

Your Project Calculations



Project Name: Morningstar Carport-RevA-JB

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

Public Model Link:
https://platform.skyciv.com/structural-viewer?project_id=gV3qmfCaSoimShQnFQBfEQMerEhmJCsW4TxLNmISAvrDGgnXSKI10QXXB0D6bBR

Array Specification

Product:	Beam
Unique ID:	4P-19.75-10TOP-XD-45-L-5Hx10W-I9EL
Duty Classification:	XD
Module Width:	45.50 in
Module Length:	89.50in
Number of Rows:	5
Number of Columns:	10
Total Number of Modules:	50
Desired Tilt Angle:	46
Front Edge Clearance:	10
Total Array Height at Tilt:	23.71 ft
Total Frame Length:	74.25 ft
Frame Weight:	5610 lbs
Array Dimensions N/S:	19.17 ft
Array Dimensions E/W:	75.42 ft
Rail Length:	230.00 in
Rail Spacing:	3.73 ft
Rail Check:	Not Checked

Support Specifications

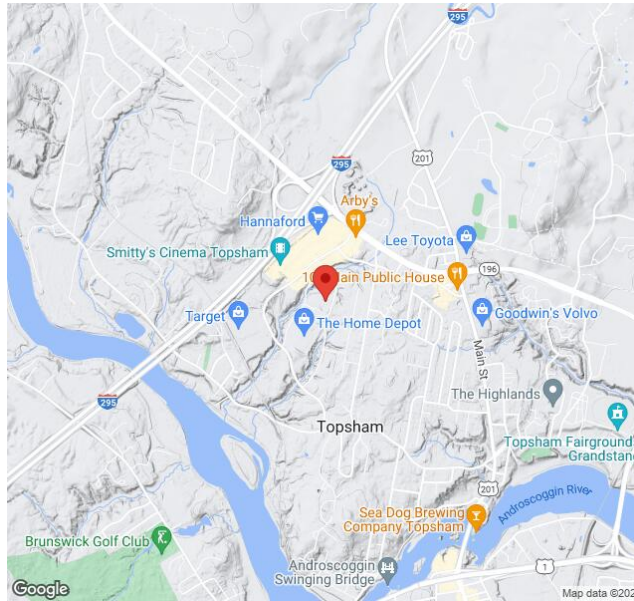
Pole Size:	10in Pipe Sch 40
Pole Length above Grade:	16.89 ft
Number of Poles:	4
Pole Spacing:	19.75 ft

Foundation Specifications

Foundation Type:	Square
Foundation Dimensions:	48 x 48 in
Foundation Depth (below grade):	Pile 1: 7.50 ft Pile 2: 7.75 ft Pile 3: 7.75 ft Pile 4: 7.50 ft
Foundation Volume:	18.074 y ³
Foundation Result:	PASSED
Mount Twist:	0.732083 kip

Site Info

Risk Category:	I
Exposure:	B
Soil Classification:	sand
Site Location:	47 Park Dr, Topsham, ME 04086, USA
Wind Speed:	104 mph
Snow Load:	60 psf
Design Uplift Pressure:	0.015976 ksf
Design Downforce Pressure:	-0.015976 ksf
Design Snow Pressure:	0.015835 ksf



Design Disclaimer

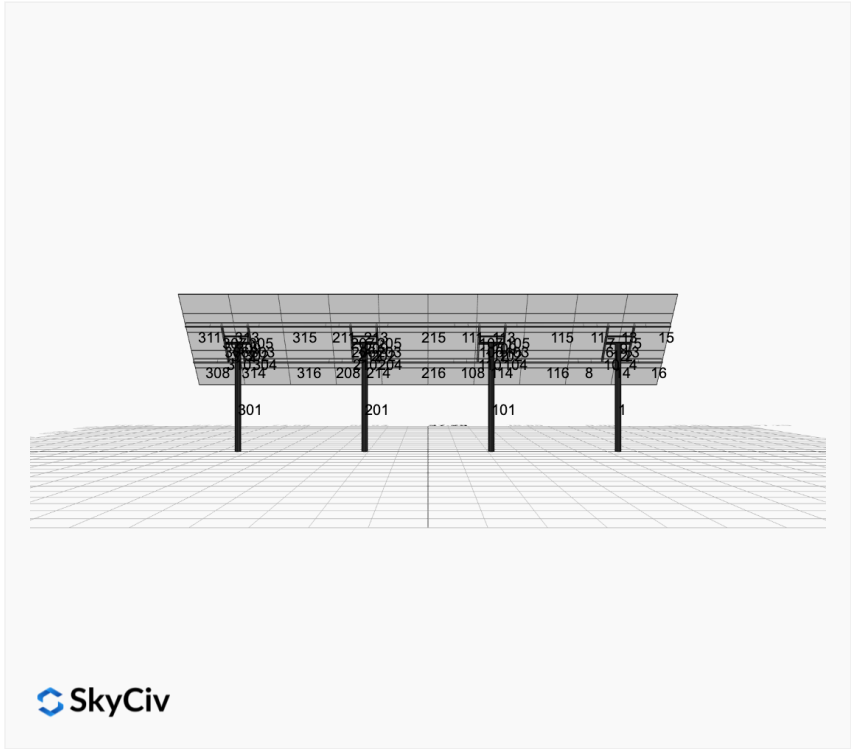
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

AutoDesigner Input

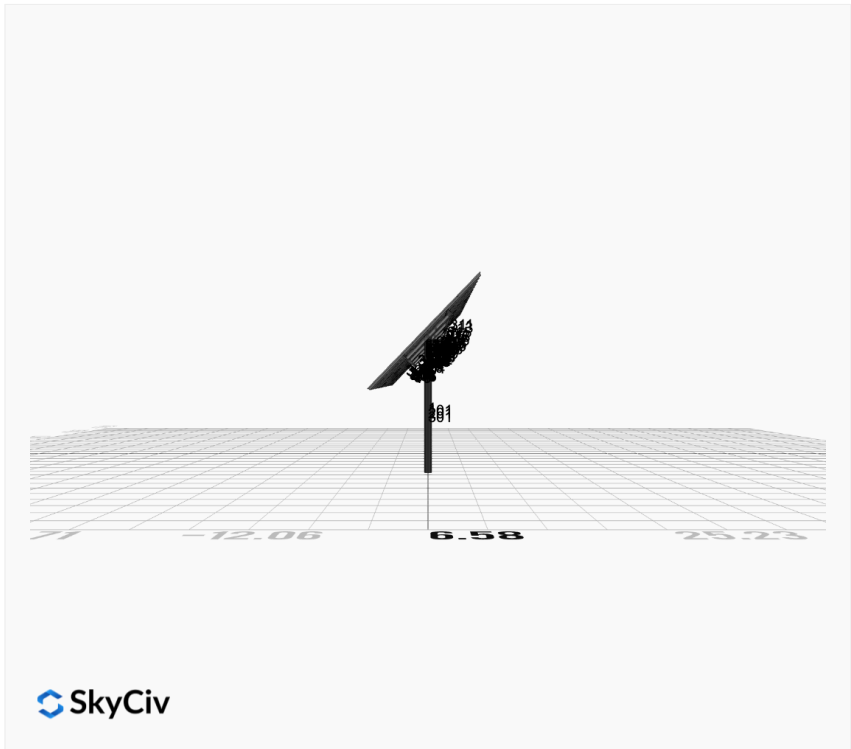
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Design Notes:

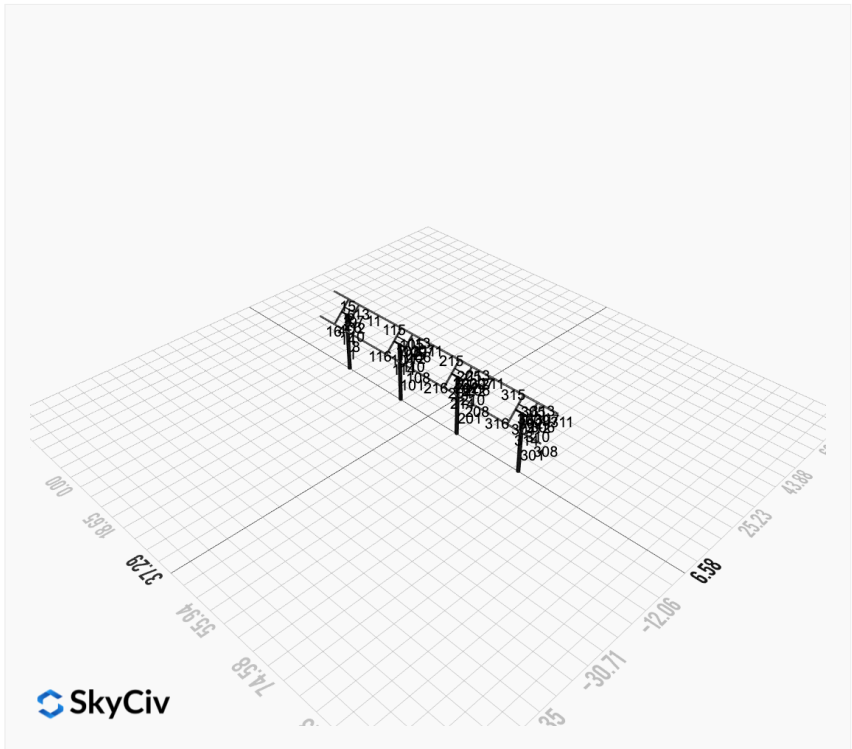
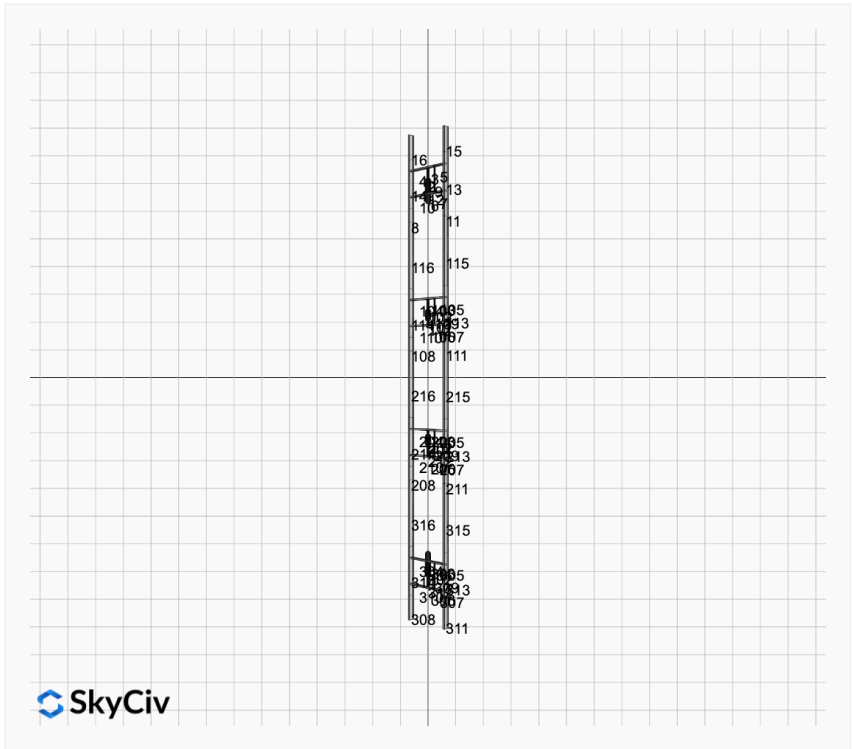
- AISC Deflection checks are set to L/1 due to structure design intent
- Foundation Soil Parameters used in this Autodesign are all estimates, proper geotechnical reports are required to confirm soil profiles
- Wind speeds, snow loads and other site specific results are based on ASCE 7 2016
- Steel frame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

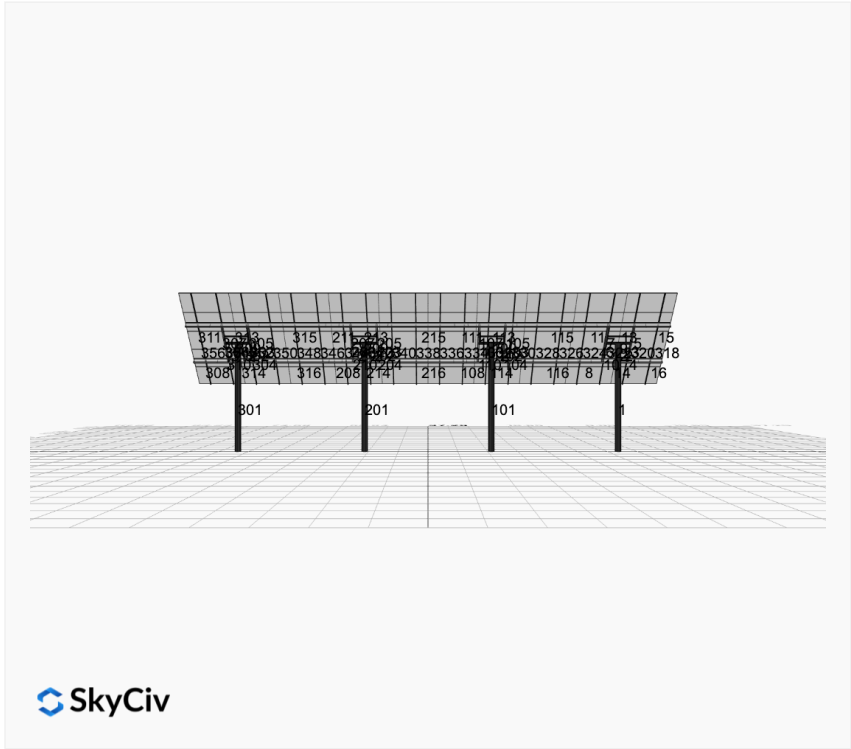


 SkyCiv

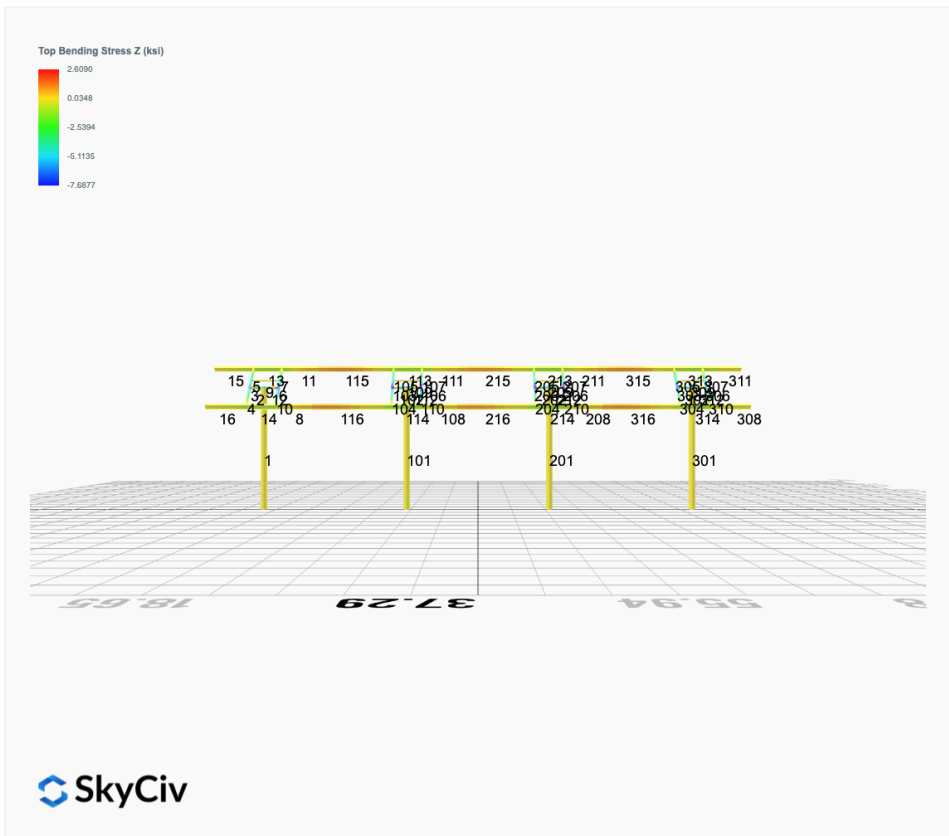
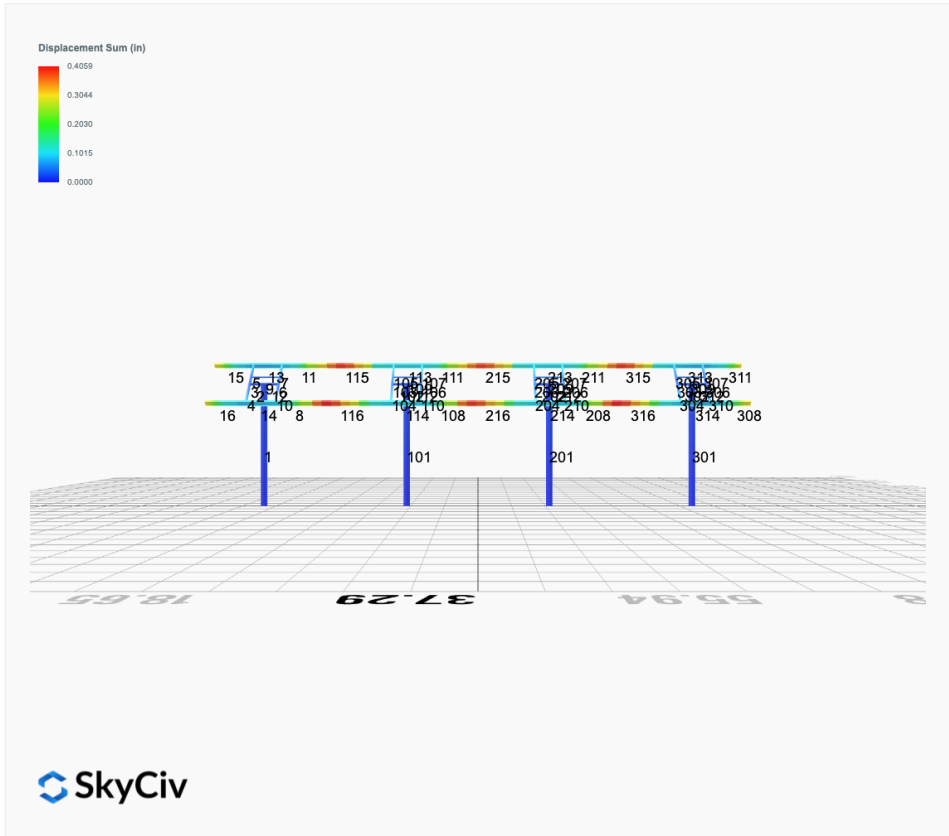


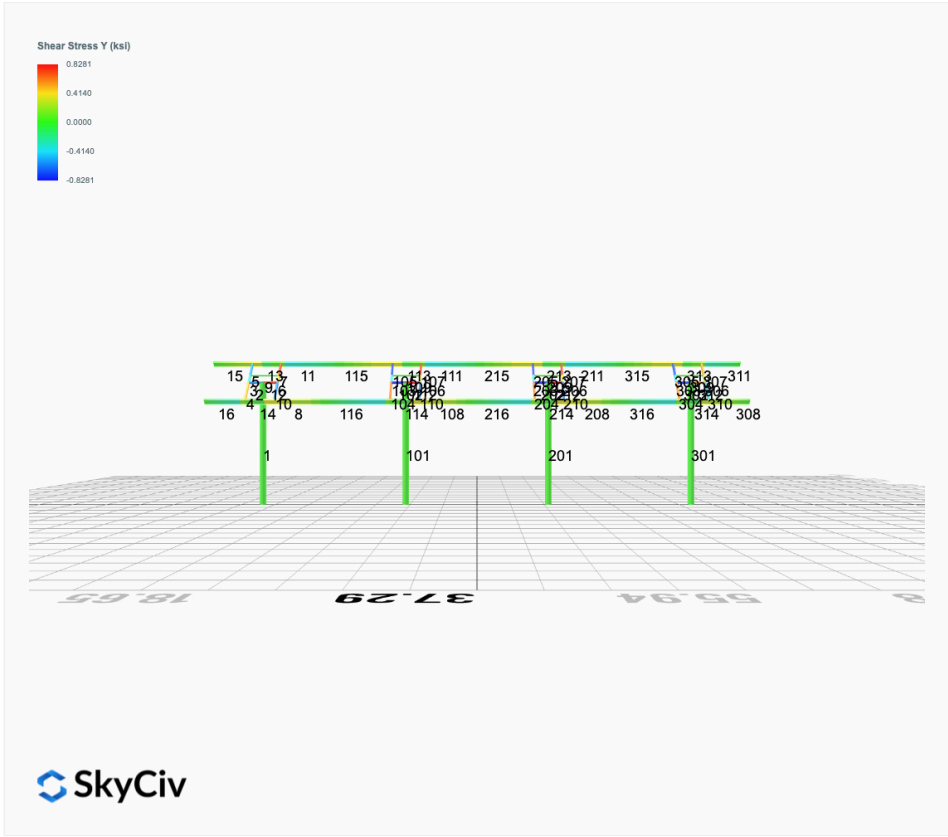
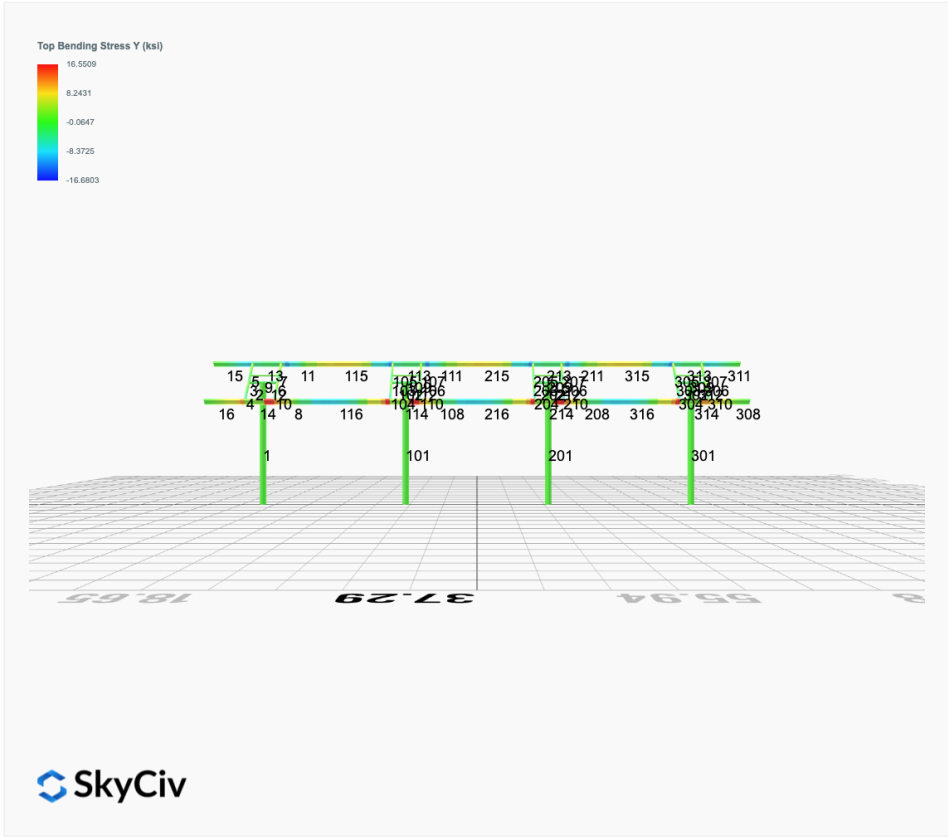
 SkyCiv

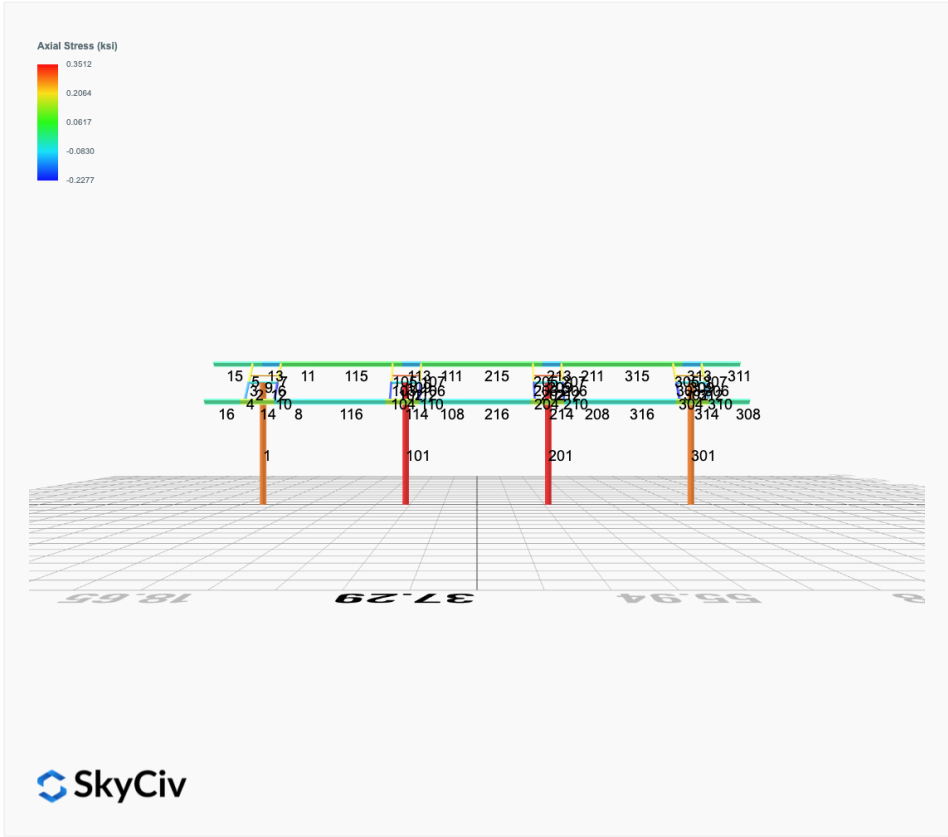




FEM Results (Envelope Worst Case for each member)







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

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	0.0078	2.8579	0.0236	0.1268	-0.0054	-0.1009
ULS: 2. D + L	0.0078	2.8579	0.0236	0.1268	-0.0054	-0.1009
ULS: 3. D + (S or Lr or R)	0.0229	6.5031	0.0692	0.3720	-0.0171	-0.3308
ULS: 3. D + (S or Lr or R)	0.0078	2.8579	0.0236	0.1268	-0.0054	-0.1009
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0191	5.5918	0.0578	0.3107	-0.0142	-0.2733
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0078	2.8579	0.0236	0.1268	-0.0054	-0.1009
ULS: 5b. D + 0.7E	0.0078	2.8579	0.0236	0.1268	-0.0054	-0.1009
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0191	5.5918	0.0578	0.3107	-0.0142	-0.2733
ULS: 8. 0.6D + 0.7E	0.0047	1.7147	0.0142	0.0761	-0.0032	-0.0606
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.3548	5.1124	0.0858	0.4433	-0.4304	40.3763
ULS: 5a. D + 0.6W_Wind downforce Case B only	0.0078	2.8579	0.0236	0.1268	-0.0054	-0.1009
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.3680	0.6047	-0.0370	-0.1809	0.4088	-39.6471
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.0078	2.8579	0.0236	0.1268	-0.0054	-0.1009
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.7528	7.2827	0.1044	0.5481	-0.3329	30.0846
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0191	5.5918	0.0578	0.3107	-0.0142	-0.2733
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.7893	3.9019	0.0123	0.0799	0.2965	-29.9329
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0191	5.5918	0.0578	0.3107	-0.0142	-0.2733
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.7641	4.5488	0.0703	0.3642	-0.3241	30.2570
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0078	2.8579	0.0236	0.1268	-0.0054	-0.1009
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.7780	1.1680	-0.0218	-0.1040	0.3053	-29.7605
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0078	2.8579	0.0236	0.1268	-0.0054	-0.1009
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.3579	3.9693	0.0764	0.3926	-0.4282	40.4167
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	0.0047	1.7147	0.0142	0.0761	-0.0032	-0.0606
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.3649	-0.5384	-0.0464	-0.2316	0.4110	-39.6067
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.0047	1.7147	0.0142	0.0761	-0.0032	-0.0606

Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	11.1419
Shear X	-3.9532
Shear Z	0.1565
Moment X	0.8197
Moment Y (Twist)	0.7320
Moment Z	68.4040

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	7.2827
Shear X	-2.3680
Shear Z	0.1044
Moment X	0.5481
Moment Y (Twist)	0.4304
Moment Z	40.4167

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	-0.0078	3.1379	0.0005	0.0024	-0.0045	0.1518
ULS: 2. D + L	-0.0078	3.1379	0.0005	0.0024	-0.0045	0.1518
ULS: 3. D + (S or Lr or R)	-0.0229	7.3197	0.0015	0.0073	-0.0134	0.4140
ULS: 3. D + (S or Lr or R)	-0.0078	3.1379	0.0005	0.0024	-0.0045	0.1518
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0191	6.2743	0.0013	0.0061	-0.0112	0.3485
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0078	3.1379	0.0005	0.0024	-0.0045	0.1518
ULS: 5b. D + 0.7E	-0.0078	3.1379	0.0005	0.0024	-0.0045	0.1518

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0191	6.2743	0.0013	0.0061	-0.0112	0.3485
ULS: 8. 0.6D + 0.7E	-0.0047	1.8827	0.0003	0.0015	-0.0027	0.0911
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.6288	5.6959	0.0197	0.0997	-0.1529	44.8748
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.0078	3.1379	0.0005	0.0024	-0.0045	0.1518
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.6155	0.5785	-0.0177	-0.0896	0.1369	-43.5112
ULS: 5a. D + 0.6W_Wind uplift Case B only	-0.0078	3.1379	0.0005	0.0024	-0.0045	0.1518
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.9849	8.1928	0.0157	0.0790	-0.1225	33.8907
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0191	6.2743	0.0013	0.0061	-0.0112	0.3485
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.9484	4.3547	-0.0124	-0.0630	0.0949	-32.3988
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0191	6.2743	0.0013	0.0061	-0.0112	0.3485
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.9736	5.0564	0.0149	0.0754	-0.1158	33.6941
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0078	3.1379	0.0005	0.0024	-0.0045	0.1518
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.9597	1.2183	-0.0132	-0.0666	0.1016	-32.5955
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0078	3.1379	0.0005	0.0024	-0.0045	0.1518
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.6257	4.4408	0.0195	0.0987	-0.1511	44.8141
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.0047	1.8827	0.0003	0.0015	-0.0027	0.0911
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.6187	-0.6767	-0.0179	-0.0906	0.1387	-43.5719
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	-0.0047	1.8827	0.0003	0.0015	-0.0027	0.0911

Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	12.5868
Shear X	-4.3823
Shear Z	0.0343
Moment X	0.1732
Moment Y (Twist)	0.2656
Moment Z	76.1897

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	8.1928
Shear X	-2.6288
Shear Z	0.0197
Moment X	0.0997
Moment Y (Twist)	0.1529
Moment Z	44.8748

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	-0.0078	3.1379	-0.0005	-0.0024	0.0045	0.1518
ULS: 2. D + L	-0.0078	3.1379	-0.0005	-0.0024	0.0045	0.1518
ULS: 3. D + (S or Lr or R)	-0.0229	7.3197	-0.0015	-0.0073	0.0134	0.4140
ULS: 3. D + (S or Lr or R)	-0.0078	3.1379	-0.0005	-0.0024	0.0045	0.1518
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0191	6.2743	-0.0013	-0.0061	0.0112	0.3485
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0078	3.1379	-0.0005	-0.0024	0.0045	0.1518
ULS: 5b. D + 0.7E	-0.0078	3.1379	-0.0005	-0.0024	0.0045	0.1518
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0191	6.2743	-0.0013	-0.0061	0.0112	0.3485
ULS: 8. 0.6D + 0.7E	-0.0047	1.8827	-0.0003	-0.0015	0.0027	0.0911
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.6288	5.6959	-0.0197	-0.0996	0.1530	44.8748
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.0078	3.1379	-0.0005	-0.0024	0.0045	0.1518
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.6155	0.5785	0.0177	0.0896	-0.1369	-43.5112
ULS: 5a. D + 0.6W_Wind uplift Case B only	-0.0078	3.1379	-0.0005	-0.0024	0.0045	0.1518
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.9849	8.1928	-0.0157	-0.0790	0.1225	33.8907
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0191	6.2743	-0.0013	-0.0061	0.0112	0.3485
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.9484	4.3547	0.0124	0.0630	-0.0949	-32.3988
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0191	6.2743	-0.0013	-0.0061	0.0112	0.3485

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.9736	5.0564	-0.0149	-0.0753	0.1159	33.6941
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0078	3.1379	-0.0005	-0.0024	0.0045	0.1518
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.9597	1.2183	0.0132	0.0666	-0.1015	-32.5955
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0078	3.1379	-0.0005	-0.0024	0.0045	0.1518
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.6257	4.4408	-0.0195	-0.0987	0.1511	44.8141
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.0047	1.8827	-0.0003	-0.0015	0.0027	0.0911
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.6187	-0.6767	0.0179	0.0906	-0.1387	-43.5719
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	-0.0047	1.8827	-0.0003	-0.0015	0.0027	0.0911

Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	12.5868
Shear X	-4.3823
Shear Z	-0.0343
Moment X	-0.1734
Moment Y (Twist)	0.2658
Moment Z	76.1900

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	8.1928
Shear X	-2.6288
Shear Z	-0.0197
Moment X	-0.0996
Moment Y (Twist)	0.1530
Moment Z	44.8748

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	0.0078	2.8579	-0.0236	-0.1268	0.0054	-0.1009
ULS: 2. D + L	0.0078	2.8579	-0.0236	-0.1268	0.0054	-0.1009
ULS: 3. D + (S or Lr or R)	0.0229	6.5030	-0.0692	-0.3721	0.0172	-0.3307
ULS: 3. D + (S or Lr or R)	0.0078	2.8579	-0.0236	-0.1268	0.0054	-0.1009
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0191	5.5918	-0.0578	-0.3108	0.0142	-0.2732
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0078	2.8579	-0.0236	-0.1268	0.0054	-0.1009
ULS: 5b. D + 0.7E	0.0078	2.8579	-0.0236	-0.1268	0.0054	-0.1009
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0191	5.5918	-0.0578	-0.3108	0.0142	-0.2732
ULS: 8. 0.6D + 0.7E	0.0047	1.7147	-0.0142	-0.0761	0.0032	-0.0605
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.3548	5.1124	-0.0858	-0.4433	0.4304	40.3763
ULS: 5a. D + 0.6W_Wind downforce Case B only	0.0078	2.8579	-0.0236	-0.1268	0.0054	-0.1009
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.3680	0.6047	0.0370	0.1809	-0.4088	-39.6470
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.0078	2.8579	-0.0236	-0.1268	0.0054	-0.1009
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.7528	7.2827	-0.1044	-0.5482	0.3330	30.0847
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0191	5.5918	-0.0578	-0.3108	0.0142	-0.2732
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.7893	3.9019	-0.0123	-0.0800	-0.2964	-29.9328
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0191	5.5918	-0.0578	-0.3108	0.0142	-0.2732
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.7641	4.5488	-0.0703	-0.3642	0.3242	30.2570
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0078	2.8579	-0.0236	-0.1268	0.0054	-0.1009
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.7780	1.1680	0.0218	0.1040	-0.3053	-29.7605
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0078	2.8579	-0.0236	-0.1268	0.0054	-0.1009
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.3579	3.9693	-0.0764	-0.3926	0.4283	40.4167
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	0.0047	1.7147	-0.0142	-0.0761	0.0032	-0.0605
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.3649	-0.5384	0.0464	0.2316	-0.4110	-39.6067
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.0047	1.7147	-0.0142	-0.0761	0.0032	-0.0605

Worst Case Reactions LRFD

Worst Case Reactions ASD

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

Result	Value (kip, kip-ft)
Axial	11.1418
Shear X	-3.9532
Shear Z	-0.1565
Moment X	-0.8201
Moment Y (Twist)	0.7321
Moment Z	68.4049

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	7.2827
Shear X	-2.3680
Shear Z	-0.1044
Moment X	-0.5482
Moment Y (Twist)	0.4304
Moment Z	40.4167

Project Details

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

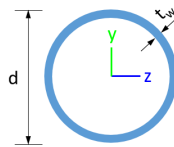


Design Input Information

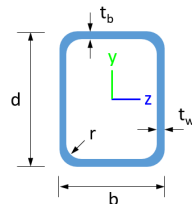
Design Factors			
Φ_t	Φ_c	Φ_b	Φ_v
0.9	0.9	0.9	0.9

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

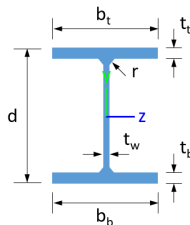
Section Dimensions



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				
11	10in Pipe Sch 40	10.75	0.36				



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
11	10in Pipe Sch 40	11.91	321.47	160.73	160.73	0.00	39.38	39.38

108	20	1.33	1.33	2.0 5	2.08,2.08,2.08,2.08,2.08,2.08,2.06,2.08,1.68,2.08,2.02,2.08,1.84,2.08,2.07,2.08,2.21,2.08,2.0 6,2.08,1.64,2.08,2.01,2.08,1.88,2.08	3 0 0	2 0 0	1
109	3	2.60	2.60	4.0 0	-	3 0 0	2 0 0	1
110	17	2.44	2.44	3.7 5	1.69,1.68,1.69,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.67,1.68,1.67,1.6 7,1.69,1.64,1.69,1.67,1.68,1.66,1.68	3 0 0	2 0 0	1
111	20	1.33	1.33	2.0 5	2.07,2.07,2.07,2.07,2.07,2.07,1.73,2.07,1.38,2.07,1.68,2.07,1.50,2.07,1.94,2.07,2.29,2.07,1.7 5,2.07,1.34,2.07,1.66,2.07,1.53,2.07	3 0 0	2 0 0	1
112	6	1.30	1.30	2.0 0	-	3 0 0	2 0 0	1
113	20	4.88	4.00	7.5 0	1.05,1.05,1.05,1.05,1.05,1.05,1.06,1.05,1.12,1.05,1.06,1.05,1.08,1.05,1.05,1.05,1.03,1.05,1.0 6,1.05,1.15,1.05,1.07,1.05,1.08,1.05	3 0 0	2 0 0	1
114	20	4.88	4.00	7.5 0	1.04,1.05,1.04,1.05,1.05,1.04,1.06,1.05,1.08,1.05,1.06,1.04,1.07,1.04,1.05,1.05,1.03,1.05,1.0 6,1.04,1.09,1.04,1.06,1.04,1.07,1.04	3 0 0	2 0 0	1
115	20	6.63	6.63	10. 20	1.14,1.14,1.14,1.14,1.14,1.14,1.12,1.14,1.09,1.14,1.11,1.14,1.09,1.14,1.13,1.14,1.19,1.14,1.1 2,1.14,1.08,1.14,1.11,1.14,1.09,1.14	3 0 0	2 0 0	1
116	20	6.63	6.63	10. 20	1.15,1.15,1.15,1.15,1.15,1.15,1.14,1.15,1.11,1.15,1.14,1.15,1.13,1.15,1.14,1.15,1.17,1.15,1.1 4,1.15,1.11,1.15,1.13,1.15,1.13,1.15	3 0 0	2 0 0	1
201	11	35.4 8	35.4 8	16. 89	-	3 0 0	2 0 0	1
202	6	1.30	1.30	2.0 0	-	3 0 0	2 0 0	1
203	17	0.92	0.92	1.4 2	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.18,1.19,1.18,1.18,1.18,1.1 8,1.19,1.17,1.19,1.18,1.19,1.18,1.19	3 0 0	2 0 0	1
204	17	2.44	2.44	3.7 5	1.69,1.68,1.69,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.67,1.68,1.67,1.6 7,1.69,1.64,1.69,1.67,1.68,1.66,1.68	3 0 0	2 0 0	1
205	17	1.52	1.52	2.3 3	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.67,1.67,1.6 7,1.68,1.65,1.68,1.67,1.68,1.66,1.68	3 0 0	2 0 0	1
206	17	0.92	0.92	1.4 2	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.17,1.19,1.18,1.18,1.18,1.1 8,1.19,1.16,1.19,1.18,1.19,1.17,1.19	3 0 0	2 0 0	1
207	17	1.52	1.52	2.3 3	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.67,1.67,1.6 7,1.68,1.65,1.68,1.67,1.68,1.66,1.68	3 0 0	2 0 0	1
208	20	1.33	1.33	2.0 5	2.06,2.06,2.06,2.06,2.06,2.06,1.88,2.06,1.59,2.06,1.85,2.06,1.71,2.06,2.00,2.06,2.10,2.06,1.8 9,2.06,1.55,2.06,1.84,2.06,1.74,2.06	3 0 0	2 0 0	1
209	3	2.60	2.60	4.0 0	-	3 0 0	2 0 0	1
210	17	2.44	2.44	3.7 5	1.69,1.68,1.69,1.67,1.68,1.68,1.67,1.68,1.65,1.68,1.67,1.69,1.66,1.69,1.67,1.67,1.68,1.67,1.6 7,1.69,1.64,1.69,1.67,1.68,1.66,1.68	3 0 0	2 0 0	1
211	20	1.33	1.33	2.0 5	2.04,2.04,2.04,2.04,2.04,2.04,1.61,2.04,1.30,2.04,1.57,2.04,1.41,2.04,1.77,2.04,2.35,2.04,1.6 3,2.04,1.26,2.04,1.56,2.04,1.44,2.04	3 0 0	2 0 0	1
212	6	1.30	1.30	2.0 0	-	3 0 0	2 0 0	1
213	20	4.88	4.00	7.5 0	1.05,1.05,1.05,1.05,1.05,1.05,1.06,1.05,1.12,1.05,1.06,1.05,1.08,1.05,1.05,1.05,1.03,1.05,1.0 6,1.05,1.15,1.05,1.07,1.05,1.08,1.05	3 0 0	2 0 0	1
214	20	4.88	4.00	7.5 0	1.04,1.05,1.04,1.05,1.05,1.04,1.06,1.05,1.08,1.05,1.06,1.04,1.07,1.04,1.05,1.05,1.03,1.05,1.0 5,1.04,1.09,1.04,1.06,1.04,1.07,1.04	3 0 0	2 0 0	1
215	20	6.63	6.63	10. 20	1.15,1.15,1.15,1.15,1.15,1.15,1.13,1.15,1.10,1.15,1.12,1.15,1.11,1.15,1.14,1.15,1.20,1.15,1.1 3,1.15,1.09,1.15,1.12,1.15,1.11,1.15	3 0 0	2 0 0	1
216	20	6.63	6.63	10. 20	1.15,1.15,1.15,1.15,1.15,1.15,1.14,1.15,1.12,1.15,1.14,1.15,1.13,1.15,1.15,1.15,1.17,1.15,1.1 4,1.15,1.12,1.15,1.14,1.15,1.13,1.15	3 0 0	2 0 0	1
301	11	35.4 8	35.4 8	16. 89	-	3 0 0	2 0 0	1

103	151.65	150.70	20.17	14.14	54.12	28.95
104	151.65	145.15	20.17	14.14	54.12	28.95
105	151.65	149.10	20.17	14.14	54.12	28.95
106	151.65	150.70	20.17	14.14	54.12	28.95
107	151.65	149.10	20.17	14.14	54.12	28.95
108	159.30	142.47	46.90	6.46	56.26	44.91
109	75.10	66.32	4.25	4.25	22.53	22.53
110	151.65	145.15	20.17	14.14	54.12	28.95
111	159.30	142.47	46.90	6.46	56.26	44.91
112	251.01	248.88	27.16	27.16	75.30	75.30
113	159.30	116.35	31.56	6.46	56.26	44.91
114	159.30	116.35	31.61	6.46	56.26	44.91
115	159.30	75.13	20.89	6.46	56.26	44.91
116	159.30	75.13	21.39	6.46	56.26	44.91
201	535.87	200.35	147.68	147.68	160.76	160.76
202	251.01	248.88	27.16	27.16	75.30	75.30
203	151.65	150.70	20.17	14.14	54.12	28.95
204	151.65	145.15	20.17	14.14	54.12	28.95
205	151.65	149.10	20.17	14.14	54.12	28.95
206	151.65	150.70	20.17	14.14	54.12	28.95
207	151.65	149.10	20.17	14.14	54.12	28.95
208	159.30	142.47	46.90	6.46	56.26	44.91
209	75.10	66.32	4.25	4.25	22.53	22.53
210	151.65	145.15	20.17	14.14	54.12	28.95
211	159.30	142.47	46.90	6.46	56.26	44.91
212	251.01	248.88	27.16	27.16	75.30	75.30
213	159.30	116.35	31.56	6.46	56.26	44.91
214	159.30	116.35	31.60	6.46	56.26	44.91
215	159.30	75.13	21.03	6.46	56.26	44.91
216	159.30	75.13	21.59	6.46	56.26	44.91
301	535.87	200.35	147.68	147.68	160.76	160.76
302	251.01	248.88	27.16	27.16	75.30	75.30
303	151.65	150.70	20.17	14.14	54.12	28.95
304	151.65	145.15	20.17	14.14	54.12	28.95
305	151.65	149.10	20.17	14.14	54.12	28.95
306	151.65	150.70	20.17	14.14	54.12	28.95
307	151.65	149.10	20.17	14.14	54.12	28.95
308	159.30	55.15	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	55.15	46.90	6.46	56.26	44.91
312	251.01	248.88	27.16	27.16	75.30	75.30
313	159.30	116.35	32.12	6.46	56.26	44.91
314	159.30	116.35	32.51	6.46	56.26	44.91
315	159.30	75.13	21.43	6.46	56.26	44.91
316	159.30	75.13	21.49	6.46	56.26	44.91

Design Ratio

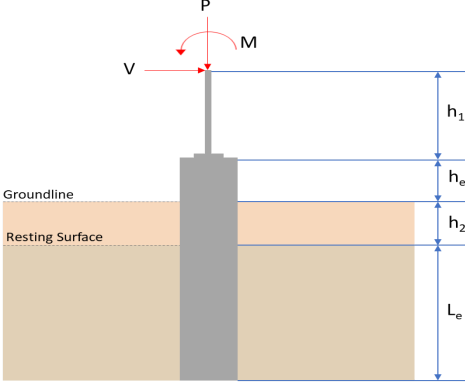
Member ID	P	M _z	M _y	V _y	V _z	(P,M _z ,M _y)	Worst LC	KL/r	φ	Status
1	0.056	0.463	0.012	0.025	0.001	0.491	#13	0.579	Not Required	Pass
2	0.003	0.254	0.135	0.062	0.025	0.353	#21	0.036	Not Required	Pass
3	0.009	0.369	0.045	0.036	0.004	0.418	#21	0.046	Not Required	Pass
4	0.008	0.266	0.142	0.027	0.022	0.460	#21	0.032	Not Required	Pass

4	0.008	0.228	0.142	0.036	0.037	0.265	#21	0.076	Not Required	Pass
5	0.011	0.429	0.081	0.043	0.016	0.511	#21	0.046	Not Required	Pass
6	0.012	0.266	0.196	0.042	0.050	0.312	#21	0.076	Not Required	Pass
7	0.002	0.046	0.205	0.026	0.023	0.208	#23	0.102	Not Required	Pass
8	0.015	0.031	0.055	0.002	0.002	0.080	#21	0.206	Not Required	Pass
9	0.012	0.416	0.190	0.041	0.041	0.537	#21	0.082	Not Required	Pass
10	0.003	0.044	0.209	0.027	0.023	0.211	#23	0.102	Not Required	Pass
11	0.003	0.320	0.162	0.076	0.030	0.436	#13	0.036	Not Required	Pass
12	0.007	0.124	0.532	0.034	0.030	0.615	#21	0.306	Not Required	Pass
13	0.008	0.123	0.526	0.033	0.030	0.601	#21	0.204	Not Required	Pass
14	0.000	0.036	0.184	0.016	0.014	0.220	#21	Not Required	Not Required	Pass
15	0.000	0.036	0.184	0.016	0.014	0.220	#21	Not Required	Not Required	Pass
16	0.063	0.516	0.003	0.027	0.000	0.542	#13	0.579	Not Required	Pass
101	0.004	0.323	0.161	0.078	0.028	0.441	#21	0.036	Not Required	Pass
102	0.011	0.445	0.070	0.044	0.010	0.521	#21	0.046	Not Required	Pass
103	0.011	0.447	0.192	0.045	0.042	0.581	#21	0.082	Not Required	Pass
104	0.011	0.276	0.198	0.044	0.051	0.327	#21	0.076	Not Required	Pass
105	0.011	0.456	0.070	0.045	0.010	0.530	#21	0.046	Not Required	Pass
106	0.011	0.283	0.194	0.045	0.050	0.334	#21	0.076	Not Required	Pass
107	0.002	0.038	0.200	0.026	0.023	0.219	#21	0.102	Not Required	Pass
108	0.018	0.032	0.041	0.001	0.000	0.077	#21	0.206	Not Required	Pass
109	0.011	0.453	0.187	0.045	0.041	0.582	#21	0.082	Not Required	Pass
110	0.003	0.046	0.204	0.026	0.023	0.219	#6	0.102	Not Required	Pass
111	0.004	0.331	0.171	0.078	0.030	0.455	#21	0.036	Not Required	Pass
112	0.007	0.125	0.539	0.034	0.030	0.644	#21	0.306	Not Required	Pass
113	0.009	0.137	0.534	0.034	0.030	0.650	#21	0.306	Not Required	Pass
114	0.005	0.187	0.289	0.026	0.023	0.479	#21	0.507	Not Required	Pass
115	0.002	0.182	0.288	0.027	0.023	0.472	#21	0.507	Not Required	Pass
116	0.063	0.516	0.003	0.027	0.000	0.542	#13	0.579	Not Required	Pass
201	0.004	0.331	0.171	0.078	0.030	0.455	#21	0.036	Not Required	Pass
202	0.011	0.456	0.070	0.045	0.010	0.530	#21	0.046	Not Required	Pass
203	0.011	0.453	0.187	0.045	0.041	0.582	#21	0.082	Not Required	Pass
204	0.011	0.283	0.194	0.045	0.050	0.334	#21	0.076	Not Required	Pass
205	0.011	0.445	0.070	0.044	0.010	0.521	#21	0.046	Not Required	Pass
206	0.011	0.276	0.198	0.044	0.051	0.327	#21	0.076	Not Required	Pass
207	0.002	0.042	0.211	0.027	0.023	0.226	#21	0.102	Not Required	Pass
208	0.018	0.032	0.041	0.001	0.000	0.077	#21	0.206	Not Required	Pass
209	0.011	0.447	0.192	0.045	0.042	0.581	#21	0.082	Not Required	Pass
210	0.003	0.049	0.215	0.026	0.023	0.225	#21	0.102	Not Required	Pass
211	0.004	0.323	0.161	0.078	0.028	0.441	#21	0.036	Not Required	Pass
212	0.007	0.125	0.539	0.034	0.030	0.644	#21	0.306	Not Required	Pass
213	0.009	0.137	0.534	0.034	0.030	0.650	#21	0.306	Not Required	Pass
214	0.005	0.186	0.289	0.026	0.023	0.468	#21	0.507	Not Required	Pass
215	0.002	0.168	0.288	0.026	0.023	0.454	#21	0.507	Not Required	Pass
216	0.056	0.463	0.012	0.025	0.001	0.491	#13	0.579	Not Required	Pass
301	0.003	0.320	0.162	0.076	0.030	0.436	#13	0.036	Not Required	Pass
302	0.011	0.429	0.081	0.043	0.016	0.511	#21	0.046	Not Required	Pass
303	0.012	0.416	0.190	0.041	0.041	0.537	#21	0.082	Not Required	Pass
304	0.012	0.266	0.196	0.042	0.050	0.312	#21	0.076	Not Required	Pass
305	0.009	0.369	0.045	0.036	0.004	0.418	#21	0.046	Not Required	Pass
306	0.008	0.228	0.142	0.036	0.037	0.265	#21	0.076	Not Required	Pass
307	0.000	0.036	0.184	0.016	0.014	0.220	#21	Not Required	Not Required	Pass
308	0.015	0.031	0.055	0.002	0.002	0.080	#21	0.206	Not Required	Pass
309										

310	0.008	0.366	0.143	0.037	0.032	0.469	#21	0.082	Not Required	Pass
311	0.000	0.036	0.184	0.016	0.014	0.220	#21	Not Required	Not Required	Pass
312	0.003	0.254	0.135	0.062	0.025	0.353	#21	0.036	Not Required	Pass
313	0.007	0.124	0.532	0.034	0.030	0.615	#21	0.204	Not Required	Pass
314	0.008	0.123	0.526	0.033	0.030	0.601	#21	0.306	Not Required	Pass
315	0.005	0.192	0.289	0.027	0.023	0.478	#21	0.507	Not Required	Pass
316	0.002	0.187	0.288	0.026	0.023	0.474	#21	0.507	Not Required	Pass

Definitions

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

REFERENCES	CALCULATIONS	RESULTS																										
	<p>SkyCiv Foundation Design Pile Foundation</p> <p>Design Information : Design code : IBC 2021 (International Building Code) Unit System : Imperial</p>																											
	<p>Pile Input</p>  <p>Geometry Pile shape: rectangular $b = 48$ in - Pile width $D = 48$ in - Pile depth $L = 7.5$ ft - Total pile length $h_1 = 0$ ft - Lateral load height from the top of the pile, $h_2 = 0$ ft - Depth to resting surface $h_e = 0$ ft - Length of pile above the ground</p> <p>Tabulation of Soil Parameters</p> <table border="1"> <thead> <tr> <th>Layer</th> <th>Label</th> <th>Allowable Bearing Pressure (q_n) (psf)</th> <th>Allowable Lateral Pressure (R) (psf/ft)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Sand, silty sand, clayey sand, silty gravel & clayey gravel</td> <td>2000.000</td> <td>150.000</td> </tr> </tbody> </table> <p>Tabulation of Loads</p> <table border="1"> <thead> <tr> <th>Load Component</th> <th>ASD</th> <th>LRFD</th> </tr> </thead> <tbody> <tr> <td>P (kip)</td> <td>7.283</td> <td>11.142</td> </tr> <tr> <td>V_x (kip)</td> <td>-2.368</td> <td>-3.953</td> </tr> <tr> <td>V_z (kip)</td> <td>0.104</td> <td>0.156</td> </tr> <tr> <td>M_x (kipft)</td> <td>0.548</td> <td>0.820</td> </tr> <tr> <td>M_z (kipft)</td> <td>40.417</td> <td>68.404</td> </tr> </tbody> </table> <p>Material Properties $f'_{ck} = 2.5$ ksi - Concrete strength,</p>	Layer	Label	Allowable Bearing Pressure (q_n) (psf)	Allowable Lateral Pressure (R) (psf/ft)	1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000	Load Component	ASD	LRFD	P (kip)	7.283	11.142	V_x (kip)	-2.368	-3.953	V_z (kip)	0.104	0.156	M_x (kipft)	0.548	0.820	M_z (kipft)	40.417	68.404	
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	<p>Required depth to resist lateral loads (ASD) H - Point of application of the lateral load</p> $H = h_1 + h_2 + h_e$ $H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})$ $H = 0 \text{ ft}$ <p>Considering x-direction: H_o - Lateral force per length of pile,</p> $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-2.368 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.37707 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$																											

$$M_o = \frac{(40.417 \text{ kipft}) + ((-2.368 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 6.4358 \text{ kipft/ft}$$

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:

$L_{e,x} = 7.0788 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.104 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.016561 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.548 \text{ kipft}) + ((0.104 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.087261 \text{ kipft/ft}$$

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:

$L_{e,z} = 2.084 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = \text{MAX}[(7.0788 \text{ ft}), (2.084 \text{ ft})]$$

$$L_{e,req} = 7.079 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_c - h_2$$

$$L_e = (7.5 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$$

$$L_e = 7.5 \text{ ft}$$

Ratio - Embedded depth

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

$$\text{Ratio} = \frac{(7.079 \text{ ft})}{(7.5 \text{ ft})}$$

$$\text{Ratio} = 0.94387$$

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

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

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

$$q = \frac{(7.283 \text{ kip})}{(16 \text{ ft}^2)}$$

$$q = 0.45519 \text{ kip/ft}^2$$

$$q = 0.45519 \text{ kip/ft}$$

Check bearing capacity ratio:

Ratio - Capacity

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

$$\text{Ratio} = \frac{(0.45519 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$\text{Ratio} = 0.22759$$

Status: **PASS**
Ratio: **0.230**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(7.5 \text{ ft})}{(48 \text{ in})}$$

$$L/D = 1.875$$

Since $L/D \leq 10$,

Pile is short.

Considering x-direction:

$H_o = -0.37707 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 6.4358 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (6.4358 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (-0.37707 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (6.4358 \text{ kipft/ft})) + (4 \times (-0.37707 \text{ kip/ft}) \times (7.5 \text{ ft}))}$$

$$a = 5.1416 \text{ ft}$$

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

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

$$p = \frac{0.75 [(4 \times (6.4358 \text{ kipft/ft})) + (3 \times (-0.37707 \text{ kip/ft}) \times (7.5 \text{ ft}))]^2}{(7.5 \text{ ft})^2 [(3 \times (6.4358 \text{ kipft/ft})) + (2 \times (-0.37707 \text{ kip/ft}) \times (7.5 \text{ ft}))]}$$

$$p = 0.29094 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

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

$$s = \frac{6 [(2 \times (6.4358 \text{ kipft/ft})) + ((-0.37707 \text{ kip/ft}) \times (7.5 \text{ ft}))]}{(7.5 \text{ ft})^2}$$

$$s = 1.0713 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(5.1416 \text{ ft})}{2}$$

$$p_a = 0.38562 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.29094 \text{ kip/ft}^2)}{(0.38562 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.75447$$

p_a - Allowable lateral soil pressure at depth L_e ,

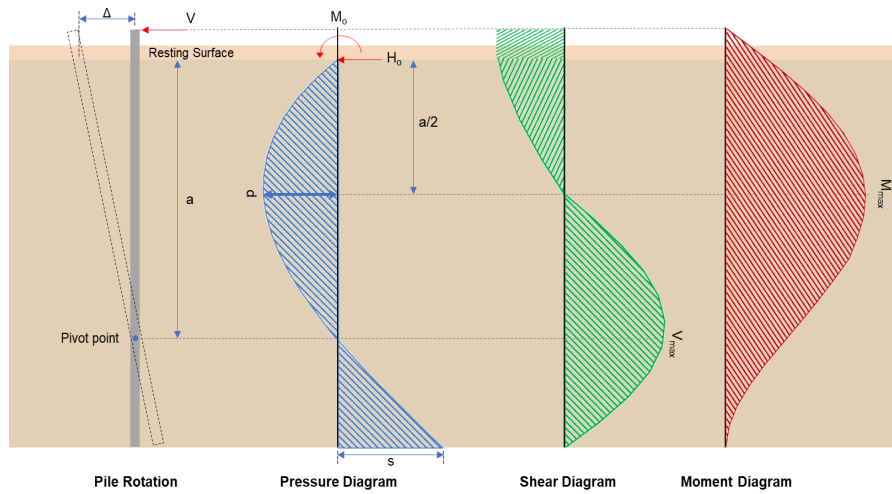
Status: **PASS**
Ratio: **0.750**

	$p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (7.5 \text{ ft})$ $p_s = 1.125 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $\text{Ratio} = \frac{s}{p_s}$ $\text{Ratio} = \frac{(1.0713 \text{ kip/ft}^2)}{(1.125 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.95228$	<p>Status: PASS Ratio: 0.950</p>
	<p>Considering z-direction:</p> <p>$H_o = 0.016561 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 0.087261 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.087261 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (0.016561 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (0.087261 \text{ kipft/ft})) + (4 \times (0.016561 \text{ kip/ft}) \times (7.5 \text{ ft}))}$ $a = 5.3043 \text{ ft}$ <p>p - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 [(4 \times (0.087261 \text{ kipft/ft})) + (3 \times (0.016561 \text{ kip/ft}) \times (7.5 \text{ ft}))]^2}{(7.5 \text{ ft})^2 [(3 \times (0.087261 \text{ kipft/ft})) + (2 \times (0.016561 \text{ kip/ft}) \times (7.5 \text{ ft}))]}$ $p = 0.01361 \text{ kip/ft}^2$ <p>s - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 [(2 \times (0.087261 \text{ kipft/ft})) + ((0.016561 \text{ kip/ft}) \times (7.5 \text{ ft}))]}{(7.5 \text{ ft})^2}$ $s = 0.031864 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p>p_a - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(5.3043 \text{ ft})}{2}$ $p_a = 0.39782 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $\text{Ratio} = \frac{p}{p_a}$ $\text{Ratio} = \frac{(0.01361 \text{ kip/ft}^2)}{(0.39782 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.034212$ <p>p_s - Allowable lateral soil pressure at depth L_e,</p> $p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (7.5 \text{ ft})$ $p_s = 1.125 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $\text{Ratio} = \frac{s}{p_s}$	<p>Status: PASS Ratio: 0.030</p>

$$Ratio = \frac{(0.031864 \text{ kip/ft}^2)}{(1.125 \text{ kip/ft}^2)}$$

$$Ratio = 0.028324$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-3.953 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.62946 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(68.404 \text{ kipft}) + ((-3.953 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 10.892 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(10.892 \text{ kipft/ft})}{(-0.62946 \text{ kip/ft})}$$

$$E = 17.304 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (10.892 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (-0.62946 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (10.892 \text{ kipft/ft})) + (4 \times (-0.62946 \text{ kip/ft}) \times (7.5 \text{ ft}))}$$

$$a = 5.1401 \text{ ft}$$

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

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

$$V_{max} = ((-0.62946 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (17.304 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.1401 \text{ ft})}{(7.5 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (17.304 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.1401 \text{ ft})}{(7.5 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 11.945 \text{ kip}$$

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

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

$$M_{max} = ((-0.62946 \text{ kip/ft}) \times (48 \text{ in}) \times (7.5 \text{ ft})) \times \left[\left(\frac{(17.304 \text{ ft})}{(7.5 \text{ ft})} + \frac{(5.1401 \text{ ft})}{2 \times (7.5 \text{ ft})} \right) - \left[\left(\frac{4 \times (17.304 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.1401 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^3 + \left[\left(\frac{3 \times (17.304 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.1401 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 43.071 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.156 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.024841 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.82 \text{ kipft}) + ((0.156 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.13057 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.13057 \text{ kipft/ft})}{(0.024841 \text{ kip/ft})}$$

$$E = 5.2564 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.13057 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (0.024841 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (0.13057 \text{ kipft/ft})) + (4 \times (0.024841 \text{ kip/ft}) \times (7.5 \text{ ft}))}$$

$$a = 5.3047 \text{ ft}$$

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

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

$$V_{max} = ((0.024841 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (5.2564 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.3047 \text{ ft})}{(7.5 \text{ ft})} \right)^2 + 4 \times \left(\frac{3 \times (5.2564 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.3047 \text{ ft})}{(7.5 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.18911 \text{ kip}$$

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

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

$$M_{max} = ((0.024841 \text{ kip/ft}) \times (48 \text{ in}) \times (7.5 \text{ ft})) \times \left[\left(\frac{(5.2564 \text{ ft})}{(7.5 \text{ ft})} + \frac{(5.3047 \text{ ft})}{2 \times (7.5 \text{ ft})} \right) - \left[\left(\frac{4 \times (5.2564 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.3047 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^3 + \left[\left(\frac{3 \times (5.2564 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.3047 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.64238 \text{ kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

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

Table 22.4.2.1

Longitudinal reinforcement:

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

22.4.2.2, 10.6.1.1

$A_{st,required}$

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

$$A_{st,required} = \text{Min} \left[\frac{\frac{(11.142 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$$

$$A_{st,required} = -84.226 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = \text{Max} [(-84.226 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$$

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

n_{rebar} - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

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

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

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

Ratio - Capacity

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

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

$$\text{Ratio} = 0.96556$$

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

25.2.3

s_{rebar} - Minimum spacing of reinforcement,

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

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

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

Ties:

25.7.2.2

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

25.7.2.1

s_{ties} - Maximum spacing of ties,

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

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

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

Summary:

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

Ties: #3(0.375 in) - 10 in

Axial Compression Strength (ACI 318-19, LRFD)

22.4.2.2

ϕP_N - Allowable axial compressive strength

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

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

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

Ratio - Capacity

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

$$\text{Ratio} = \frac{(11.142 \text{ kip})}{(2675.2 \text{ kip})}$$

$$\text{Ratio} = 0.0041649$$

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

Shear Strength (ACI 318-19, LRFD)

Parameters:

22.5.2.2

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

$$d = 0.80 D$$

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

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

22.5.5.1.3

λ_s - size effect modification factor

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

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

$$\lambda_s = 0.64282$$

22.5.5.1.1

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

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

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

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

22.5.5.1.1(a)

The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 11.142 \text{ kip} \rightarrow 11142 \text{ lbf}$,
 $V_{c,a}$ - Shear strength of concrete (a)

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(11142 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 119.97 \text{ kip}$$

22.5.5.1.2

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

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

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

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

V_c - Governing shear strength of concrete

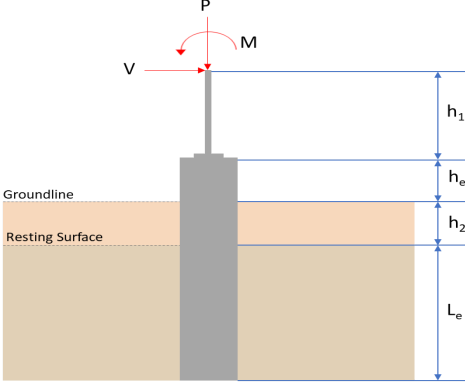
$$V_c = \text{Min}[V_{c,max}, V_{c,a}, V_{c,b}]$$

$$V_c = \text{Min}[(296.21 \text{ kip}), (119.97 \text{ kip}), (348.89 \text{ kip})]$$

$$V_c = 119.97 \text{ kip}$$

<p>22.5.1.2</p>	<p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$.</p> <p>$V_{s,a}$ - Shear strength of steel (a)</p> $V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$ $V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{s,a} = 737.28 \text{ kip}$ <p>A_v - Ties rebar area,</p> $A_v = \frac{\pi d_{ties}^2}{4}$ $A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$ $A_v = 0.11045 \text{ in}^2$ <p>22.5.8.5.3 $V_{s,b}$ - Shear strength of steel (b)</p> $V_{s,b} = \frac{2 A_v f_{yt} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$ <p>V_s - Governing shear strength of steel</p> $V_s = \text{MIN}[V_{s,a}, V_{s,b}]$ $V_s = \text{MIN}[(737.28 \text{ kip}), (50.894 \text{ kip})]$ $V_s = 50.894 \text{ kip}$ <p>22.5.1.1 ϕV_n - Allowable shear strength</p> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((119.97 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 111.06 \text{ kip}$ <p>Considering x-direction:</p> <p>$V_{max} = 11.945 \text{ kip}$ - Maximum shear force in the x-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{V_{max}}{\phi V_n}$ $\text{Ratio} = \frac{(11.945 \text{ kip})}{(111.06 \text{ kip})}$ $\text{Ratio} = 0.10755$ <p>Considering z-direction:</p> <p>$V_{max} = 0.18911 \text{ kip}$ - Maximum shear force in the z-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{V_{max}}{\phi V_n}$ $\text{Ratio} = \frac{(0.18911 \text{ kip})}{(111.06 \text{ kip})}$ $\text{Ratio} = 0.0017027$	<p>Status: PASS Ratio: 0.110</p> <p>Status: PASS Ratio: 0.000</p>
	<p>Flexural Strength (ACI 318-19, LRFD)</p> <p>S_m - Section modulus</p> $S_m = \frac{b D^2}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$	

<p>14.5.2.1b</p>	<p>$\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$</p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{2.5 \text{ksi}} \times 18432.001 \text{in}^3$ $\phi M_{n,1} = 249.600 \text{kipft}$ <p>$\phi M_{n,2}$</p> $\phi M_{n,2} = \phi \times 0.85 \times f'_c \times S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ksi}) \times (18432 \text{in}^3)$ $\phi M_{n,2} = 2121.6 \text{kipft}$ <p>Therefore, ϕM_n - Allowable flexural strength,</p> $\phi M_n = \text{MIN}[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = \text{MIN}[(249.6 \text{kipft}), (2121.6 \text{kipft})]$ $\phi M_n = 249.6 \text{kipft}$ <p>Considering x-direction: $M_{max} = 43.071 \text{kipft}$ - Maximum moment in the x-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(43.071 \text{kipft})}{(249.6 \text{kipft})}$ $\text{Ratio} = 0.17256$	<p>Status: PASS Ratio: 0.170</p>
	<p>Considering z-direction: $M_{max} = 0.64238 \text{kipft}$ - Maximum moment in the z-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(0.64238 \text{kipft})}{(249.6 \text{kipft})}$ $\text{Ratio} = 0.0025736$	<p>Status: PASS Ratio: 0.000</p>

REFERENCES	CALCULATIONS	RESULTS																										
	<p>SkyCiv Foundation Design Pile Foundation</p> <p>Design Information : Design code : IBC 2021 (International Building Code) Unit System : Imperial</p>																											
	<p>Pile Input</p>  <p>Geometry Pile shape: rectangular $b = 48$ in - Pile width $D = 48$ in - Pile depth $L = 7.5$ ft - Total pile length $h_1 = 0$ ft - Lateral load height from the top of the pile, $h_2 = 0$ ft - Depth to resting surface $h_e = 0$ ft - Length of pile above the ground</p> <p>Tabulation of Soil Parameters</p> <table border="1"> <thead> <tr> <th>Layer</th> <th>Label</th> <th>Allowable Bearing Pressure (q_n) (psf)</th> <th>Allowable Lateral Pressure (R) (psf/ft)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Sand, silty sand, clayey sand, silty gravel & clayey gravel</td> <td>2000.000</td> <td>150.000</td> </tr> </tbody> </table> <p>Tabulation of Loads</p> <table border="1"> <thead> <tr> <th>Load Component</th> <th>ASD</th> <th>LRFD</th> </tr> </thead> <tbody> <tr> <td>P (kip)</td> <td>7.283</td> <td>11.142</td> </tr> <tr> <td>V_x (kip)</td> <td>-2.368</td> <td>-3.953</td> </tr> <tr> <td>V_z (kip)</td> <td>-0.104</td> <td>-0.156</td> </tr> <tr> <td>M_x (kipft)</td> <td>-0.548</td> <td>-0.820</td> </tr> <tr> <td>M_z (kipft)</td> <td>40.417</td> <td>68.405</td> </tr> </tbody> </table> <p>Material Properties $f'_{ck} = 2.5$ ksi - Concrete strength,</p>	Layer	Label	Allowable Bearing Pressure (q_n) (psf)	Allowable Lateral Pressure (R) (psf/ft)	1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000	Load Component	ASD	LRFD	P (kip)	7.283	11.142	V_x (kip)	-2.368	-3.953	V_z (kip)	-0.104	-0.156	M_x (kipft)	-0.548	-0.820	M_z (kipft)	40.417	68.405	
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	<p>Required depth to resist lateral loads (ASD) H - Point of application of the lateral load</p> $H = h_1 + h_2 + h_e$ $H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})$ $H = 0 \text{ ft}$ <p>Considering x-direction: H_o - Lateral force per length of pile,</p> $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-2.368 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.37707 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$																											

$$M_o = \frac{(40.417 \text{ kipft}) + ((-2.368 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 6.4358 \text{ kipft/ft}$$

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:

$L_{e,x} = 7.0788 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.104 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.016561 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.548 \text{ kipft}) + ((-0.104 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.087261 \text{ kipft/ft}$$

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:

$L_{e,z} = 1.7384 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = \text{MAX}[(7.0788 \text{ ft}), (1.7384 \text{ ft})]$$

$$L_{e,req} = 7.079 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_c - h_2$$

$$L_e = (7.5 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$$

$$L_e = 7.5 \text{ ft}$$

Ratio - Embedded depth

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

$$\text{Ratio} = \frac{(7.079 \text{ ft})}{(7.5 \text{ ft})}$$

$$\text{Ratio} = 0.94387$$

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

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

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

$$q = \frac{(7.283 \text{ kip})}{(16 \text{ ft}^2)}$$

$$q = 0.45519 \text{ kip/ft}^2$$

$$q = 0.45519 \text{ kip/ft}$$

Check bearing capacity ratio:

Ratio - Capacity

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

$$\text{Ratio} = \frac{(0.45519 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$\text{Ratio} = 0.22759$$

Status: **PASS**
Ratio: **0.230**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(7.5 \text{ ft})}{(48 \text{ in})}$$

$$L/D = 1.875$$

Since $L/D \leq 10$,

Pile is short.

Considering x-direction:

$H_o = -0.37707 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 6.4358 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (6.4358 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (-0.37707 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (6.4358 \text{ kipft/ft})) + (4 \times (-0.37707 \text{ kip/ft}) \times (7.5 \text{ ft}))}$$

$$a = 5.1416 \text{ ft}$$

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

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

$$p = \frac{0.75 [(4 \times (6.4358 \text{ kipft/ft})) + (3 \times (-0.37707 \text{ kip/ft}) \times (7.5 \text{ ft}))]^2}{(7.5 \text{ ft})^2 [(3 \times (6.4358 \text{ kipft/ft})) + (2 \times (-0.37707 \text{ kip/ft}) \times (7.5 \text{ ft}))]}$$

$$p = 0.29094 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

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

$$s = \frac{6 [(2 \times (6.4358 \text{ kipft/ft})) + ((-0.37707 \text{ kip/ft}) \times (7.5 \text{ ft}))]}{(7.5 \text{ ft})^2}$$

$$s = 1.0713 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(5.1416 \text{ ft})}{2}$$

$$p_a = 0.38562 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.29094 \text{ kip/ft}^2)}{(0.38562 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.75447$$

p_a - Allowable lateral soil pressure at depth L_e ,

Status: **PASS**
Ratio: **0.750**

$$p_s = R L_e$$

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

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

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(1.0713 \text{ kip/ft}^2)}{(1.125 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.95228$$

Status: **PASS**
Ratio: **0.950**

Considering z-direction:

$H_o = -0.016561 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 0.087261 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.087261 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (-0.016561 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (0.087261 \text{ kipft/ft})) + (4 \times (-0.016561 \text{ kip/ft}) \times (7.5 \text{ ft}))}$$

$$a = 5.3043 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.087261 \text{ kipft/ft})) + (3 \times (-0.016561 \text{ kip/ft}) \times (7.5 \text{ ft}))]^2}{(7.5 \text{ ft})^2 \times [(3 \times (0.087261 \text{ kipft/ft})) + (2 \times (-0.016561 \text{ kip/ft}) \times (7.5 \text{ ft}))]}$$

$$p = 0.00055363 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

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

$$s = \frac{6 \times [(2 \times (0.087261 \text{ kipft/ft})) + ((-0.016561 \text{ kip/ft}) \times (7.5 \text{ ft}))]}{(7.5 \text{ ft})^2}$$

$$s = 0.0053673 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(5.3043 \text{ ft})}{2}$$

$$p_a = 0.39782 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.00055363 \text{ kip/ft}^2)}{(0.39782 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.0013917$$

p_s - Allowable lateral soil pressure at depth L_e ,

$$p_s = R L_e$$

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

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

Ratio - Lateral soil capacity

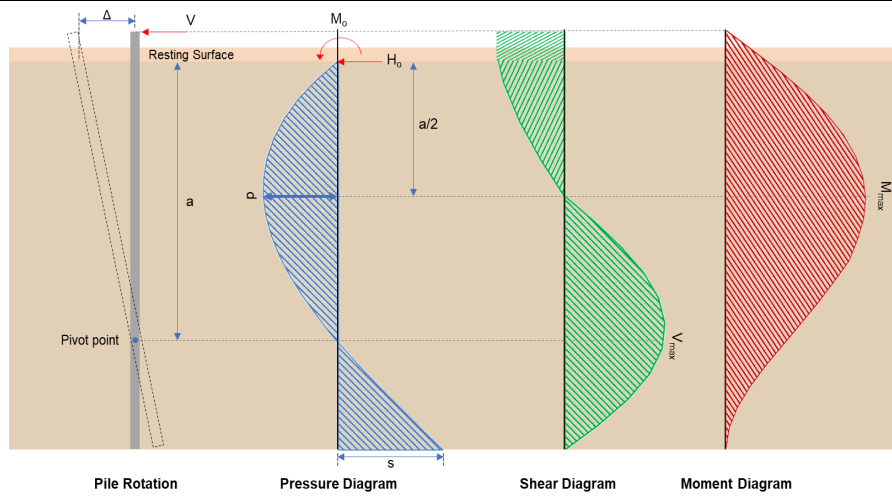
$$\text{Ratio} = \frac{s}{p_s}$$

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

$$Ratio = \frac{(0.0053673 \text{ kip/ft}^2)}{(1.125 \text{ kip/ft}^2)}$$

$$Ratio = 0.0047709$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-3.953 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.62946 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(68.405 \text{ kipft}) + ((-3.953 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 10.893 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(10.893 \text{ kipft/ft})}{(-0.62946 \text{ kip/ft})}$$

$$E = 17.305 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (10.893 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (-0.62946 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (10.893 \text{ kipft/ft})) + (4 \times (-0.62946 \text{ kip/ft}) \times (7.5 \text{ ft}))}$$

$$a = 5.1401 \text{ ft}$$

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

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

$$V_{max} = ((-0.62946 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (17.305 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.1401 \text{ ft})}{(7.5 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (17.305 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.1401 \text{ ft})}{(7.5 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 11.945 \text{ kip}$$

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

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

$$M_{max} = ((-0.62946 \text{ kip/ft}) \times (48 \text{ in}) \times (7.5 \text{ ft})) \times \left[\left(\frac{(17.305 \text{ ft})}{(7.5 \text{ ft})} + \frac{(5.1401 \text{ ft})}{2 \times (7.5 \text{ ft})} \right) - \left[\left(\frac{4 \times (17.305 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.1401 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (17.305 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.1401 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 43.072 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.156 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.024841 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.82 \text{ kipft}) + ((-0.156 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.13057 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.13057 \text{ kipft/ft})}{(-0.024841 \text{ kip/ft})}$$

$$E = 5.2564 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.13057 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (-0.024841 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (0.13057 \text{ kipft/ft})) + (4 \times (-0.024841 \text{ kip/ft}) \times (7.5 \text{ ft}))}$$

$$a = 5.3047 \text{ ft}$$

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

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

$$V_{max} = ((-0.024841 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (5.2564 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.3047 \text{ ft})}{(7.5 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (5.2564 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.3047 \text{ ft})}{(7.5 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.18911 \text{ kip}$$

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

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

$$M_{max} = ((-0.024841 \text{ kip/ft}) \times (48 \text{ in}) \times (7.5 \text{ ft})) \times \left[\left(\frac{(5.2564 \text{ ft})}{(7.5 \text{ ft})} + \frac{(5.3047 \text{ ft})}{2 \times (7.5 \text{ ft})} \right) - \left[\left(\frac{4 \times (5.2564 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left(\frac{(5.3047 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (5.2564 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left(\frac{(5.3047 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.64238 \text{ kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

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

Table 22.4.2.1

Longitudinal reinforcement:

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

22.4.2.2, 10.6.1.1

$A_{st,required}$

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

$$A_{st,required} = \text{Min} \left[\frac{\frac{(11.142 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$$

$$A_{st,required} = -84.226 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = \text{Max} [(-84.226 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$$

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

n_{rebar} - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

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

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

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

Ratio - Capacity

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

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

$$\text{Ratio} = 0.96556$$

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

25.2.3

s_{rebar} - Minimum spacing of reinforcement,

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

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

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

Ties:

25.7.2.2

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

25.7.2.1

s_{ties} - Maximum spacing of ties,

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

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

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

Summary:

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

Ties: #3(0.375 in) - 10 in

Axial Compression Strength (ACI 318-19, LRFD)

22.4.2.2

ϕP_N - Allowable axial compressive strength

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

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

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

Ratio - Capacity

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

$$\text{Ratio} = \frac{(11.142 \text{ kip})}{(2675.2 \text{ kip})}$$

$$\text{Ratio} = 0.0041649$$

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

Shear Strength (ACI 318-19, LRFD)

Parameters:

22.5.2.2

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

$$d = 0.80 D$$

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

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

22.5.5.1.3

λ_s - size effect modification factor

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

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

$$\lambda_s = 0.64282$$

22.5.5.1.1

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

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

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

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

22.5.5.1.1(a)

The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 11.142 \text{ kip} \rightarrow 11142 \text{ lbf}$,
 $V_{c,a}$ - Shear strength of concrete (a)

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(11142 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 119.97 \text{ kip}$$

22.5.5.1.2

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

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

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

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

V_c - Governing shear strength of concrete

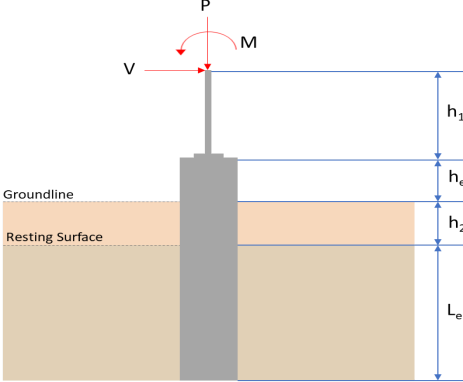
$$V_c = \text{Min}[V_{c,max}, V_{c,a}, V_{c,b}]$$

$$V_c = \text{Min}[(296.21 \text{ kip}), (119.97 \text{ kip}), (348.89 \text{ kip})]$$

$$V_c = 119.97 \text{ kip}$$

<p>22.5.1.2</p>	<p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$.</p> <p>$V_{s,a}$ - Shear strength of steel (a)</p> $V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$ $V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{s,a} = 737.28 \text{ kip}$ <p>A_v - Ties rebar area,</p> $A_v = \frac{\pi d_{ties}^2}{4}$ $A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$ $A_v = 0.11045 \text{ in}^2$ <p>22.5.8.5.3 $V_{s,b}$ - Shear strength of steel (b)</p> $V_{s,b} = \frac{2 A_v f_{yt} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$ <p>V_s - Governing shear strength of steel</p> $V_s = \text{MIN}[V_{s,a}, V_{s,b}]$ $V_s = \text{MIN}[(737.28 \text{ kip}), (50.894 \text{ kip})]$ $V_s = 50.894 \text{ kip}$ <p>22.5.1.1 ϕV_n - Allowable shear strength</p> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((119.97 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 111.06 \text{ kip}$ <p>Considering x-direction:</p> <p>$V_{max} = 11.945 \text{ kip}$ - Maximum shear force in the x-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{V_{max}}{\phi V_n}$ $\text{Ratio} = \frac{(11.945 \text{ kip})}{(111.06 \text{ kip})}$ $\text{Ratio} = 0.10755$ <p>Considering z-direction:</p> <p>$V_{max} = 0.18911 \text{ kip}$ - Maximum shear force in the z-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{V_{max}}{\phi V_n}$ $\text{Ratio} = \frac{(0.18911 \text{ kip})}{(111.06 \text{ kip})}$ $\text{Ratio} = 0.0017027$	<p>Status: PASS Ratio: 0.110</p> <p>Status: PASS Ratio: 0.000</p>
	<p>Flexural Strength (ACI 318-19, LRFD)</p> <p>S_m - Section modulus</p> $S_m = \frac{b D^2}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$	

<p>14.5.2.1b</p>	<p>$\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$</p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{2.5 \text{ksi}} \times 18432.001 \text{in}^3$ $\phi M_{n,1} = 249.600 \text{kipft}$ <p>$\phi M_{n,2}$</p> $\phi M_{n,2} = \phi \times 0.85 \times f'_c \times S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ksi}) \times (18432 \text{in}^3)$ $\phi M_{n,2} = 2121.6 \text{kipft}$ <p>Therefore, ϕM_n - Allowable flexural strength,</p> $\phi M_n = \text{MIN}[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = \text{MIN}[(249.6 \text{kipft}), (2121.6 \text{kipft})]$ $\phi M_n = 249.6 \text{kipft}$ <p>Considering x-direction: $M_{max} = 43.072 \text{kipft}$ - Maximum moment in the x-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(43.072 \text{kipft})}{(249.6 \text{kipft})}$ $\text{Ratio} = 0.17256$	<p>Status: PASS Ratio: 0.170</p>
	<p>Considering z-direction: $M_{max} = 0.64238 \text{kipft}$ - Maximum moment in the z-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(0.64238 \text{kipft})}{(249.6 \text{kipft})}$ $\text{Ratio} = 0.0025736$	<p>Status: PASS Ratio: 0.000</p>

REFERENCES	CALCULATIONS	RESULTS																										
	<p>SkyCiv Foundation Design Pile Foundation</p> <p>Design Information : Design code : IBC 2021 (International Building Code) Unit System : Imperial</p>																											
	<p>Pile Input</p>  <p>Geometry Pile shape: rectangular $b = 48$ in - Pile width $D = 48$ in - Pile depth $L = 7.75$ ft - Total pile length $h_1 = 0$ ft - Lateral load height from the top of the pile, $h_2 = 0$ ft - Depth to resting surface $h_e = 0$ ft - Length of pile above the ground</p> <p>Tabulation of Soil Parameters</p> <table border="1"> <thead> <tr> <th>Layer</th> <th>Label</th> <th>Allowable Bearing Pressure (q_a) (psf)</th> <th>Allowable Lateral Pressure (R) (psf/ft)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Sand, silty sand, clayey sand, silty gravel & clayey gravel</td> <td>2000.000</td> <td>150.000</td> </tr> </tbody> </table> <p>Tabulation of Loads</p> <table border="1"> <thead> <tr> <th>Load Component</th> <th>ASD</th> <th>LRFD</th> </tr> </thead> <tbody> <tr> <td>P (kip)</td> <td>8.193</td> <td>12.587</td> </tr> <tr> <td>V_x (kip)</td> <td>-2.629</td> <td>-4.382</td> </tr> <tr> <td>V_z (kip)</td> <td>0.020</td> <td>0.034</td> </tr> <tr> <td>M_x (kipft)</td> <td>0.100</td> <td>0.173</td> </tr> <tr> <td>M_z (kipft)</td> <td>44.875</td> <td>76.190</td> </tr> </tbody> </table> <p>Material Properties $f'_{ck} = 2.5$ ksi - Concrete strength,</p>	Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) (psf/ft)	1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000	Load Component	ASD	LRFD	P (kip)	8.193	12.587	V_x (kip)	-2.629	-4.382	V_z (kip)	0.020	0.034	M_x (kipft)	0.100	0.173	M_z (kipft)	44.875	76.190	
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M_x (kipft)	0.100	0.173																										
M_z (kipft)	44.875	76.190																										
	<p>Required depth to resist lateral loads (ASD) H - Point of application of the lateral load</p> $H = h_1 + h_2 + h_e$ $H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})$ $H = 0 \text{ ft}$ <p>Considering x-direction: H_o - Lateral force per length of pile,</p> $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-2.629 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.41863 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$																											

$$M_o = \frac{(44.875 \text{ kipft}) + ((-2.629 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 7.1457 \text{ kipft/ft}$$

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:

$L_{e,x} = 7.2961 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.02 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.0031847 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.1 \text{ kipft}) + ((0.02 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.015924 \text{ kipft/ft}$$

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:

$L_{e,z} = 1.1426 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = \text{MAX}[(7.2961 \text{ ft}), (1.1426 \text{ ft})]$$

$$L_{e,req} = 7.296 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (7.75 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$$

$$L_e = 7.75 \text{ ft}$$

Ratio - Embedded depth

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

$$\text{Ratio} = \frac{(7.296 \text{ ft})}{(7.75 \text{ ft})}$$

$$\text{Ratio} = 0.94142$$

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

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

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

$$q = \frac{(8.193 \text{ kip})}{(16 \text{ ft}^2)}$$

$$q = 0.51206 \text{ kip/ft}^2$$

$$q = 0.01200 \text{ kip/ft}$$

Check bearing capacity ratio:

Ratio - Capacity

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

$$\text{Ratio} = \frac{(0.51206 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$\text{Ratio} = 0.25603$$

Status: **PASS**
Ratio: **0.260**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(7.75 \text{ ft})}{(48 \text{ in})}$$

$$L/D = 1.9375$$

Since $L/D \leq 10$,

Pile is short.

Considering x-direction:

$H_o = -0.41863 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 7.1457 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (7.1457 \text{ kipft/ft}) \times (7.75 \text{ ft})) + (3 \times (-0.41863 \text{ kip/ft}) \times (7.75 \text{ ft})^2)}{(6 \times (7.1457 \text{ kipft/ft})) + (4 \times (-0.41863 \text{ kip/ft}) \times (7.75 \text{ ft}))}$$

$$a = 5.3167 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (7.1457 \text{ kipft/ft})) + (3 \times (-0.41863 \text{ kip/ft}) \times (7.75 \text{ ft}))]^2}{(7.75 \text{ ft})^2 \times [(3 \times (7.1457 \text{ kipft/ft})) + (2 \times (-0.41863 \text{ kip/ft}) \times (7.75 \text{ ft}))]}$$

$$p = 0.29681 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

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

$$s = \frac{6 \times [(2 \times (7.1457 \text{ kipft/ft})) + ((-0.41863 \text{ kip/ft}) \times (7.75 \text{ ft}))]}{(7.75 \text{ ft})^2}$$

$$s = 1.1036 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(5.3167 \text{ ft})}{2}$$

$$p_a = 0.39875 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.29681 \text{ kip/ft}^2)}{(0.39875 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.74433$$

p_a - Allowable lateral soil pressure at depth L_e ,

Status: **PASS**
Ratio: **0.740**

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (7.75 \text{ ft})$$

$$p_s = 1.1625 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(1.1036 \text{ kip/ft}^2)}{(1.1625 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.9493$$

Status: **PASS**
Ratio: **0.950**

Considering z-direction:

$H_o = 0.0031847 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 0.015924 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.015924 \text{ kipft/ft}) \times (7.75 \text{ ft})) + (3 \times (0.0031847 \text{ kip/ft}) \times (7.75 \text{ ft})^2)}{(6 \times (0.015924 \text{ kipft/ft})) + (4 \times (0.0031847 \text{ kip/ft}) \times (7.75 \text{ ft}))}$$

$$a = 5.4949 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.015924 \text{ kipft/ft})) + (3 \times (0.0031847 \text{ kip/ft}) \times (7.75 \text{ ft}))]^2}{(7.75 \text{ ft})^2 \times [(3 \times (0.015924 \text{ kipft/ft})) + (2 \times (0.0031847 \text{ kip/ft}) \times (7.75 \text{ ft}))]}$$

$$p = 0.0024389 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

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

$$s = \frac{6 \times [(2 \times (0.015924 \text{ kipft/ft})) + ((0.0031847 \text{ kip/ft}) \times (7.75 \text{ ft}))]}{(7.75 \text{ ft})^2}$$

$$s = 0.005647 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(5.4949 \text{ ft})}{2}$$

$$p_a = 0.41212 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.0024389 \text{ kip/ft}^2)}{(0.41212 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.0059181$$

p_s - Allowable lateral soil pressure at depth L_e ,

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (7.75 \text{ ft})$$

$$p_s = 1.1625 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

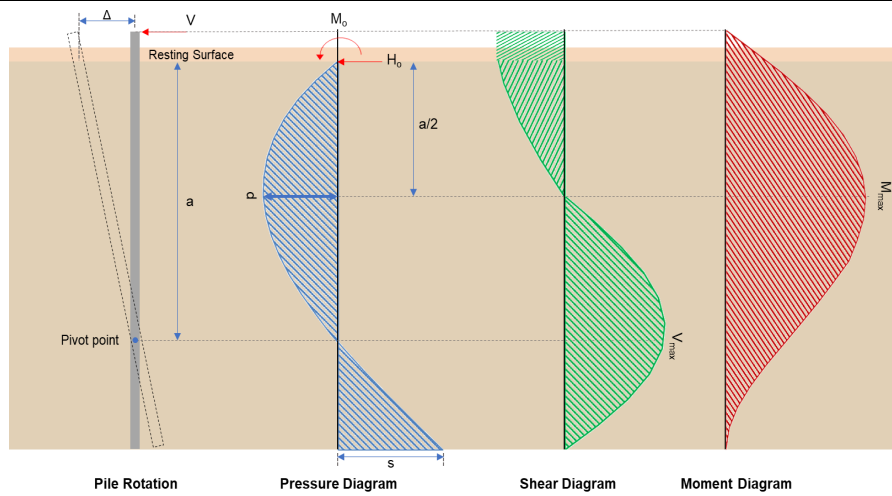
$$\text{Ratio} = \frac{s}{p_s}$$

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

$$Ratio = \frac{(0.005647 \text{ kip/ft}^2)}{(1.1625 \text{ kip/ft}^2)}$$

$$Ratio = 0.0048576$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-4.382 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.69777 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(76.19 \text{ kipft}) + ((-4.382 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 12.132 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(12.132 \text{ kipft/ft})}{(-0.69777 \text{ kip/ft})}$$

$$E = 17.387 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (12.132 \text{ kipft/ft}) \times (7.75 \text{ ft})) + (3 \times (-0.69777 \text{ kip/ft}) \times (7.75 \text{ ft})^2)}{(6 \times (12.132 \text{ kipft/ft})) + (4 \times (-0.69777 \text{ kip/ft}) \times (7.75 \text{ ft}))}$$

$$a = 5.3146 \text{ ft}$$

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

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

$$V_{max} = ((-0.69777 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (17.387 \text{ ft})}{(7.75 \text{ ft})} + 3 \right) \times \left(\frac{(5.3146 \text{ ft})}{(7.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (17.387 \text{ ft})}{(7.75 \text{ ft})} + 2 \right) \times \left(\frac{(5.3146 \text{ ft})}{(7.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 12.925 \text{ kip}$$

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

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

$$M_{max} = ((-0.69777 \text{ kip/ft}) \times (48 \text{ in}) \times (7.75 \text{ ft})) \times \left[\left(\frac{(17.387 \text{ ft})}{(7.75 \text{ ft})} + \frac{(5.3146 \text{ ft})}{2 \times (7.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (17.387 \text{ ft})}{(7.75 \text{ ft})} + 3 \right) \times \left(\frac{(5.3146 \text{ ft})}{2 \times (7.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (17.387 \text{ ft})}{(7.75 \text{ ft})} + 2 \right) \times \left(\frac{(5.3146 \text{ ft})}{2 \times (7.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 48.115 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.034 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.005414 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.173 \text{ kipft}) + ((0.034 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.027548 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.027548 \text{ kipft/ft})}{(0.005414 \text{ kip/ft})}$$

$$E = 5.0882 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.027548 \text{ kipft/ft}) \times (7.75 \text{ ft})) + (3 \times (0.005414 \text{ kip/ft}) \times (7.75 \text{ ft})^2)}{(6 \times (0.027548 \text{ kipft/ft})) + (4 \times (0.005414 \text{ kip/ft}) \times (7.75 \text{ ft}))}$$

$$a = 5.4921 \text{ ft}$$

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

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

$$V_{max} = ((0.005414 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (5.0882 \text{ ft})}{(7.75 \text{ ft})} + 3 \right) \times \left(\frac{(5.4921 \text{ ft})}{(7.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (5.0882 \text{ ft})}{(7.75 \text{ ft})} + 2 \right) \times \left(\frac{(5.4921 \text{ ft})}{(7.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.039531 \text{ kip}$$

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

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

$$M_{max} = ((0.005414 \text{ kip/ft}) \times (48 \text{ in}) \times (7.75 \text{ ft})) \times \left[\left(\frac{(5.0882 \text{ ft})}{(7.75 \text{ ft})} + \frac{(5.4921 \text{ ft})}{2 \times (7.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (5.0882 \text{ ft})}{(7.75 \text{ ft})} + 3 \right) \times \left(\frac{(5.4921 \text{ ft})}{2 \times (7.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (5.0882 \text{ ft})}{(7.75 \text{ ft})} + 2 \right) \times \left(\frac{(5.4921 \text{ ft})}{2 \times (7.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.13816 \text{ kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

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

Table 22.4.2.1

Longitudinal reinforcement:

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

22.4.2.2, 10.6.1.1

$A_{st,required}$

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

$$A_{st,required} = \text{Min} \left[\frac{\frac{(12.587 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$$

$$A_{st,required} = -84.178 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = \text{Max} [(-84.178 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$$

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

n_{rebar} - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

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

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

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

Ratio - Capacity

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

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

$$\text{Ratio} = 0.96556$$

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

25.2.3

s_{rebar} - Minimum spacing of reinforcement,

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

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

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

Ties:

25.7.2.2

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

25.7.2.1

s_{ties} - Maximum spacing of ties,

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

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

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

Summary:

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

Ties: #3(0.375 in) - 10 in

Axial Compression Strength (ACI 318-19, LRFD)

22.4.2.2

ϕP_N - Allowable axial compressive strength

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

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

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

Ratio - Capacity

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

$$\text{Ratio} = \frac{(12.587 \text{ kip})}{(2675.2 \text{ kip})}$$

$$\text{Ratio} = 0.0047051$$

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

Shear Strength (ACI 318-19, LRFD)

Parameters:

22.5.2.2

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

$$d = 0.80 D$$

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

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

22.5.5.1.3

λ_s - size effect modification factor

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

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

$$\lambda_s = 0.64282$$

22.5.5.1.1

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

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

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

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

22.5.5.1.1(a)

The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 12.587 \text{ kip} \rightarrow 12587 \text{ lbf}$,
 $V_{c,a}$ - Shear strength of concrete (a)

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(12587 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 120.16 \text{ kip}$$

22.5.5.1.2

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

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

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

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

V_c - Governing shear strength of concrete

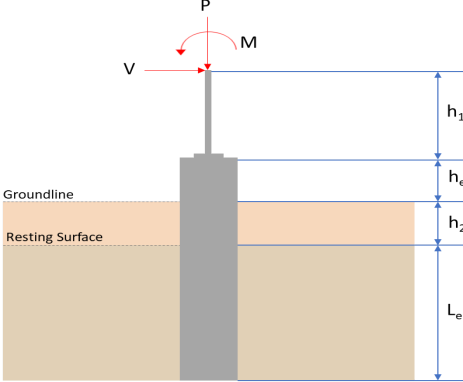
$$V_c = \text{Min}[V_{c,max}, V_{c,a}, V_{c,b}]$$

$$V_c = \text{Min}[(296.21 \text{ kip}), (120.16 \text{ kip}), (348.89 \text{ kip})]$$

$$V_c = 120.16 \text{ kip}$$

<p>22.5.1.2</p>	<p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$.</p> <p>$V_{s,a}$ - Shear strength of steel (a)</p> $V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$ $V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{s,a} = 737.28 \text{ kip}$ <p>A_v - Ties rebar area,</p> $A_v = \frac{\pi d_{ties}^2}{4}$ $A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$ $A_v = 0.11045 \text{ in}^2$ <p>22.5.8.5.3 $V_{s,b}$ - Shear strength of steel (b)</p> $V_{s,b} = \frac{2 A_v f_{yt} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$ <p>V_s - Governing shear strength of steel</p> $V_s = \text{MIN}[V_{s,a}, V_{s,b}]$ $V_s = \text{MIN}[(737.28 \text{ kip}), (50.894 \text{ kip})]$ $V_s = 50.894 \text{ kip}$ <p>22.5.1.1 ϕV_n - Allowable shear strength</p> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((120.16 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 111.19 \text{ kip}$ <p>Considering x-direction:</p> <p>$V_{max} = 12.925 \text{ kip}$ - Maximum shear force in the x-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{V_{max}}{\phi V_n}$ $\text{Ratio} = \frac{(12.925 \text{ kip})}{(111.19 \text{ kip})}$ $\text{Ratio} = 0.11625$ <p>Considering z-direction:</p> <p>$V_{max} = 0.039531 \text{ kip}$ - Maximum shear force in the z-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{V_{max}}{\phi V_n}$ $\text{Ratio} = \frac{(0.039531 \text{ kip})}{(111.19 \text{ kip})}$ $\text{Ratio} = 0.00035553$	<p>Status: PASS Ratio: 0.120</p> <p>Status: PASS Ratio: 0.000</p>
	<p>Flexural Strength (ACI 318-19, LRFD)</p> <p>S_m - Section modulus</p> $S_m = \frac{b D^2}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$	

<p>14.5.2.1b</p>	<p>$\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$</p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{2.5 \text{ksi}} \times 18432.001 \text{in}^3$ $\phi M_{n,1} = 249.600 \text{kipft}$ <p>$\phi M_{n,2}$</p> $\phi M_{n,2} = \phi \times 0.85 \times f'_c \times S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ksi}) \times (18432 \text{in}^3)$ $\phi M_{n,2} = 2121.6 \text{kipft}$ <p>Therefore, ϕM_n - Allowable flexural strength,</p> $\phi M_n = \text{MIN}[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = \text{MIN}[(249.6 \text{kipft}), (2121.6 \text{kipft})]$ $\phi M_n = 249.6 \text{kipft}$ <p>Considering x-direction: $M_{max} = 48.115 \text{kipft}$ - Maximum moment in the x-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(48.115 \text{kipft})}{(249.6 \text{kipft})}$ $\text{Ratio} = 0.19277$	<p>Status: PASS Ratio: 0.190</p>
	<p>Considering z-direction: $M_{max} = 0.13816 \text{kipft}$ - Maximum moment in the z-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(0.13816 \text{kipft})}{(249.6 \text{kipft})}$ $\text{Ratio} = 0.0005351$	<p>Status: PASS Ratio: 0.000</p>

REFERENCES	CALCULATIONS	RESULTS																										
	<p>SkyCiv Foundation Design Pile Foundation</p> <p>Design Information : Design code : IBC 2021 (International Building Code) Unit System : Imperial</p>																											
	<p>Pile Input</p>  <p>Geometry Pile shape: rectangular $b = 48$ in - Pile width $D = 48$ in - Pile depth $L = 7.75$ ft - Total pile length $h_1 = 0$ ft - Lateral load height from the top of the pile, $h_2 = 0$ ft - Depth to resting surface $h_e = 0$ ft - Length of pile above the ground</p> <p>Tabulation of Soil Parameters</p> <table border="1"> <thead> <tr> <th>Layer</th> <th>Label</th> <th>Allowable Bearing Pressure (q_a) (psf)</th> <th>Allowable Lateral Pressure (R) (psf/ft)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Sand, silty sand, clayey sand, silty gravel & clayey gravel</td> <td>2000.000</td> <td>150.000</td> </tr> </tbody> </table> <p>Tabulation of Loads</p> <table border="1"> <thead> <tr> <th>Load Component</th> <th>ASD</th> <th>LRFD</th> </tr> </thead> <tbody> <tr> <td>P (kip)</td> <td>8.193</td> <td>12.587</td> </tr> <tr> <td>V_x (kip)</td> <td>-2.629</td> <td>-4.382</td> </tr> <tr> <td>V_z (kip)</td> <td>-0.020</td> <td>-0.034</td> </tr> <tr> <td>M_x (kipft)</td> <td>-0.100</td> <td>-0.173</td> </tr> <tr> <td>M_z (kipft)</td> <td>44.875</td> <td>76.190</td> </tr> </tbody> </table> <p>Material Properties $f'_{ck} = 2.5$ ksi - Concrete strength,</p>	Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) (psf/ft)	1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000	Load Component	ASD	LRFD	P (kip)	8.193	12.587	V_x (kip)	-2.629	-4.382	V_z (kip)	-0.020	-0.034	M_x (kipft)	-0.100	-0.173	M_z (kipft)	44.875	76.190	
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	<p>Required depth to resist lateral loads (ASD) H - Point of application of the lateral load</p> $H = h_1 + h_2 + h_e$ $H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})$ $H = 0 \text{ ft}$ <p>Considering x-direction: H_o - Lateral force per length of pile,</p> $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-2.629 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.41863 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$																											

$$M_o = \frac{(44.875 \text{ kipft}) + ((-2.629 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 7.1457 \text{ kipft/ft}$$

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:

$L_{e,x} = 7.2961 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.02 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.0031847 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.1 \text{ kipft}) + ((-0.02 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.015924 \text{ kipft/ft}$$

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:

$L_{e,z} = 1.0253 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = \text{MAX}[(7.2961 \text{ ft}), (1.0253 \text{ ft})]$$

$$L_{e,req} = 7.296 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (7.75 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$$

$$L_e = 7.75 \text{ ft}$$

Ratio - Embedded depth

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

$$\text{Ratio} = \frac{(7.296 \text{ ft})}{(7.75 \text{ ft})}$$

$$\text{Ratio} = 0.94142$$

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

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

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

$$q = \frac{(8.193 \text{ kip})}{(16 \text{ ft}^2)}$$

$$q = 0.51206 \text{ kip/ft}^2$$

$$q = 0.01200 \text{ kip/ft}$$

Check bearing capacity ratio:

Ratio - Capacity

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

$$\text{Ratio} = \frac{(0.51206 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$\text{Ratio} = 0.25603$$

Status: **PASS**
Ratio: **0.260**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(7.75 \text{ ft})}{(48 \text{ in})}$$

$$L/D = 1.9375$$

Since $L/D \leq 10$,

Pile is short.

Considering x-direction:

$H_o = -0.41863 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 7.1457 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (7.1457 \text{ kipft/ft}) \times (7.75 \text{ ft})) + (3 \times (-0.41863 \text{ kip/ft}) \times (7.75 \text{ ft})^2)}{(6 \times (7.1457 \text{ kipft/ft})) + (4 \times (-0.41863 \text{ kip/ft}) \times (7.75 \text{ ft}))}$$

$$a = 5.3167 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (7.1457 \text{ kipft/ft})) + (3 \times (-0.41863 \text{ kip/ft}) \times (7.75 \text{ ft}))]^2}{(7.75 \text{ ft})^2 \times [(3 \times (7.1457 \text{ kipft/ft})) + (2 \times (-0.41863 \text{ kip/ft}) \times (7.75 \text{ ft}))]}$$

$$p = 0.29681 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

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

$$s = \frac{6 \times [(2 \times (7.1457 \text{ kipft/ft})) + ((-0.41863 \text{ kip/ft}) \times (7.75 \text{ ft}))]}{(7.75 \text{ ft})^2}$$

$$s = 1.1036 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(5.3167 \text{ ft})}{2}$$

$$p_a = 0.39875 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.29681 \text{ kip/ft}^2)}{(0.39875 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.74433$$

p_a - Allowable lateral soil pressure at depth L_e ,

Status: **PASS**
Ratio: **0.740**

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (7.75 \text{ ft})$$

$$p_s = 1.1625 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(1.1036 \text{ kip/ft}^2)}{(1.1625 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.9493$$

Status: **PASS**
Ratio: **0.950**

Considering z-direction:

$H_o = -0.0031847 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 0.015924 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.015924 \text{ kipft/ft}) \times (7.75 \text{ ft})) + (3 \times (-0.0031847 \text{ kip/ft}) \times (7.75 \text{ ft})^2)}{(6 \times (0.015924 \text{ kipft/ft})) + (4 \times (-0.0031847 \text{ kip/ft}) \times (7.75 \text{ ft}))}$$

$$a = 5.4949 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (0.015924 \text{ kipft/ft})) + (3 \times (-0.0031847 \text{ kip/ft}) \times (7.75 \text{ ft}))]^2}{(7.75 \text{ ft})^2 \times [(3 \times (0.015924 \text{ kipft/ft})) + (2 \times (-0.0031847 \text{ kip/ft}) \times (7.75 \text{ ft}))]}$$

$$p = -0.00084009 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

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

$$s = \frac{6 \times [(2 \times (0.015924 \text{ kipft/ft})) + ((-0.0031847 \text{ kip/ft}) \times (7.75 \text{ ft}))]}{(7.75 \text{ ft})^2}$$

$$s = 0.00071581 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(5.4949 \text{ ft})}{2}$$

$$p_a = 0.41212 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(-0.00084009 \text{ kip/ft}^2)}{(0.41212 \text{ kip/ft}^2)}$$

$$\text{Ratio} = -0.0020385$$

p_s - Allowable lateral soil pressure at depth L_e ,

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (7.75 \text{ ft})$$

$$p_s = 1.1625 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

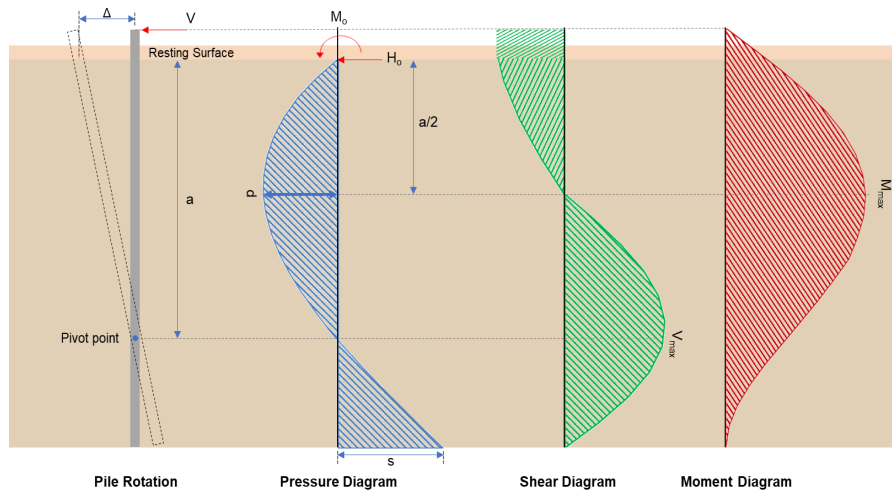
$$\text{Ratio} = \frac{s}{p_s}$$

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

$$\text{Ratio} = \frac{(0.00071581 \text{ kip/ft}^2)}{(1.1625 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.00061575$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-4.382 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.69777 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(76.19 \text{ kipft}) + ((-4.382 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 12.132 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(12.132 \text{ kipft/ft})}{(-0.69777 \text{ kip/ft})}$$

$$E = 17.387 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (12.132 \text{ kipft/ft}) \times (7.75 \text{ ft})) + (3 \times (-0.69777 \text{ kip/ft}) \times (7.75 \text{ ft})^2)}{(6 \times (12.132 \text{ kipft/ft})) + (4 \times (-0.69777 \text{ kip/ft}) \times (7.75 \text{ ft}))}$$

$$a = 5.3146 \text{ ft}$$

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

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

$$V_{max} = ((-0.69777 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (17.387 \text{ ft})}{(7.75 \text{ ft})} + 3 \right) \times \left(\frac{(5.3146 \text{ ft})}{(7.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (17.387 \text{ ft})}{(7.75 \text{ ft})} + 2 \right) \times \left(\frac{(5.3146 \text{ ft})}{(7.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 12.925 \text{ kip}$$

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

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

$$M_{max} = ((-0.69777 \text{ kip/ft}) \times (48 \text{ in}) \times (7.75 \text{ ft})) \times \left[\left(\frac{(17.387 \text{ ft})}{(7.75 \text{ ft})} + \frac{(5.3146 \text{ ft})}{2 \times (7.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (17.387 \text{ ft})}{(7.75 \text{ ft})} + 3 \right) \times \left(\frac{(5.3146 \text{ ft})}{2 \times (7.75 \text{ ft})} \right)^3 + \left[\left(\frac{3 \times (17.387 \text{ ft})}{(7.75 \text{ ft})} + 2 \right) \times \left(\frac{(5.3146 \text{ ft})}{2 \times (7.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 48.115 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.034 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.005414 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.173 \text{ kipft}) + ((-0.034 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.027548 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.027548 \text{ kipft/ft})}{(-0.005414 \text{ kip/ft})}$$

$$E = 5.0882 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.027548 \text{ kipft/ft}) \times (7.75 \text{ ft})) + (3 \times (-0.005414 \text{ kip/ft}) \times (7.75 \text{ ft})^2)}{(6 \times (0.027548 \text{ kipft/ft})) + (4 \times (-0.005414 \text{ kip/ft}) \times (7.75 \text{ ft}))}$$

$$a = 5.4921 \text{ ft}$$

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

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

$$V_{max} = ((-0.005414 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (5.0882 \text{ ft})}{(7.75 \text{ ft})} + 3 \right) \times \left(\frac{(5.4921 \text{ ft})}{(7.75 \text{ ft})} \right)^2 + 4 \times \left(\frac{3 \times (5.0882 \text{ ft})}{(7.75 \text{ ft})} + 2 \right) \times \left(\frac{(5.4921 \text{ ft})}{(7.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.039531 \text{ kip}$$

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

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

$$M_{max} = ((-0.005414 \text{ kip/ft}) \times (48 \text{ in}) \times (7.75 \text{ ft})) \times \left[\left(\frac{(5.0882 \text{ ft})}{(7.75 \text{ ft})} + \frac{(5.4921 \text{ ft})}{2 \times (7.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (5.0882 \text{ ft})}{(7.75 \text{ ft})} + 3 \right) \times \left(\frac{(5.4921 \text{ ft})}{2 \times (7.75 \text{ ft})} \right)^3 + \left[\left(\frac{3 \times (5.0882 \text{ ft})}{(7.75 \text{ ft})} + 2 \right) \times \left(\frac{(5.4921 \text{ ft})}{2 \times (7.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.13816 \text{ kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

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

Table 22.4.2.1

Longitudinal reinforcement:

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

22.4.2.2, 10.6.1.1

$A_{st,required}$

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

$$A_{st,required} = \text{Min} \left[\frac{\frac{(12.587 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$$

$$A_{st,required} = -84.178 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = \text{Max} [(-84.178 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$$

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

n_{rebar} - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

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

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

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

Ratio - Capacity

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

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

$$\text{Ratio} = 0.96556$$

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

25.2.3 s_{rebar} - Minimum spacing of reinforcement,

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

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

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

Ties:

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

25.7.2.1 s_{ties} - Maximum spacing of ties,

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

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

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

Summary:

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

Ties: #3(0.375 in) - 10 in

Axial Compression Strength (ACI 318-19, LRFD)

22.4.2.2

ϕP_N - Allowable axial compressive strength

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

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

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

Ratio - Capacity

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

$$\text{Ratio} = \frac{(12.587 \text{ kip})}{(2675.2 \text{ kip})}$$

$$\text{Ratio} = 0.0047051$$

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

Shear Strength (ACI 318-19, LRFD)

Parameters:

22.5.2.2

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

$$d = 0.80 D$$

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

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

22.5.5.1.3

λ_s - size effect modification factor

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

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

$$\lambda_s = 0.64282$$

22.5.5.1.1

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

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

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

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

22.5.5.1.1(a)

The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 12.587 \text{ kip} \rightarrow 12587 \text{ lbf}$,
 $V_{c,a}$ - Shear strength of concrete (a)

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

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(12587 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 120.16 \text{ kip}$$

22.5.5.1.2

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

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

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

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

V_c - Governing shear strength of concrete

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

$$V_c = \text{Min}[(296.21 \text{ kip}), (120.16 \text{ kip}), (348.89 \text{ kip})]$$

$$V_c = 120.16 \text{ kip}$$

<p>22.5.1.2</p>	<p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$.</p> <p>$V_{s,a}$ - Shear strength of steel (a)</p> $V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$ $V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{s,a} = 737.28 \text{ kip}$ <p>A_v - Ties rebar area,</p> $A_v = \frac{\pi d_{ties}^2}{4}$ $A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$ $A_v = 0.11045 \text{ in}^2$ <p>22.5.8.5.3 $V_{s,b}$ - Shear strength of steel (b)</p> $V_{s,b} = \frac{2 A_v f_{yt} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$ <p>V_s - Governing shear strength of steel</p> $V_s = \text{MIN}[V_{s,a}, V_{s,b}]$ $V_s = \text{MIN}[(737.28 \text{ kip}), (50.894 \text{ kip})]$ $V_s = 50.894 \text{ kip}$ <p>22.5.1.1 ϕV_n - Allowable shear strength</p> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((120.16 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 111.19 \text{ kip}$ <p>Considering x-direction:</p> <p>$V_{max} = 12.925 \text{ kip}$ - Maximum shear force in the x-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{V_{max}}{\phi V_n}$ $\text{Ratio} = \frac{(12.925 \text{ kip})}{(111.19 \text{ kip})}$ $\text{Ratio} = 0.11625$ <p>Considering z-direction:</p> <p>$V_{max} = 0.039531 \text{ kip}$ - Maximum shear force in the z-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{V_{max}}{\phi V_n}$ $\text{Ratio} = \frac{(0.039531 \text{ kip})}{(111.19 \text{ kip})}$ $\text{Ratio} = 0.00035553$	<p>Status: PASS Ratio: 0.120</p> <p>Status: PASS Ratio: 0.000</p>
	<p>Flexural Strength (ACI 318-19, LRFD)</p> <p>S_m - Section modulus</p> $S_m = \frac{b D^2}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$	

<p>14.5.2.1b</p>	<p>$\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$</p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{2.5 \text{ksi}} \times 18432.001 \text{in}^3$ $\phi M_{n,1} = 249.600 \text{kipft}$ <p>$\phi M_{n,2}$</p> $\phi M_{n,2} = \phi \times 0.85 \times f'_c \times S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ksi}) \times (18432 \text{in}^3)$ $\phi M_{n,2} = 2121.6 \text{kipft}$ <p>Therefore, ϕM_n - Allowable flexural strength,</p> $\phi M_n = \text{MIN}[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = \text{MIN}[(249.6 \text{kipft}), (2121.6 \text{kipft})]$ $\phi M_n = 249.6 \text{kipft}$ <p>Considering x-direction: $M_{max} = 48.115 \text{kipft}$ - Maximum moment in the x-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(48.115 \text{kipft})}{(249.6 \text{kipft})}$ $\text{Ratio} = 0.19277$	<p>Status: PASS Ratio: 0.190</p>
	<p>Considering z-direction: $M_{max} = 0.13816 \text{kipft}$ - Maximum moment in the z-direction, Ratio - Capacity</p> $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(0.13816 \text{kipft})}{(249.6 \text{kipft})}$ $\text{Ratio} = 0.0005351$	<p>Status: PASS Ratio: 0.000</p>