M_{max} = ((-0.03551\ \text{kip/ft}) \times (48\ \text{in}) \times (7\ \text{ft})) \times \left[\left(\frac{(129.57\ \text{ft})}{(7\ \text{ft})} + \frac{(4.6869\ \text{ft})}{2 \times (7\ \text{ft})}\right) - \left[\left(\frac{4 \times (129.57\ \text{ft})}{(7\ \text{ft})} + 3\right) \times \left(\frac{(4.6869\ \text{ft})}{2 \times (7\ \text{ft})}\right)^3\right] + \left[\left(\frac{3 \times (129.57\ \text{ft})}{(7\ \text{ft})} + 2\right) \times \left(\frac{(4.6869\ \text{ft})}{2 \times (7\ \text{ft})}\right)^4\right]\right]$$

$$M_{max} = 16.581\ \text{kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = 0\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.002\ \text{kipft}) + ((0\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 0.00031847\ \text{kipft/ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.00031847\ \text{kipft/ft}) \times (7\ \text{ft})) + \left(3 \times (0\ \text{kip/ft}) \times (7\ \text{ft})^2\right)}{(6 \times (0.00031847\ \text{kipft/ft})) + (4 \times (0\ \text{kip/ft}) \times (7\ \text{ft}))}$$

$$a = 4.6667\ \text{ft}$$

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

$$V_{max} = 12\left(\frac{M_o\,b}{L_e}\right)\left(\frac{a}{L_e} - 1\right)\left(\frac{a}{L_e}\right)^2$$

$$V_{max} = 12 \times \left(\frac{(0.00031847\ \text{kipft/ft}) \times (48\ \text{in})}{(7\ \text{ft})}\right) \times \left(\frac{(4.6667\ \text{ft})}{(7\ \text{ft})} - 1\right) \times \left(\frac{(4.6667\ \text{ft})}{(7\ \text{ft})}\right)^2$$

$$V_{max} = 0.00032353\ \text{kip}$$

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

$$M_{max} = (M_o\ b)\left[1-\left(4\ \frac{\ }{2\ L_e}\right)+\left(3\ \frac{\ }{2\ L_e}\right)\right]$$

$$M_{max} = ((0.00031847\ \text{kipft/ft}) \times (48\ \text{in})) \times \left[1-\left(4 \times \frac{(4.6667\ \text{ft})}{2 \times (7\ \text{ft})}^{3}\right)+\left(3 \times \frac{(4.6667\ \text{ft})}{2 \times (7\ \text{ft})}^{4}\right)\right]$$

$$M_{max} = 0.0011323\ \text{kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

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

Longitudinal reinforcement:

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

22.4.2.2, 10.6.1.1 $A_{st,required}$

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

$$A_{st,required} = Min\left[\frac{\frac{(14.634\ \text{kip})}{(0.65)\times(0.8)}-(0.85 \times (2.5\ \text{ksi}) \times (2304\ \text{in}^2))}{(60\ \text{ksi})-(0.85 \times (2.5\ \text{ksi}))}, (0.08 \times (2304\ \text{in}^2))\right]$$

$$A_{st,required} = -84.11\ \text{in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[(-84.11\ \text{in}^2), (0.0018 \times (2304\ \text{in}^2))\right]$$

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

n_{rebar} - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

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

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

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

$Ratio$ - Capacity

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

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

$$Ratio = 0.96556$$

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

25.2.3 s_{rebar} - Minimum spacing of reinforcement,

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

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

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

Ties:

25.7.2.2 Since longitudinal reinforcement is $\leq$ No. 10⌀: 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 $$\phi P_N = \phi\, 0.80\, \left[\left(0.85\, f'_{ck}\, [A_g - A_{st}]\right) + (f_{yk}\, A_{st})\right]$$ $$\phi P_N = (0.65) \times 0.80 \times \left[\left(0.85 \times (2.5\ \text{ksi}) \times \left[\left(2304\ \text{in}^2\right) - \left(4.2951\ \text{in}^2\right)\right]\right) + \left((60\ \text{ksi}) \times \left(4.2951\ \text{in}^2\right)\right)\right]$$ $$\phi P_N = 2675.2\ \text{kip}$$ $Ratio$ - Capacity $$Ratio = \frac{P}{\phi P_N}$$ $$Ratio = \frac{(14.634\ \text{kip})}{(2675.2\ \text{kip})}$$ $$Ratio = 0.0054703$$	Status: **PASS** Ratio: **0.010**
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 $f'_{ck} = 2.5\ \text{ksi} \rightarrow 2500\ \text{psi}$, $V_{c,max}$ - Max shear strength of concrete $$V_{c,max} = 5\, \lambda_s\, \sqrt{f'_{ck}}\, b_w\, d$$ $$V_{c,max} = 5 \times (0.64282) \times \sqrt{(2500\ \text{psi})} \times (48\ \text{in}) \times (38.4\ \text{in})$$ $$V_{c,max} = 296.21\ \text{kip}$$ The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5\ \text{ksi} \rightarrow 2500\ \text{psi}, P = 14.634\ \text{kip} \rightarrow 14634\ \text{lbf}$, $V_{c,a}$ - Shear strength of concrete (a) $$V_{c,a} = \left[2\, \lambda_s\, \sqrt{f'_{ck}} + \frac{P}{6\, A_g}\right]\, b_w\, d$$ $$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500\ \text{psi})} + \frac{(14634\ \text{lbf})}{6 \times (2304\ \text{in}^2)}\right] \times (48\ \text{in}) \times (38.4\ \text{in})$$ $$V_{c,a} = 120.44\ \text{kip}$$ The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5\ \text{ksi} \rightarrow 2500\ \text{psi}$, $V_{c,b}$ - Shear strength of concrete (b) $$V_{c,b} = \left[2\, \lambda_s\, \sqrt{f'_{ck}} + \left(0.05\, f'_{ck}\right)\right]\, b_w\, d$$	

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

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

V_c - Governing shear strength of concrete

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

$$V_c = Min\left[(296.21\ \text{kip}), (120.44\ \text{kip}), (348.89\ \text{kip})\right]$$

$$V_c = 120.44\ \text{kip}$$

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

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

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

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

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

A_v - Ties rebar area,

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

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

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

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

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

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

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

V_s - Governing shear strength of steel

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

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

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

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((120.44\ \text{kip}) + (50.894\ \text{kip}))$$

$$\phi V_n = 111.36\ \text{kip}$$

Considering x-direction:

$V_{max} = 4.7637\ \text{kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(4.7637\ \text{kip})}{(111.36\ \text{kip})}$$

$$Ratio = 0.042776$$

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

Flexural Strength (ACI 318-19, LRFD)

S_m - Section modulus

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

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

	$$S_m = 18432 \text{ in}^3$$ $\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$ $$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f'_c)} \times S_m$$ $$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5ksi)} \times 18432.001in^3$$ $$\phi M_{n,1} = 249.600kipft$$	
14.5.2.1b	$\phi M_{n,2}$ $$\phi M_{n,2} = \phi \; 0.85 \; f'_{ck} \; S_m$$ $$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times \left(18432 \text{ in}^3\right)$$ $$\phi M_{n,2} = 2121.6 \text{ kipft}$$ Therefore, ϕM_n - Allowable flexural strength, $$\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$$ $$\phi M_n = MIN[(249.6 \text{ kipft}), (2121.6 \text{ kipft})]$$ $$\phi M_n = 249.6 \text{ kipft}$$ **Considering x-direction:** $M_{max} = 16.581 \text{ kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(16.581 \text{ kipft})}{(249.6 \text{ kipft})}$$ $$Ratio = 0.066431$$	Status: **PASS** Ratio: **0.070**
	Considering z-direction: $M_{max} = 0.0011323 \text{ kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity $$Ratio = \frac{M_{max}}{\phi M_n}$$ $$Ratio = \frac{(0.0011323 \text{ kipft})}{(249.6 \text{ kipft})}$$ $$Ratio = 4.5366 \times 10^{-6}$$	Status: **PASS** Ratio: **0.000**

REFERENCES	CALCULATIONS	RESULTS

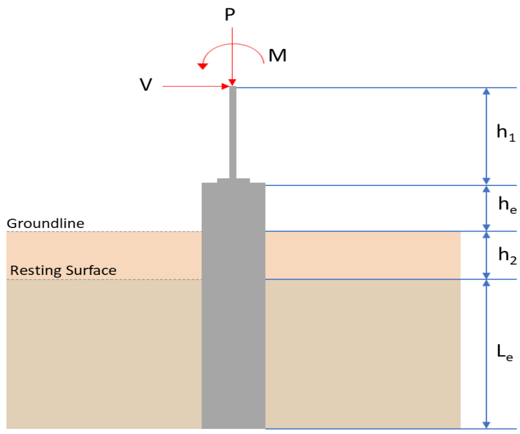
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: rectangular
$b = 48$ in - Pile width
$D = 48$ in - Pile depth
$L = 7$ 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	Clay, sandy clay, silty clay, clayey silt, silt and sandy silt	1500.000	100.000

Tabulation of Loads

Load Component	ASD	LRFD
P (kip)	9.487	14.715
V_x (kip)	-0.137	-0.230
V_z (kip)	0.024	0.037
M_x (kipft)	0.065	0.103
M_z (kipft)	16.628	28.250

Material Properties

$f'_{ck} = 2.5$ 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,

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

$$H_o = \frac{(-0.137 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.021815 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(16.628\ \text{kipft}) + ((-0.137\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 2.6478\ \text{kipft/ft}$$

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:
$L_{e,x} = 6.7278\ \text{ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.024\ \text{kip})}{1.57 \times (48\ \text{in})}$$

$$H_o = 0.0038217\ \text{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.065\ \text{kipft}) + ((0.024\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

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

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:
$L_{e,z} = 1.1812\ \text{ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(6.7278\ \text{ft}), (1.1812\ \text{ft})]$$

$$L_{e,req} = 6.728\ \text{ft}$$

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

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

$$Ratio = \frac{(6.728\ \text{ft})}{(7\ \text{ft})}$$

$$Ratio = 0.96114$$

Status: **PASS**
Ratio: **0.960**

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

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

$$q = \frac{(9.487\ \text{kip})}{(16\ \text{ft}^2)}$$

$$q = 0.59294\ \text{kip/ft}^2$$

Check bearing capacity ratio:

$Ratio$ - Capacity

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

$$Ratio = \frac{(0.59294\ \text{kip/ft}^2)}{(1500\ \text{psf})}$$

$$Ratio = 0.39529$$

Status: **PASS**
Ratio: **0.400**

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:

$H_o = -0.021815\ \text{kip/ft}$ - Lateral force per length of pile,
$M_o = 2.6478\ \text{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (2.6478\ \text{kipft/ft}) \times (7\ \text{ft})) + \left(3 \times (-0.021815\ \text{kip/ft}) \times (7\ \text{ft})^2\right)}{(6 \times (2.6478\ \text{kipft/ft})) + (4 \times (-0.021815\ \text{kip/ft}) \times (7\ \text{ft}))}$$

$$a = 4.6883\ \text{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (2.6478\ \text{kipft/ft})) + (3 \times (-0.021815\ \text{kip/ft}) \times (7\ \text{ft}))]^2}{(7\ \text{ft})^2 \times [(3 \times (2.6478\ \text{kipft/ft})) + (2 \times (-0.021815\ \text{kip/ft}) \times (7\ \text{ft}))]}$$

$$p = 0.20576\ \text{kip/ft}^2$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (2.6478\ \text{kipft/ft})) + ((-0.021815\ \text{kip/ft}) \times (7\ \text{ft}))]}{(7\ \text{ft})^2}$$

$$s = 0.62973\ \text{kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (100\ \text{psf/ft}) \times \frac{(4.6883\ \text{ft})}{2}$$

$$p_a = 0.23441\ \text{kip/ft}^2$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.20576\ \mathrm{kip/ft^2}\right)}{\left(0.23441\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.87777$$

Status: **PASS**
Ratio: **0.880**

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (100\ \mathrm{psf/ft}) \times (7\ \mathrm{ft})$$

$$p_s = 0.7\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.62973\ \mathrm{kip/ft^2}\right)}{\left(0.7\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.89962$$

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

Considering z-direction:

$H_o = 0.0038217\ \mathrm{kip/ft}$ - Lateral force per length of pile,
$M_o = 0.01035\ \mathrm{kipft/ft}$ - Overturning moment per length of pile,
a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.01035\ \mathrm{kipft/ft}) \times (7\ \mathrm{ft})) + \left(3 \times (0.0038217\ \mathrm{kip/ft}) \times (7\ \mathrm{ft})^2\right)}{(6 \times (0.01035\ \mathrm{kipft/ft})) + (4 \times (0.0038217\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))}$$

$$a = 5.0358\ \mathrm{ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.01035\ \mathrm{kipft/ft})) + (3 \times (0.0038217\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))]^2}{(7\ \mathrm{ft})^2 \times [(3 \times (0.01035\ \mathrm{kipft/ft})) + (2 \times (0.0038217\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))]}$$

$$p = 0.0026792\ \mathrm{kip/ft^2}$$

s - Earth pressure against the pile at distance L_e,

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

$$s = \frac{6 \times [(2 \times (0.01035\ \mathrm{kipft/ft})) + ((0.0038217\ \mathrm{kip/ft}) \times (7\ \mathrm{ft}))]}{(7\ \mathrm{ft})^2}$$

$$s = 0.0058105\ \mathrm{kip/ft^2}$$

Check lateral soil pressure capacity:

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

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

$$p_a = (100\ \mathrm{psf/ft}) \times \frac{(5.0358\ \mathrm{ft})}{2}$$

$$p_a = 0.25179\ \mathrm{kip/ft^2}$$

$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{\left(0.0026792\ \mathrm{kip/ft^2}\right)}{\left(0.25179\ \mathrm{kip/ft^2}\right)}$$

$$Ratio = 0.01064$$

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

p_s - Allowable lateral soil pressure at depth L_e,

$$p_s = R\,L_e$$

$$p_s = (100\ \mathrm{psf/ft}) \times (7\ \mathrm{ft})$$

$$p_s = 0.7\ \mathrm{kip/ft^2}$$

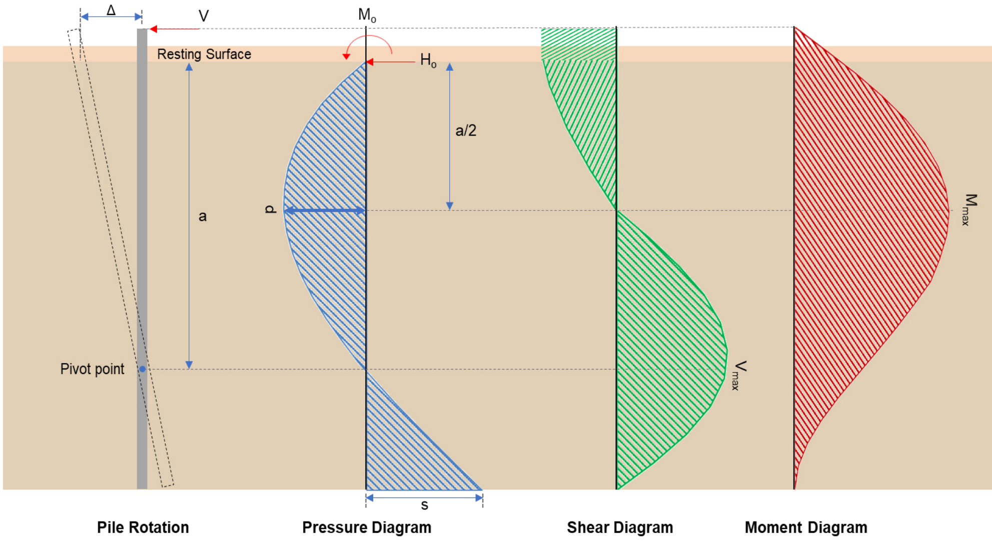
$Ratio$ - Lateral soil capacity

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

$$Ratio = \frac{(0.0058105\ \mathrm{kip/ft^2})}{(0.7\ \mathrm{kip/ft^2})}$$

$$Ratio = 0.0083007$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.23\ \mathrm{kip})}{1.57 \times (48\ \mathrm{in})}$$

$$H_o = -0.036624\ \mathrm{kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(28.25\ \mathrm{kipft}) + ((-0.23\ \mathrm{kip}) \times (0\ \mathrm{ft}))}{1.57 \times (48\ \mathrm{in})}$$

$$M_o = 4.4984\ \mathrm{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(4.4984\ \mathrm{kipft/ft})}{(-0.036624\ \mathrm{kip/ft})}$$

$$E = 122.83\ \mathrm{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (4.4984\ \mathrm{kipft/ft}) \times (7\ \mathrm{ft})) + \left(3 \times (-0.036624\ \mathrm{kip/ft}) \times (7\ \mathrm{ft})^2\right)}{\ldots}$$

$$a = \frac{}{(6 \times (4.4984\ \text{kipft/ft})) + (4 \times (-0.036624\ \text{kip/ft}) \times (7\ \text{ft}))}$$

$$a = 4.688\ \text{ft}$$

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

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

$$V_{max} = ((-0.036624\ \text{kip/ft}) \times (48\ \text{in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (122.83\ \text{ft})}{(7\ \text{ft})} + 3\right) \times \left(\frac{(4.688\ \text{ft})}{(7\ \text{ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (122.83\ \text{ft})}{(7\ \text{ft})} + 2\right) \times \left(\frac{(4.688\ \text{ft})}{(7\ \text{ft})}\right)^3\right]\right]$$

$$V_{max} = 4.6623\ \text{kip}$$

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

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

$$M_{max} = ((-0.036624\ \text{kip/ft}) \times (48\ \text{in}) \times (7\ \text{ft})) \times \left[\left(\frac{(122.83\ \text{ft})}{(7\ \text{ft})} + \frac{(4.688\ \text{ft})}{2 \times (7\ \text{ft})}\right) - \left[\left(\frac{4 \times (122.83\ \text{ft})}{(7\ \text{ft})} + 3\right) \times \left(\frac{(4.688\ \text{ft})}{2 \times (7\ \text{ft})}\right)^3\right] + \left[\left(\frac{3 \times (122.83\ \text{ft})}{(7\ \text{ft})} + 2\right) \times \left(\frac{(4.688\ \text{ft})}{2 \times (7\ \text{ft})}\right)^4\right]\right]$$

$$M_{max} = 16.224\ \text{kipft}$$

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

H_o - Lateral force per length of pile,

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

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

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

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.103\ \text{kipft}) + ((0.037\ \text{kip}) \times (0\ \text{ft}))}{1.57 \times (48\ \text{in})}$$

$$M_o = 0.016401\ \text{kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.016401\ \text{kipft/ft})}{(0.0058917\ \text{kip/ft})}$$

$$E = 2.7838\ \text{ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.016401\ \text{kipft/ft}) \times (7\ \text{ft})) + \left(3 \times (0.0058917\ \text{kip/ft}) \times (7\ \text{ft})^2\right)}{(6 \times (0.016401\ \text{kipft/ft})) + (4 \times (0.0058917\ \text{kip/ft}) \times (7\ \text{ft}))}$$

$$a = 5.032\ \text{ft}$$

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

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

$$V_{max} = ((0.0058917 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (2.7838 \text{ ft})}{(7 \text{ ft})} + 3\right) \times \left(\frac{(5.032 \text{ ft})}{(7 \text{ ft})}\right)^2\right] + \left[4 \times \left(\frac{3 \times (2.7838 \text{ ft})}{(7 \text{ ft})} + 2\right) \times \left(\frac{(5.032 \text{ ft})}{(7 \text{ ft})}\right)^3\right]\right]$$

$$V_{max} = 0.032341 \text{ kip}$$

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

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

$$M_{max} = ((0.0058917 \text{ kip/ft}) \times (48 \text{ in}) \times (7 \text{ ft})) \times \left[\left(\frac{(2.7838 \text{ ft})}{(7 \text{ ft})} + \frac{(5.032 \text{ ft})}{2 \times (7 \text{ ft})}\right) - \left[\left(\frac{4 \times (2.7838 \text{ ft})}{(7 \text{ ft})} + 3\right) \times \left(\frac{(5.032 \text{ ft})}{2 \times (7 \text{ ft})}\right)^3\right] + \left[\left(\frac{3 \times (2.7838 \text{ ft})}{(7 \text{ ft})} + 2\right) \times \left(\frac{(5.032 \text{ ft})}{2 \times (7 \text{ ft})}\right)^4\right]\right]$$

$$M_{max} = 0.098525 \text{ kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

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

Longitudinal reinforcement:

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

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

$$A_{st,required} = Min\left[\frac{\frac{(14.715 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2))\right]$$

$$A_{st,required} = -84.107 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = Max\left[(-84.107 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))\right]$$

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

n_{rebar} - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

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

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

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

$Ratio$ - Capacity

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

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

$$Ratio = 0.96556$$

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

25.2.3 s_{rebar} - Minimum spacing of reinforcement,

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

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

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

Ties:

25.7.2.2 Since longitudinal reinforcement is $\leq$ No. 10⌀: Use #3(0.375 in)

25.7.2.1 s_{ties} - Maximum spacing of ties,

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

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

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

Summary:

Main reinforcement: **14 - #5 (0.625 in)**
Ties: **#3(0.375 in) - 10 in**

Axial Compression Strength (ACI 318-19, LRFD)

22.4.2.2 ϕP_N - Allowable axial compressive strength

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

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

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

$Ratio$ - Capacity

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

$$Ratio = \frac{(14.715\text{ kip})}{(2675.2\text{ kip})}$$

$$Ratio = 0.0055006$$

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

Shear Strength (ACI 318-19, LRFD)

Parameters:

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

22.5.2.2 d - Effective depth

$$d = 0.80\, D$$

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

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

22.5.5.1.3 λ_s - size effect modification factor

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

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

$$\lambda_s = 0.64282$$

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

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

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

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

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

The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 14.715 \text{ kip} \rightarrow 14715 \text{ lbf}$,

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

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(14715 \text{ lbf})}{6 \times (2304 \text{ in}^2)}\right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 120.45 \text{ kip}$$

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

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

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

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

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

V_c - Governing shear strength of concrete

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

$$V_c = Min\left[(296.21 \text{ kip}), (120.45 \text{ kip}), (348.89 \text{ kip})\right]$$

$$V_c = 120.45 \text{ kip}$$

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

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

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

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

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

A_v - Ties rebar area,

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

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

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

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

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

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

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

V_s - Governing shear strength of steel

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

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

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

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((120.45 \text{ kip}) + (50.894 \text{ kip}))$$

$$\phi V_n = 111.37 \text{ kip}$$

Considering x-direction:

$V_{max} = 4.6623 \text{ kip}$ - Maximum shear force in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(4.6623 \text{ kip})}{(111.37 \text{ kip})}$$

$$Ratio = 0.041863$$

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

Considering z-direction:

$V_{max} = 0.032341 \text{ kip}$ - Maximum shear force in the z-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(0.032341 \text{ kip})}{(111.37 \text{ kip})}$$

$$Ratio = 0.00029039$$

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

Flexural Strength (ACI 318-19, LRFD)

S_m - Section modulus

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

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

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

$\lambda = 1$ - Concrete modification factor (Normal concrete),
Allowable flexural strength:
M_n shall be the lesser of:
$\phi M_{n,1}$

$$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f'_c)} \times S_m$$

$$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 ksi)} \times 18432.001 in^3$$

$$\phi M_{n,1} = 249.600 kipft$$

14.5.2.1b $\phi M_{n,2}$

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

$$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times \left(18432 \text{ in}^3\right)$$

$$\phi M_{n,2} = 2121.6 \text{ kipft}$$

Therefore,
ϕM_n - Allowable flexural strength,

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

$$\phi M_n = MIN[(249.6 \text{ kipft}), (2121.6 \text{ kipft})]$$

$$\phi M_n = 249.6 \text{ kipft}$$

Considering x-direction:

$M_{max} = 16.224 \text{ kipft}$ - Maximum moment in the x-direction,
$Ratio$ - Capacity

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

$$Ratio = \frac{(16.224 \text{ kipft})}{(249.6 \text{ kipft})}$$

$$Ratio = 0.064998$$

Status: **PASS**
Ratio: **0.060**

Considering z-direction:

$M_{max} = 0.098525 \text{ kipft}$ - Maximum moment in the z-direction,
$Ratio$ - Capacity

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

	$$Ratio = \frac{(0.098525 \text{ kipft})}{(249.6 \text{ kipft})}$$ $$Ratio = 0.00039473$$	Status: **PASS** Ratio: **0.000**