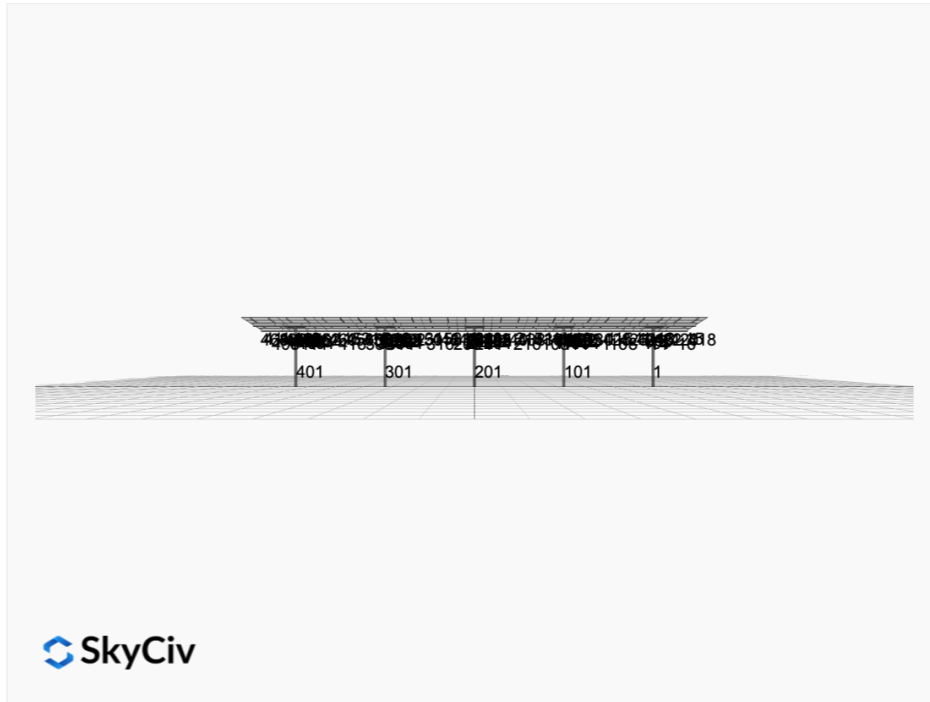


Project Details



Project Name: MTSOLAR_ODGE3JAC68E66 **Date:** Wed Apr 16 2025
Location: 123 Fake Street, Oak Lawn, IL 60453, USA **Number of Modules:** 65
Unique ID: 5P-19.75-6TOP-XD-57-L-5Hx13W-L64B **Number of Poles:** 5
Dealer: _____ **Date Sold:** _____



Array Dimensions N/S	18.85 ft
Array Dimensions E/W	98.20 ft
Winter Tilt Angle	7
Front Edge Clearance	12 ft

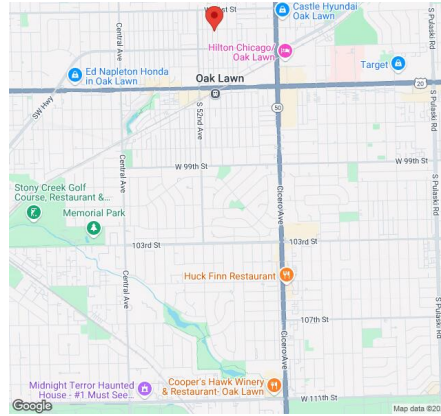
MT Solar Bill of Materials (5P-19.75-6TOP-XD-57-L-5Hx13W-L64B)

Part	Short Description	BOM Qty
MTS-PC-6	6IN Pole Cap Assembly	5
MTS-HF-XD	H-Frame Assembly-XD	5
MTS-XD-Wing-57	57IN XD Wing	4
MTS-XD-Splice-90	90IN XD Splice	8
MTS-XD-Splice-57	57IN XD Splice	8
MTS-CLAMP-ANGLE-4PK	Angle Clamp	13

Rail Bill of Materials

Part	Qty
Rails (226in)	26
Rail Attachment	104
Module Mid Clamp	104
Module End Clamp	52
Ground Lug	13

Site Details:



Site Address: 123 Fake Street, Oak Lawn, IL 60453, USA

Array Specification

Duty Classification:	XD
Module Width:	44.75 in
Module Length:	89.65in
Number of Rows:	5
Number of Columns:	13
Total Number of Modules:	65
Winter Tilt Angle:	7
Front Edge Clearance:	12
Total Array Height at Tilt:	14.30 ft
Total Frame Length:	96.00 ft
Module Info/Notes:	
Array Dimensions N/S:	18.85 ft
Array Dimensions E/W:	98.20 ft
Rail Length:	226.25 in
Rail Spacing:	3.78 ft

Support Specifications

Pole Size:	6in Pipe Sch 40
Pole Length above Grade:	13.15 ft
Number of Poles:	5
Pole Spacing:	19.75 ft

Foundation Specifications

Foundation Type:	Round
Foundation Dimensions:	Ø36 in
Foundation Depth (below grade):	Pile 1: 6.75 ft Pile 2: 6.75 ft Pile 3: 7.00 ft Pile 4: 6.75 ft Pile 5: 6.75 ft
Foundation Volume:	8.901 y ³

Site Info

Risk Category:	I
Exposure:	B
Soil Classification:	sand
Site Location:	123 Fake Street, Oak Lawn, IL 60453, USA
Wind Speed:	101 mph

Snow Load:

25 psf

Design Disclaimer

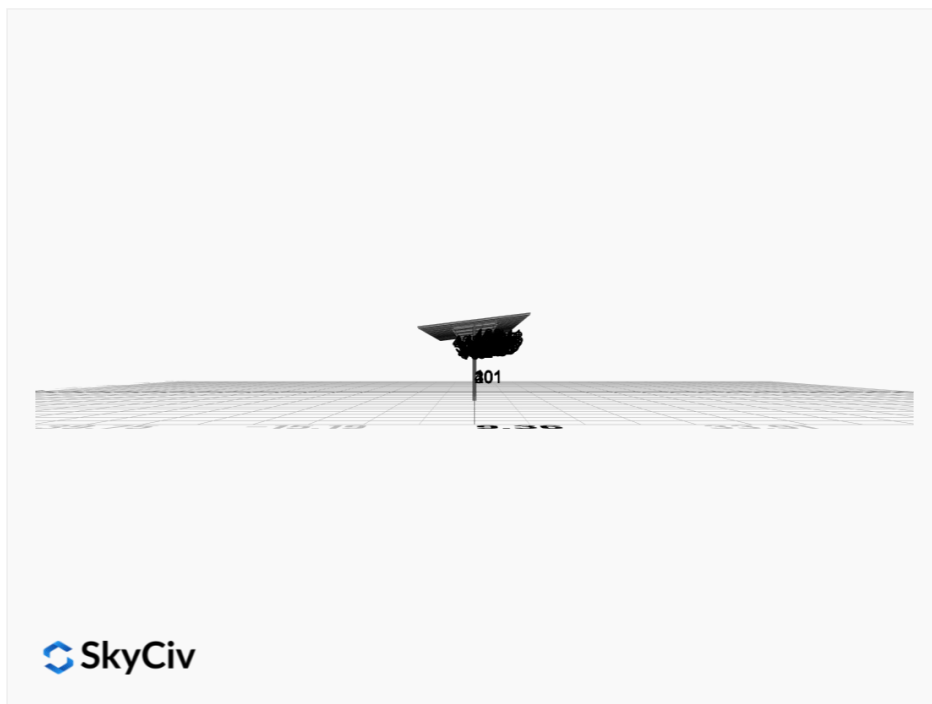
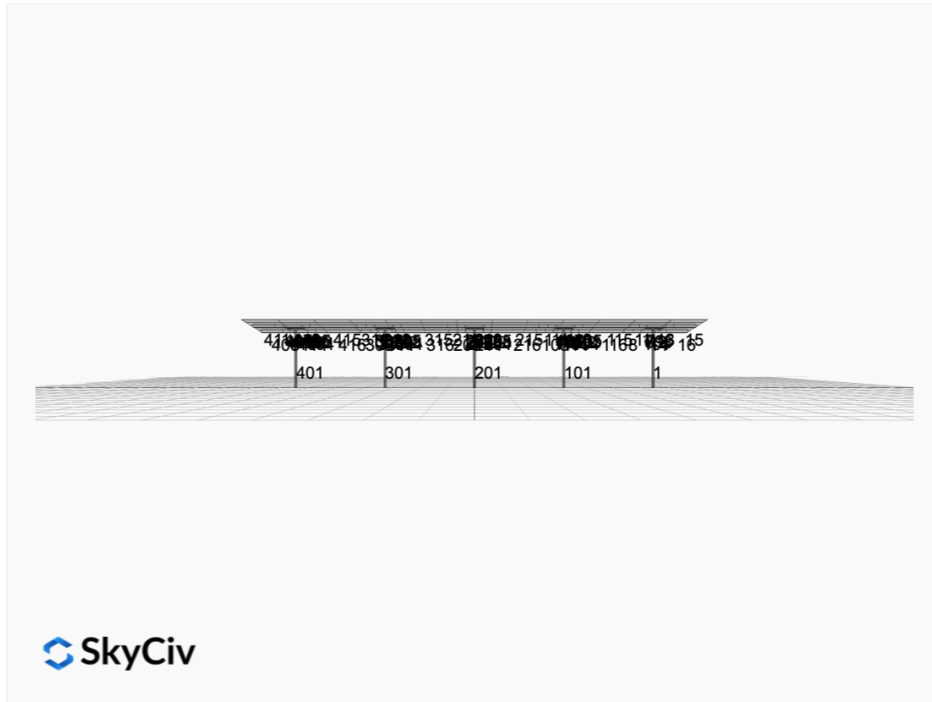
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

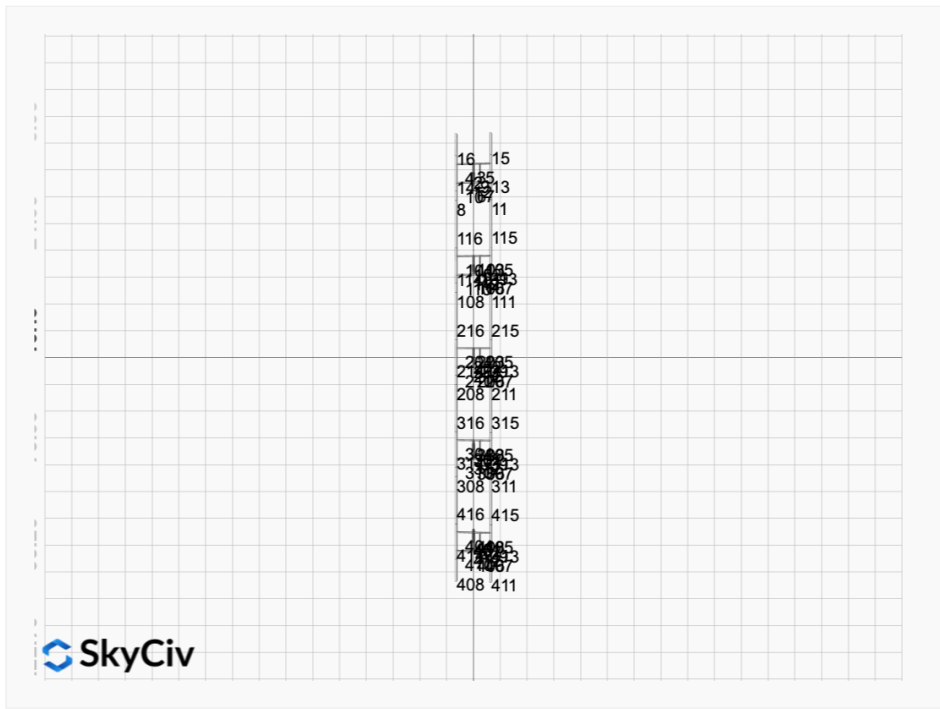
AutoDesigner Input

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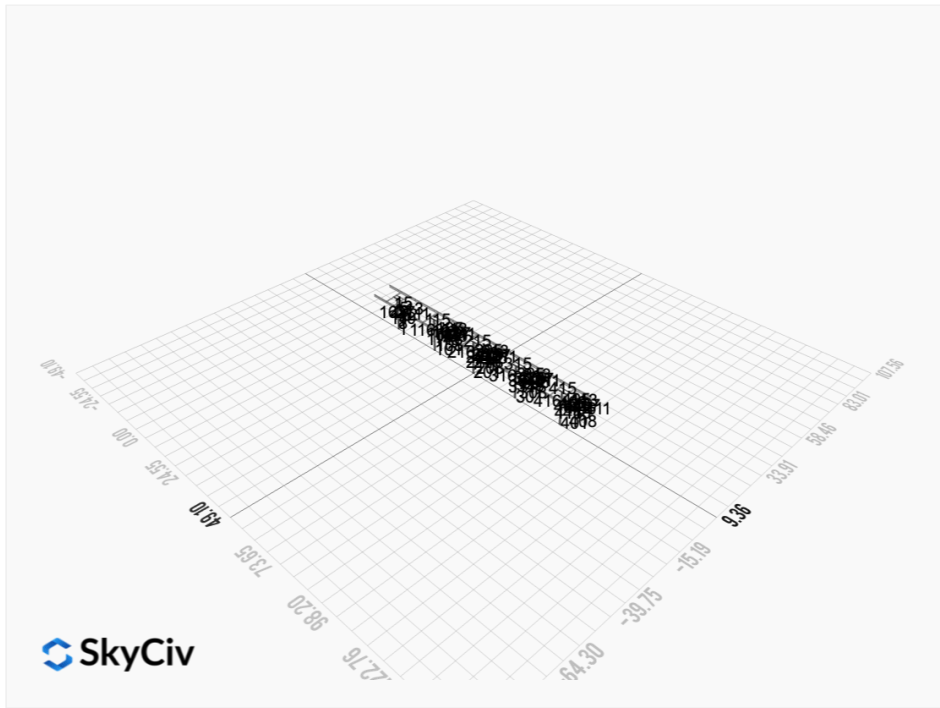
Design Notes:

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

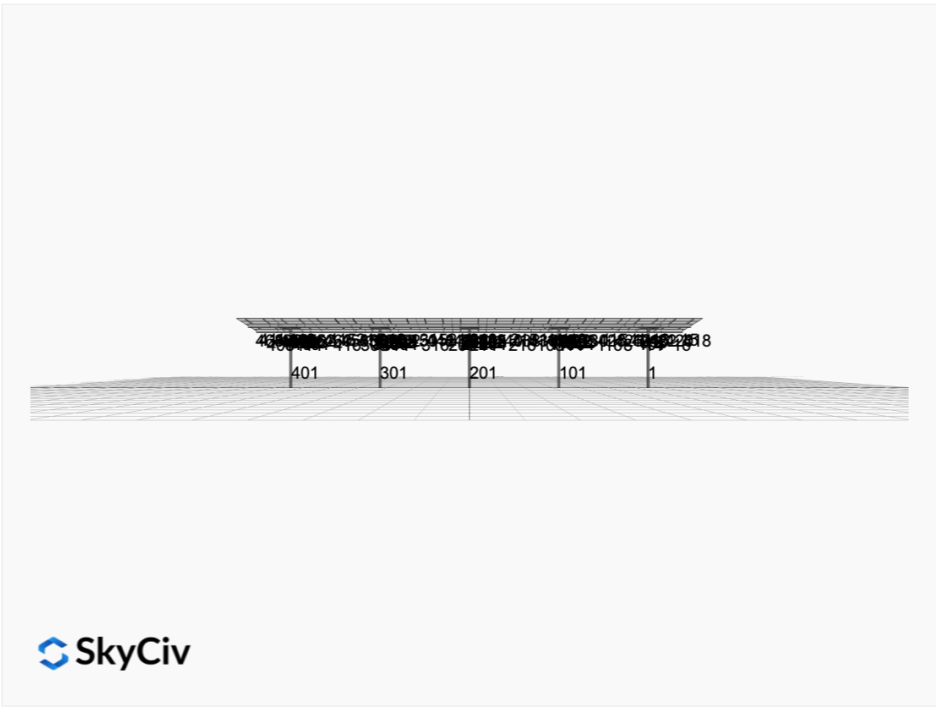




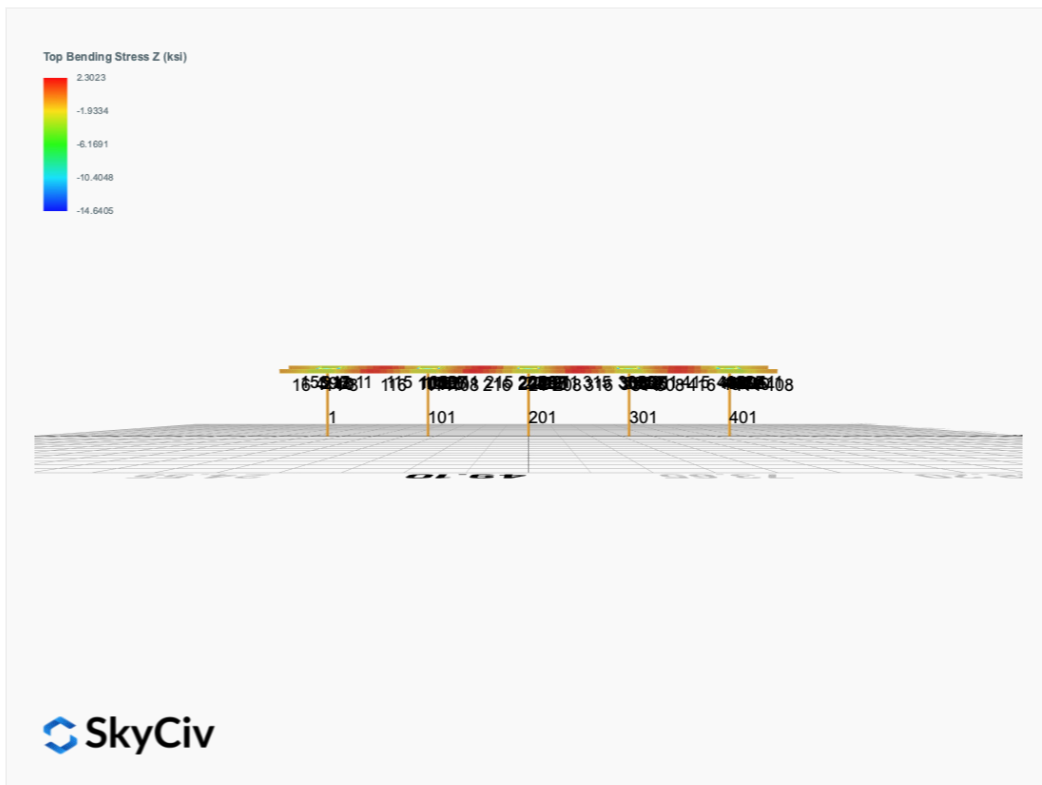
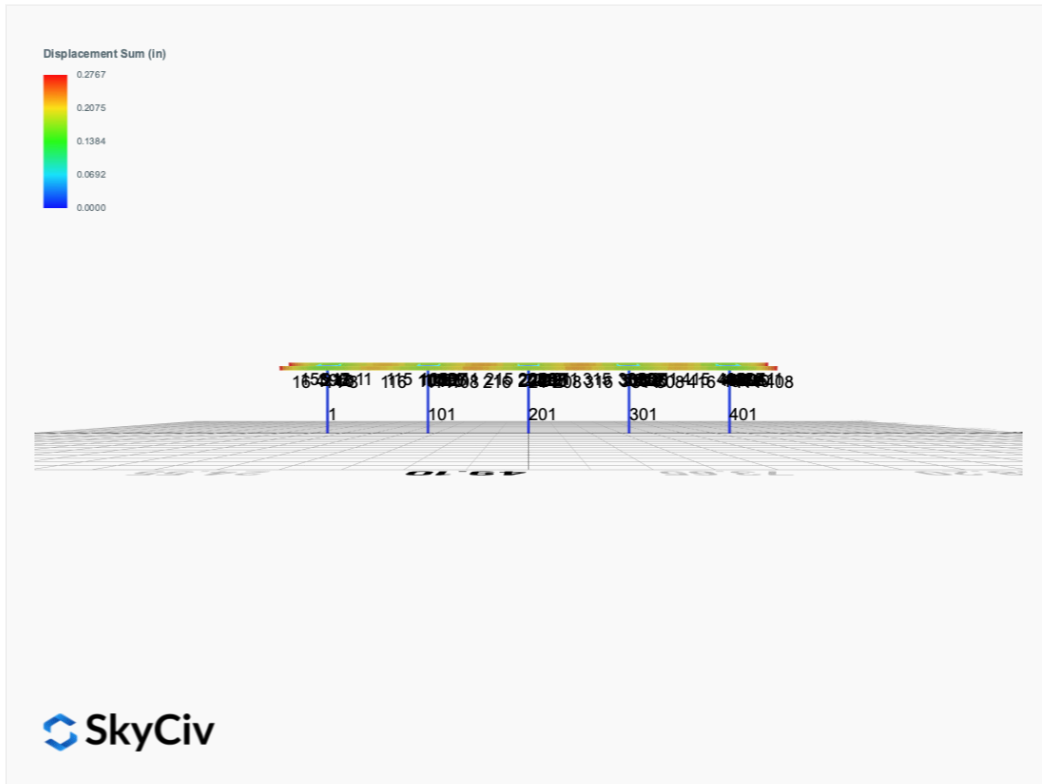
SkyCiv

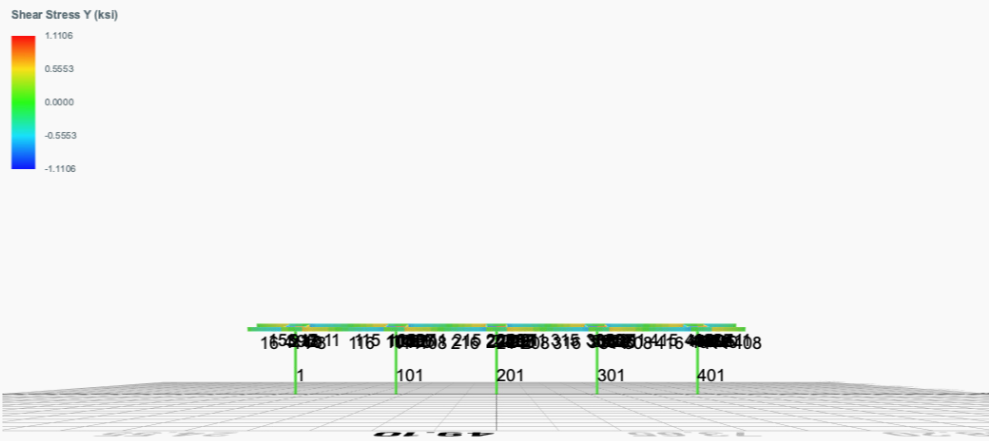
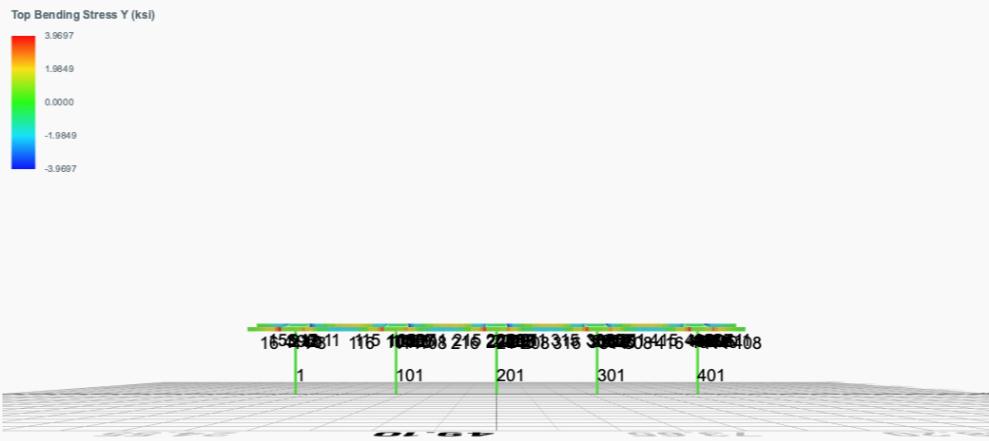


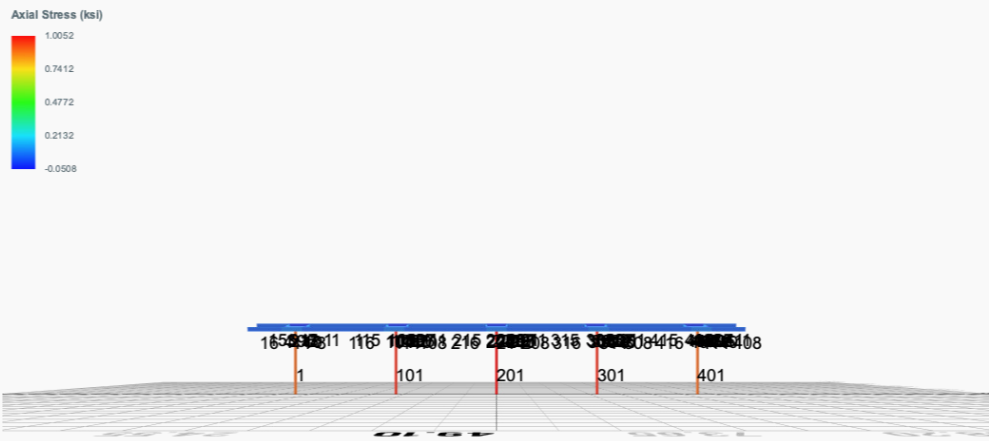
SkyCiv



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	-0.0012	2.5439	-0.0038	-0.0158	0.0034	0.0458
ULS: 2. D + L	-0.0012	2.5439	-0.0038	-0.0158	0.0034	0.0458
ULS: 3. D + (S or Lr or R)	-0.0042	7.7784	-0.0132	-0.0557	0.0121	0.0862
ULS: 3. D + (S or Lr or R)	-0.0012	2.5439	-0.0038	-0.0158	0.0034	0.0458
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0034	6.4698	-0.0108	-0.0457	0.0099	0.0761
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0012	2.5439	-0.0038	-0.0158	0.0034	0.0458
ULS: 5b. D + 0.7E	-0.0012	2.5439	-0.0038	-0.0158	0.0034	0.0458
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0034	6.4698	-0.0108	-0.0457	0.0099	0.0761
ULS: 8. 0.6D + 0.7E	-0.0007	1.5263	-0.0023	-0.0095	0.0020	0.0275
ULS: 5a. D + 0.6W_Wind downforce Case A only	-0.3313	5.1816	-0.0070	-0.0299	0.0025	6.9059
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.3313	5.1816	-0.0070	-0.0299	0.0025	6.9059
ULS: 5a. D + 0.6W_Wind uplift Case A only	0.1917	0.9738	-0.0009	-0.0038	0.0024	-0.6442
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.1986	0.9802	-0.0028	-0.0115	0.0056	-8.1867
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.2510	8.4481	-0.0133	-0.0563	0.0092	5.2212
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.2510	8.4481	-0.0133	-0.0563	0.0092	5.2212
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.1412	5.2922	-0.0087	-0.0367	0.0092	-0.4414
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.1464	5.2970	-0.0101	-0.0425	0.0115	-6.0983
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.2488	4.5222	-0.0062	-0.0264	0.0027	5.1908
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.2488	4.5222	-0.0062	-0.0264	0.0027	5.1908
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.1435	1.3663	-0.0016	-0.0068	0.0027	-0.4717
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.1486	1.3711	-0.0030	-0.0126	0.0050	-6.1286
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-0.3308	4.1641	-0.0055	-0.0236	0.0012	6.8875
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.3308	4.1641	-0.0055	-0.0236	0.0012	6.8875
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	0.1922	-0.0438	0.0006	0.0025	0.0011	-0.6625
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.1991	-0.0373	-0.0013	-0.0051	0.0042	-8.2050

Worst Case Reactions LFRD

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

Result	Value (kip, kip-ft)
Axial	13.6262
Shear X	-0.5544
Shear Z	-0.0222
Moment X	-0.0947
Moment Y (Twist)	0.0206
Moment Z	14.7853

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	8.4481
Shear X	-0.3313
Shear Z	-0.0133
Moment X	-0.0563
Moment Y (Twist)	0.0121
Moment Z	8.2050

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	0.0015	2.6621	0.0020	0.0086	-0.0007	0.0193
ULS: 2. D + L	0.0015	2.6621	0.0020	0.0086	-0.0007	0.0193
ULS: 3. D + (S or Lr or R)	0.0051	8.2039	0.0072	0.0307	-0.0026	-0.0085
ULS: 3. D + (S or Lr or R)	0.0015	2.6621	0.0020	0.0086	-0.0007	0.0193
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0042	6.8185	0.0059	0.0252	-0.0021	-0.0016

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0015	2.6621	0.0020	0.0086	-0.0007	0.0193
ULS: 5b. D + 0.7E	0.0015	2.6621	0.0020	0.0086	-0.0007	0.0193
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0042	6.8185	0.0059	0.0252	-0.0021	-0.0016
ULS: 8. 0.6D + 0.7E	0.0009	1.5972	0.0012	0.0052	-0.0004	0.0116
ULS: 5a. D + 0.6W_Wind downforce Case A only	-0.3372	5.4512	0.0058	0.0247	-0.0046	7.0947
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.3372	5.4512	0.0058	0.0247	-0.0046	7.0947
ULS: 5a. D + 0.6W_Wind uplift Case A only	0.2053	1.0010	0.0005	0.0020	-0.0002	-0.7207
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.1998	1.0097	-0.0010	-0.0039	0.0035	-8.4170
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.2498	8.9103	0.0087	0.0373	-0.0050	5.3049
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.2498	8.9103	0.0087	0.0373	-0.0050	5.3049
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.1571	5.5726	0.0047	0.0203	-0.0017	-0.5566
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.1529	5.5792	0.0036	0.0158	0.0010	-6.3288
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.2526	4.7539	0.0049	0.0207	-0.0036	5.3258
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.2526	4.7539	0.0049	0.0207	-0.0036	5.3258
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.1543	1.4162	0.0009	0.0037	-0.0003	-0.5357
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.1502	1.4228	-0.0002	-0.0008	0.0025	-6.3079
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-0.3378	4.3863	0.0050	0.0213	-0.0043	7.0869
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.3378	4.3863	0.0050	0.0213	-0.0043	7.0869
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	0.2047	-0.0639	-0.0003	-0.0014	0.0001	-0.7284
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.1992	-0.0551	-0.0018	-0.0074	0.0038	-8.4247

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	14.3856
Shear X	-0.5645
Shear Z	0.0141
Moment X	0.0607
Moment Y (Twist)	0.0089
Moment Z	15.2389

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	8.9103
Shear X	-0.3378
Shear Z	0.0087
Moment X	0.0373
Moment Y (Twist)	0.0050
Moment Z	8.4247

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	-0.0005	2.6890	-0.0000	0.0000	0.0000	0.0357
ULS: 2. D + L	-0.0005	2.6890	-0.0000	0.0000	0.0000	0.0357
ULS: 3. D + (S or Lr or R)	-0.0019	8.2995	0.0000	0.0000	-0.0000	0.0500
ULS: 3. D + (S or Lr or R)	-0.0005	2.6890	-0.0000	0.0000	0.0000	0.0357
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0015	6.8969	0.0000	0.0000	-0.0000	0.0464
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0005	2.6890	-0.0000	0.0000	0.0000	0.0357
ULS: 5b. D + 0.7E	-0.0005	2.6890	-0.0000	0.0000	0.0000	0.0357
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0015	6.8969	0.0000	0.0000	-0.0000	0.0464
ULS: 8. 0.6D + 0.7E	-0.0003	1.6134	-0.0000	0.0000	0.0000	0.0214
ULS: 5a. D + 0.6W_Wind downforce Case A only	-0.3427	5.5157	-0.0000	0.0000	0.0000	7.1964
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.3427	5.5157	-0.0000	0.0000	0.0000	7.1964
ULS: 5a. D + 0.6W_Wind uplift Case A only	0.2063	1.0057	-0.0000	0.0000	0.0000	-0.7158
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.1987	1.0143	-0.0000	0.0000	0.0000	-8.4918

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.2581	9.0169	0.0000	0.0000	-0.0000	5.4169
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.2581	9.0169	0.0000	0.0000	-0.0000	5.4169
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.1536	5.6344	0.0000	0.0000	-0.0000	-0.5172
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.1479	5.6408	0.0000	0.0000	-0.0000	-6.3492
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.2571	4.8090	-0.0000	0.0000	0.0000	5.4062
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.2571	4.8090	-0.0000	0.0000	0.0000	5.4062
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.1546	1.4265	-0.0000	0.0000	0.0000	-0.5279
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.1489	1.4330	-0.0000	0.0000	0.0000	-6.3599
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-0.3424	4.4400	-0.0000	0.0000	0.0000	7.1821
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.3424	4.4400	-0.0000	0.0000	0.0000	7.1821
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	0.2065	-0.0699	-0.0000	0.0000	0.0000	-0.7301
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.1989	-0.0613	-0.0000	0.0000	0.0000	-8.5061

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	14.5590
Shear X	-0.5704
Shear Z	-0.0000
Moment X	0.0000
Moment Y (Twist)	0.0000
Moment Z	15.3716

Worst Case Reactions ASD

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

Result	Value (kip, kip-ft)
Axial	9.0169
Shear X	-0.3427
Shear Z	-0.0000
Moment X	0.0000
Moment Y (Twist)	0.0000
Moment Z	8.5061

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	0.0015	2.6621	-0.0020	-0.0086	0.0007	0.0193
ULS: 2. D + L	0.0015	2.6621	-0.0020	-0.0086	0.0007	0.0193
ULS: 3. D + (S or Lr or R)	0.0051	8.2039	-0.0072	-0.0307	0.0026	-0.0085
ULS: 3. D + (S or Lr or R)	0.0015	2.6621	-0.0020	-0.0086	0.0007	0.0193
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0042	6.8185	-0.0059	-0.0252	0.0021	-0.0016
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0015	2.6621	-0.0020	-0.0086	0.0007	0.0193
ULS: 5b. D + 0.7E	0.0015	2.6621	-0.0020	-0.0086	0.0007	0.0193
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0042	6.8185	-0.0059	-0.0252	0.0021	-0.0016
ULS: 8. 0.6D + 0.7E	0.0009	1.5972	-0.0012	-0.0052	0.0004	0.0116
ULS: 5a. D + 0.6W_Wind downforce Case A only	-0.3372	5.4512	-0.0058	-0.0247	0.0046	7.0947
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.3372	5.4512	-0.0058	-0.0247	0.0046	7.0947
ULS: 5a. D + 0.6W_Wind uplift Case A only	0.2053	1.0010	-0.0005	-0.0020	0.0002	-0.7207
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.1998	1.0097	0.0010	0.0039	-0.0035	-8.4170
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.2498	8.9103	-0.0087	-0.0373	0.0050	5.3049
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.2498	8.9103	-0.0087	-0.0373	0.0050	5.3049
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.1571	5.5726	-0.0047	-0.0203	0.0017	-0.5566
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.1529	5.5792	-0.0036	-0.0158	-0.0010	-6.3288
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.2526	4.7539	-0.0049	-0.0207	0.0036	5.3258
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.2526	4.7539	-0.0049	-0.0207	0.0036	5.3258
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.1543	1.4162	-0.0009	-0.0037	0.0003	-0.5357
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.1502	1.4228	0.0002	0.0008	-0.0025	-6.3079

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-0.3378	4.3863	-0.0050	-0.0213	0.0043	7.0869
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.3378	4.3863	-0.0050	-0.0213	0.0043	7.0869
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	0.2047	-0.0639	0.0003	0.0014	-0.0001	-0.7284
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.1992	-0.0551	0.0018	0.0074	-0.0038	-8.4247

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	14.3856
Shear X	-0.5645
Shear Z	-0.0141
Moment X	-0.0607
Moment Y (Twist)	0.0089
Moment Z	15.2390

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	8.9103
Shear X	-0.3378
Shear Z	-0.0087
Moment X	-0.0373
Moment Y (Twist)	0.0050
Moment Z	8.4247

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

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	-0.0012	2.5439	0.0038	0.0158	-0.0034	0.0458
ULS: 2. D + L	-0.0012	2.5439	0.0038	0.0158	-0.0034	0.0458
ULS: 3. D + (S or Lr or R)	-0.0042	7.7784	0.0132	0.0557	-0.0121	0.0862
ULS: 3. D + (S or Lr or R)	-0.0012	2.5439	0.0038	0.0158	-0.0034	0.0458
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0034	6.4698	0.0108	0.0457	-0.0099	0.0761
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0012	2.5439	0.0038	0.0158	-0.0034	0.0458
ULS: 5b. D + 0.7E	-0.0012	2.5439	0.0038	0.0158	-0.0034	0.0458
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0034	6.4698	0.0108	0.0457	-0.0099	0.0761
ULS: 8. 0.6D + 0.7E	-0.0007	1.5263	0.0023	0.0095	-0.0020	0.0275
ULS: 5a. D + 0.6W_Wind downforce Case A only	-0.3313	5.1816	0.0070	0.0299	-0.0025	6.9059
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.3313	5.1816	0.0070	0.0299	-0.0025	6.9059
ULS: 5a. D + 0.6W_Wind uplift Case A only	0.1917	0.9738	0.0009	0.0038	-0.0024	-0.6442
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.1986	0.9802	0.0028	0.0115	-0.0056	-8.1867
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.2510	8.4481	0.0133	0.0563	-0.0092	5.2212
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.2510	8.4481	0.0133	0.0563	-0.0092	5.2212
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.1412	5.2922	0.0087	0.0367	-0.0092	-0.4414
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.1464	5.2970	0.0101	0.0425	-0.0115	-6.0983
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.2488	4.5222	0.0062	0.0264	-0.0027	5.1908
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.2488	4.5222	0.0062	0.0264	-0.0027	5.1908
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.1435	1.3663	0.0016	0.0068	-0.0027	-0.4717
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.1486	1.3711	0.0030	0.0126	-0.0050	-6.1286
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-0.3308	4.1641	0.0055	0.0236	-0.0012	6.8875
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.3308	4.1641	0.0055	0.0236	-0.0012	6.8875
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	0.1922	-0.0438	-0.0006	-0.0025	-0.0011	-0.6625
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.1991	-0.0373	0.0013	0.0052	-0.0042	-8.2050

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.

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	13.6262
Shear X	-0.5544
Shear Z	0.0222
Moment X	0.0947
Moment Y (Twist)	0.0206
Moment Z	14.7856

Result	Value (kip, kip-ft)
Axial	8.4481
Shear X	-0.3313
Shear Z	0.0133
Moment X	0.0563
Moment Y (Twist)	0.0121
Moment Z	8.2050

Project Details

Design Code: AISC 360-16 LRFD
 Provision: LRFD
 Country: United States

User Name: sales@mtsolar.us
 Unit System: imperial

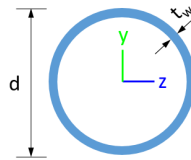


Design Input Information

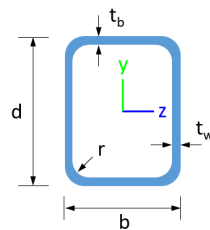
Design Factors			
Φ_t	Φ_c	Φ_b	Φ_v
0.9	0.9	0.9	0.9

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

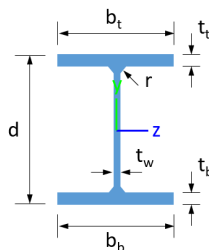
Section Dimensions



ID	Name	d (in)	t_w (in)				
3	2in Pipe Sch 120	2.38	0.25				
6	4in Pipe Sch 120	4.50	0.44				
7	6in Pipe Sch 40	6.63	0.28				



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



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

Section Properties

ID	Name	A (in ²)	J (in ⁴)	I_{yp} (in ⁴)	I_{zp} (in ⁴)	I_w (in ⁶)	S_{yp} (in ³)	S_{zp} (in ³)
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3	2in Pipe Sch 120	1.67	1.91	0.96	0.96	0.00	1.13	1.13
6	4in Pipe Sch 120	5.58	23.29	11.64	11.64	0.00	7.24	7.24
7	6in Pipe Sch 40	5.58	56.28	28.14	28.14	0.00	11.28	11.28
17	HSS5x3x1/4	3.37	11.00	4.81	10.70	0.93	3.77	5.38
20	W10x12	3.54	0.05	2.18	53.80	50.90	1.74	12.60

Member Properties

Member ID	Section ID	K _z L (ft)	K _y L (ft)	L _b (ft)	C _b	LS T	LS C	L D
1	7	27.61	27.61	13.15	-	30	20	1
2	6	1.30	1.30	2.00	-	30	20	1
3	17	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.19,1.02,1.18,1.18,1.21,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.1	30	20	1
4	17	2.44	2.44	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.70,1.68,1.67,1.67,1.62,1.69,1.67,1.67,1.67,1.67,1.68,1.68,1.7	30	20	1
5	17	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.68,1.47,1.67,1.67,1.71,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.6	30	20	1
6	17	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.19,1.08,1.18,1.18,1.21,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.1	30	20	1
7	17	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.68,1.56,1.67,1.67,1.71,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.6	30	20	1
8	20	1.33	1.33	2.05	2.12,2.12,2.12,2.12,2.12,2.12,2.11,2.11,2.11,2.36,2.11,2.11,2.34,2.35,2.12,2.12,2.12,2.18,2.11,2.11,2.1	30	20	1
9	3	2.60	2.60	4.00	-	30	20	1
10	17	2.44	2.44	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.70,1.68,1.67,1.67,1.62,1.69,1.67,1.67,1.67,1.67,1.68,1.68,1.7	30	20	1
11	20	1.33	1.33	2.05	2.12,2.12,2.12,2.12,2.12,2.12,2.20,2.20,2.18,1.46,2.22,2.22,2.38,2.34,2.15,2.15,2.13,2.11,2.19,2.19,2.1	30	20	1
12	6	1.30	1.30	2.00	-	30	20	1
13	20	4.88	4.00	7.50	1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,4.30,1.09,1.09,1.13,1.10,1.09,1.09,1.09,1.09,1.09,1.09,1.0	30	20	1
14	20	4.88	4.00	7.50	1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.13,1.10,1.09,1.09,1.09,1.09,1.09,1.09,1.0	30	20	1
15	20	9.97	9.97	4.75	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.3	30	20	1
16	20	9.97	9.97	4.75	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.3	30	20	1
101	7	27.61	27.61	13.15	-	30	20	1
102	6	1.30	1.30	2.00	-	30	20	1
103	17	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.18,1.05,1.18,1.18,1.21,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.1	30	20	1
104	17	2.44	2.44	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.69,1.68,1.67,1.67,1.62,1.69,1.67,1.67,1.67,1.67,1.68,1.68,1.7	30	20	1
105	17	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.68,1.44,1.67,1.67,1.71,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.6	30	20	1
106	17	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.18,1.04,1.18,1.18,1.21,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.1	30	20	1
107	17	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.68,1.53,1.67,1.67,1.71,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.6	30	20	1
108	20	1.33	1.33	2.05	2.07,2.07,2.07,2.07,2.07,2.07,2.07,2.07,2.06,2.07,2.07,2.07,2.08,2.06,2.07,2.07,2.07,2.07,2.07,2.07,2.0	30	20	1
109	3	2.60	2.60	4.00	-	30	20	1
110	17	2.44	2.44	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.69,1.68,1.67,1.67,1.62,1.69,1.67,1.67,1.67,1.67,1.68,1.68,1.7	30	20	1
111	20	1.33	1.33	2.05	2.07,2.07,2.07,2.07,2.07,2.07,2.07,2.07,2.07,1.40,2.07,2.07,2.08,2.06,2.07,2.07,2.07,2.07,2.07,2.07,2.0	30	20	1
112	6	1.30	1.30	2.00	-	30	20	1

113	20	4.88	4.00	7.50	1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.03,1.04,1.04,1.11,1.11,1.04,1.04,1.04,1.04,1.04,1.04,1.0	300	200	1
114	20	4.88	4.00	7.50	1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.09,1.11,1.04,1.04,1.04,1.04,1.04,1.04,1.0	300	200	1
115	20	6.63	6.63	10.20	1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.18,1.14,1.14,1.15,1.13,1.15,1.15,1.15,1.15,1.15,1.15,1.1	300	200	1
116	20	6.63	6.63	10.20	1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.15,1.14,1.15,1.15,1.15,1.13,1.15,1.15,1.15,1.15,1.15,1.1	300	200	1
201	7	27.61	27.61	13.15	-	300	200	1
202	6	1.30	1.30	2.00	-	300	200	1
203	17	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.18,1.01,1.18,1.18,1.21,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.1	300	200	1
204	17	2.44	2.44	3.75	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.69,1.68,1.67,1.67,1.62,1.69,1.67,1.67,1.67,1.67,1.68,1.68,1.7	300	200	1
205	17	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.68,1.51,1.67,1.67,1.71,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.6	300	200	1
206	17	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.18,1.01,1.18,1.18,1.21,1.17,1.18,1.18,1.18,1.18,1.18,1.1	300	200	1
207	17	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.68,1.51,1.67,1.67,1.71,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.6	300	200	1
208	20	1.33	1.33	2.05	2.08,2.08,2.08,2.08,2.08,2.08,2.09,2.09,2.08,2.07,2.09,2.09,2.08,2.06,2.08,2.08,2.08,2.08,2.08,2.0	300	200	1
209	3	2.60	2.60	4.00	-	300	200	1
210	17	2.44	2.44	3.75	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.69,1.68,1.67,1.67,1.62,1.69,1.67,1.67,1.67,1.67,1.68,1.68,1.7	300	200	1
211	20	1.33	1.33	2.05	2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,1.22,2.07,2.07,2.07,2.06,2.08,2.08,2.08,2.09,2.08,2.08,2.0	300	200	1
212	6	1.30	1.30	2.00	-	300	200	1
213	20	4.88	4.00	7.50	1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.03,1.04,1.04,1.09,1.08,1.04,1.04,1.04,1.04,1.04,1.04,1.0	300	200	1
214	20	4.88	4.00	7.50	1.04,1.04,1.04,1.04,1.04,1.04,1.03,1.03,1.03,1.04,1.03,1.03,1.07,1.08,1.04,1.04,1.04,1.04,1.03,1.03,1.0	300	200	1
215	20	6.63	6.63	10.20	1.15,1.16,1.15,1.16,1.15,1.15,1.15,1.15,1.15,1.15,1.07,1.15,1.15,1.15,1.14,1.15,1.15,1.16,1.16,1.15,1.15,1.1	300	200	1
216	20	6.63	6.63	10.20	1.15,1.15,1.15,1.16,1.15,1.15,1.16,1.16,1.15,1.15,1.16,1.16,1.16,1.15,1.16,1.16,1.16,1.15,1.16,1.16,1.1	300	200	1
301	7	27.61	27.61	13.15	-	300	200	1
302	6	1.30	1.30	2.00	-	300	200	1
303	17	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.18,1.04,1.18,1.18,1.21,1.17,1.18,1.18,1.18,1.18,1.18,1.1	300	200	1
304	17	2.44	2.44	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.69,1.68,1.67,1.67,1.62,1.69,1.67,1.67,1.67,1.67,1.68,1.68,1.7	300	200	1
305	17	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.68,1.53,1.67,1.67,1.71,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.6	300	200	1
306	17	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.18,1.05,1.18,1.18,1.21,1.17,1.18,1.18,1.18,1.18,1.18,1.1	300	200	1
307	17	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.68,1.44,1.67,1.67,1.71,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.6	300	200	1
308	20	1.33	1.33	2.05	2.07,2.07,2.07,2.07,2.07,2.07,2.07,2.07,2.07,2.06,2.08,2.08,2.07,2.05,2.07,2.07,2.07,2.07,2.07,2.0	300	200	1
309	3	2.60	2.60	4.00	-	300	200	1
310	17	2.44	2.44	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.69,1.68,1.67,1.67,1.62,1.69,1.67,1.67,1.67,1.67,1.68,1.68,1.7	300	200	1
311	20	1.33	1.33	2.05	2.07,2.07,2.07,2.07,2.07,2.07,2.07,2.07,2.07,2.07,1.09,2.07,2.07,2.07,1.99,2.07,2.07,2.07,2.08,2.07,2.0	300	200	1
312	6	1.30	1.30	2.00	-	300	200	1
313	20	4.88	4.00	7.50	1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.03,1.04,1.04,1.11,1.11,1.04,1.04,1.04,1.04,1.04,1.04,1.0	300	200	1
314	20	4.88	4.00	7.50	1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.04,1.09,1.11,1.04,1.04,1.04,1.04,1.04,1.04,1.0	300	200	1

104	151.65	145.15	20.17	14.14	54.12	28.95
105	151.65	149.10	20.17	14.14	54.12	28.95
106	151.65	150.70	20.17	14.14	54.12	28.95
107	151.65	149.10	20.17	14.14	54.12	28.95
108	159.30	140.46	46.90	6.46	56.26	44.91
109	75.10	66.32	4.25	4.25	22.53	22.53
110	151.65	145.15	20.17	14.14	54.12	28.95
111	159.30	140.46	46.90	6.46	56.26	44.91
112	251.01	248.88	27.16	27.16	75.30	75.30
113	159.30	97.43	30.74	6.46	56.26	44.91
114	159.30	97.43	31.60	6.46	56.26	44.91
115	159.30	75.13	21.48	6.46	56.26	44.91
116	159.30	75.13	21.76	6.46	56.26	44.91
201	251.16	57.91	42.30	42.30	75.35	75.35
202	251.01	248.88	27.16	27.16	75.30	75.30
203	151.65	150.70	20.17	14.14	54.12	28.95
204	151.65	145.15	20.17	14.14	54.12	28.95
205	151.65	149.10	20.17	14.14	54.12	28.95
206	151.65	150.70	20.17	14.14	54.12	28.95
207	151.65	149.10	20.17	14.14	54.12	28.95
208	159.30	140.46	46.90	6.46	56.26	44.91
209	75.10	66.32	4.25	4.25	22.53	22.53
210	151.65	145.15	20.17	14.14	54.12	28.95
211	159.30	140.46	46.90	6.46	56.26	44.91
212	251.01	248.88	27.16	27.16	75.30	75.30
213	159.30	97.43	30.64	6.46	56.26	44.91
214	159.30	97.43	31.53	6.46	56.26	44.91
215	159.30	75.13	20.53	6.46	56.26	44.91
216	159.30	75.13	22.02	6.46	56.26	44.91
301	251.16	57.91	42.30	42.30	75.35	75.35
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	140.46	46.90	6.46	56.26	44.91
309	75.10	66.32	4.25	4.25	22.53	22.53
310	151.65	145.15	20.17	14.14	54.12	28.95
311	159.30	140.46	46.90	6.46	56.26	44.91
312	251.01	248.88	27.16	27.16	75.30	75.30
313	159.30	97.43	30.73	6.46	56.26	44.91
314	159.30	97.43	31.61	6.46	56.26	44.91
315	159.30	75.13	21.35	6.46	56.26	44.91
316	159.30	75.13	22.01	6.46	56.26	44.91
401	251.16	57.91	42.30	42.30	75.35	75.35
402	251.01	248.88	27.16	27.16	75.30	75.30
403	151.65	150.70	20.17	14.14	54.12	28.95
404	151.65	145.15	20.17	14.14	54.12	28.95
405	151.65	149.10	20.17	14.14	54.12	28.95
406	151.65	150.70	20.17	14.14	54.12	28.95
407	151.65	145.15	20.17	14.14	54.12	28.95

407	151.05	149.10	20.17	14.14	54.12	28.95
408	159.30	34.37	46.90	6.46	56.26	44.91
409	75.10	66.32	4.25	4.25	22.53	22.53
410	151.65	145.15	20.17	14.14	54.12	28.95
411	159.30	34.37	46.90	6.46	56.26	44.91
412	251.01	248.88	27.16	27.16	75.30	75.30
413	159.30	97.43	32.25	6.46	56.26	44.91
414	159.30	97.43	33.18	6.46	56.26	44.91
415	159.30	75.13	22.50	6.46	56.26	44.91
416	159.30	75.13	22.47	6.46	56.26	44.91

Design Ratio

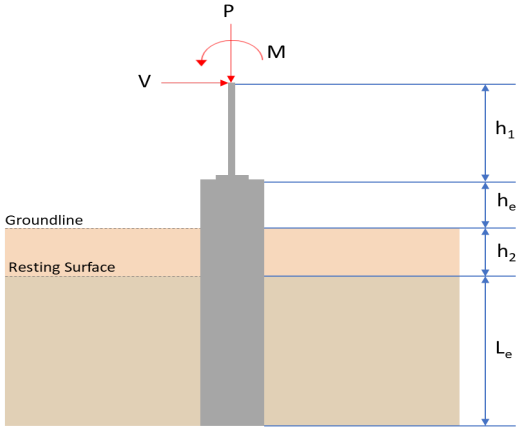
Member ID	P	M _z	M _y	V _y	V _z	(P,M _z ,M _y)	Worst LC	KL/r	δ	Status
1	0.235	0.350	0.005	0.007	0.000	0.382	#13	0.738	Not Required	Pass
2	0.001	0.433	0.025	0.089	0.004	0.457	#21	0.036	Not Required	Pass
3	0.002	0.633	0.012	0.063	0.001	0.646	#21	0.046	Not Required	Pass
4	0.002	0.587	0.040	0.059	0.008	0.612	#21	0.082	Not Required	Pass
5	0.002	0.392	0.042	0.063	0.011	0.402	#21	0.076	Not Required	Pass
6	0.002	0.628	0.013	0.063	0.001	0.642	#21	0.046	Not Required	Pass
7	0.002	0.389	0.044	0.062	0.012	0.401	#21	0.076	Not Required	Pass
8	0.000	0.039	0.048	0.037	0.005	0.082	#24	0.102	Not Required	Pass
9	0.004	0.068	0.011	0.001	0.000	0.080	#21	0.206	Not Required	Pass
10	0.002	0.581	0.044	0.058	0.010	0.610	#21	0.082	Not Required	Pass
11	0.000	0.042	0.048	0.040	0.005	0.083	#21	0.102	Not Required	Pass
12	0.001	0.425	0.024	0.088	0.004	0.449	#21	0.036	Not Required	Pass
13	0.002	0.247	0.117	0.052	0.006	0.346	#21	0.306	Not Required	Pass
14	0.002	0.234	0.117	0.048	0.006	0.330	#21	0.204	Not Required	Pass
15	0.000	0.087	0.062	0.031	0.004	0.149	#21	Not Required	Not Required	Pass
16	0.000	0.081	0.062	0.028	0.004	0.143	#21	Not Required	Not Required	Pass
101	0.248	0.360	0.003	0.007	0.000	0.395	#13	0.738	Not Required	Pass
102	0.001	0.448	0.025	0.093	0.004	0.472	#21	0.036	Not Required	Pass
103	0.002	0.664	0.015	0.066	0.002	0.680	#21	0.046	Not Required	Pass
104	0.002	0.616	0.040	0.062	0.009	0.645	#21	0.082	Not Required	Pass
105	0.002	0.412	0.041	0.066	0.010	0.422	#21	0.076	Not Required	Pass
106	0.002	0.669	0.016	0.067	0.003	0.685	#21	0.046	Not Required	Pass
107	0.002	0.415	0.041	0.066	0.010	0.425	#21	0.076	Not Required	Pass
108	0.000	0.049	0.043	0.036	0.005	0.066	#21	0.102	Not Required	Pass
109	0.004	0.068	0.011	0.001	0.000	0.080	#21	0.206	Not Required	Pass
110	0.002	0.620	0.039	0.062	0.009	0.646	#21	0.082	Not Required	Pass
111	0.000	0.052	0.044	0.039	0.005	0.069	#21	0.102	Not Required	Pass
112	0.001	0.453	0.025	0.094	0.004	0.476	#21	0.036	Not Required	Pass
113	0.002	0.202	0.112	0.051	0.006	0.292	#21	0.306	Not Required	Pass
114	0.002	0.193	0.112	0.047	0.006	0.280	#21	0.306	Not Required	Pass
115	0.000	0.231	0.061	0.039	0.005	0.292	#21	0.507	Not Required	Pass
116	0.000	0.216	0.061	0.036	0.005	0.277	#21	0.507	Not Required	Pass
201	0.251	0.363	0.000	0.008	0.000	0.399	#13	0.738	Not Required	Pass
202	0.001	0.456	0.025	0.095	0.004	0.480	#21	0.036	Not Required	Pass
203	0.002	0.674	0.015	0.068	0.002	0.690	#21	0.046	Not Required	Pass
204	0.002	0.626	0.040	0.063	0.009	0.654	#21	0.082	Not Required	Pass
205	0.002	0.418	0.042	0.067	0.011	0.429	#21	0.076	Not Required	Pass

206	0.002	0.674	0.015	0.068	0.002	0.690	#21	0.046	Not Required	Pass
207	0.002	0.418	0.042	0.067	0.011	0.429	#21	0.076	Not Required	Pass
208	0.000	0.046	0.044	0.037	0.005	0.074	#21	0.102	Not Required	Pass
209	0.004	0.068	0.011	0.001	0.000	0.080	#21	0.206	Not Required	Pass
210	0.002	0.626	0.040	0.063	0.009	0.654	#21	0.082	Not Required	Pass
211	0.000	0.050	0.045	0.040	0.005	0.076	#21	0.102	Not Required	Pass
212	0.001	0.456	0.025	0.095	0.004	0.480	#21	0.036	Not Required	Pass
213	0.002	0.208	0.113	0.051	0.006	0.300	#21	0.306	Not Required	Pass
214	0.003	0.201	0.112	0.047	0.006	0.288	#21	0.306	Not Required	Pass
215	0.001	0.243	0.060	0.040	0.005	0.303	#21	0.507	Not Required	Pass
216	0.000	0.225	0.061	0.037	0.005	0.286	#21	0.507	Not Required	Pass
301	0.248	0.360	0.003	0.007	0.000	0.395	#13	0.738	Not Required	Pass
302	0.001	0.453	0.025	0.094	0.004	0.476	#21	0.036	Not Required	Pass
303	0.002	0.669	0.016	0.067	0.003	0.685	#21	0.046	Not Required	Pass
304	0.002	0.620	0.039	0.062	0.009	0.646	#21	0.082	Not Required	Pass
305	0.002	0.415	0.041	0.066	0.010	0.425	#21	0.076	Not Required	Pass
306	0.002	0.664	0.015	0.066	0.002	0.680	#21	0.046	Not Required	Pass
307	0.002	0.412	0.041	0.066	0.010	0.422	#21	0.076	Not Required	Pass
308	0.000	0.046	0.044	0.036	0.005	0.071	#21	0.102	Not Required	Pass
309	0.004	0.068	0.011	0.001	0.000	0.080	#21	0.206	Not Required	Pass
310	0.002	0.616	0.040	0.062	0.009	0.645	#21	0.082	Not Required	Pass
311	0.000	0.049	0.044	0.039	0.005	0.074	#21	0.102	Not Required	Pass
312	0.001	0.448	0.025	0.093	0.004	0.472	#21	0.036	Not Required	Pass
313	0.002	0.202	0.112	0.051	0.006	0.292	#21	0.306	Not Required	Pass
314	0.002	0.193	0.112	0.047	0.006	0.280	#21	0.306	Not Required	Pass
315	0.001	0.244	0.060	0.039	0.005	0.304	#21	0.507	Not Required	Pass
316	0.000	0.226	0.061	0.036	0.005	0.287	#21	0.507	Not Required	Pass
401	0.235	0.350	0.005	0.007	0.000	0.382	#13	0.738	Not Required	Pass
402	0.001	0.425	0.024	0.088	0.004	0.449	#21	0.036	Not Required	Pass
403	0.002	0.628	0.013	0.063	0.001	0.642	#21	0.046	Not Required	Pass
404	0.002	0.581	0.044	0.058	0.010	0.610	#21	0.082	Not Required	Pass
405	0.002	0.389	0.044	0.062	0.012	0.401	#21	0.076	Not Required	Pass
406	0.002	0.633	0.012	0.063	0.001	0.646	#21	0.046	Not Required	Pass
407	0.002	0.392	0.042	0.063	0.011	0.402	#21	0.076	Not Required	Pass
408	0.000	0.081	0.062	0.028	0.004	0.143	#21	Not Required	Not Required	Pass
409	0.004	0.068	0.011	0.001	0.000	0.080	#21	0.206	Not Required	Pass
410	0.002	0.587	0.040	0.059	0.008	0.612	#21	0.082	Not Required	Pass
411	0.000	0.087	0.062	0.031	0.004	0.149	#21	Not Required	Not Required	Pass
412	0.001	0.433	0.025	0.089	0.004	0.457	#21	0.036	Not Required	Pass
413	0.002	0.247	0.117	0.052	0.006	0.346	#21	0.204	Not Required	Pass
414	0.002	0.234	0.117	0.048	0.006	0.330	#21	0.306	Not Required	Pass
415	0.000	0.227	0.061	0.040	0.005	0.287	#21	0.507	Not Required	Pass
416	0.000	0.212	0.061	0.037	0.005	0.273	#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</p> <p>Pile shape: round $D = 36$ in - Pile diameter $L = 6.75$ ft - Total pile length $h_1 = 0$ ft - Lateral load height from the top of the pile, $h_2 = 0$ ft - Depth to resisting surface $h_e = 0$ ft - Length of pile above the ground</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>8.448</td> <td>13.626</td> </tr> <tr> <td>V_x (kip)</td> <td>-0.331</td> <td>-0.554</td> </tr> <tr> <td>V_z (kip)</td> <td>-0.013</td> <td>-0.022</td> </tr> <tr> <td>M_x (kipft)</td> <td>-0.056</td> <td>-0.095</td> </tr> <tr> <td>M_z (kipft)</td> <td>8.205</td> <td>14.785</td> </tr> </tbody> </table> <p>Material Properties</p> <p>$f'_{ck} = 2.5$ 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)	8.448	13.626	V_x (kip)	-0.331	-0.554	V_z (kip)	-0.013	-0.022	M_x (kipft)	-0.056	-0.095	M_z (kipft)	8.205	14.785	
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)	8.448	13.626																										
V_x (kip)	-0.331	-0.554																										
V_z (kip)	-0.013	-0.022																										
M_x (kipft)	-0.056	-0.095																										
M_z (kipft)	8.205	14.785																										
	<p>Required depth to resist lateral loads (ASD)</p> <p>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:</p> <p>H_o - Lateral force per length of pile,</p> $H_o = \frac{V_x}{D}$ $H_o = \frac{(-0.331 \text{ kip})}{(36 \text{ in})}$ $H_o = -0.11033 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p>																											

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

$$M_o = \frac{(8.205 \text{ kipft}) + ((-0.331 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 2.735 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$L_{e,x} = 6.5107 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

$$H_o = \frac{V_z}{D}$$

$$H_o = \frac{(-0.013 \text{ kip})}{(36 \text{ in})}$$

$$H_o = -0.0043333 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.056 \text{ kipft}) + ((-0.013 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 0.018667 \text{ kipft/ft}$$

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:

$L_{e,z} = 1.2266 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = \text{MAX}[(6.5107 \text{ ft}), (1.2266 \text{ ft})]$$

$$L_{e,req} = 6.511 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

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

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

Ratio - Embedded depth

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

$$\text{Ratio} = \frac{(6.511 \text{ ft})}{(6.75 \text{ ft})}$$

$$\text{Ratio} = 0.96459$$

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

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = \pi \left(\frac{D}{2}\right)^2$$

$$A = \pi \times \left(\frac{(36 \text{ in})}{2}\right)^2$$

$$A = 7.0686 \text{ ft}^2$$

q - End-bearing pressure

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

$$q = \frac{(8.448 \text{ kip})}{(7.0686 \text{ ft}^2)}$$

$$q = 1.1951 \text{ kip/ft}^2$$

Check bearing capacity ratio:

Ratio - Capacity

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

$$\text{Ratio} = \frac{(1.1951 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$\text{Ratio} = 0.59757$$

Status: **PASS**
Ratio: **0.600**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(6.75 \text{ ft})}{(36 \text{ in})}$$

$$L/D = 2.25$$

Since $L/D \leq 10$,

Pile is short.

Considering x-direction:

$H_o = -0.11033 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 2.735 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (2.735 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.11033 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (2.735 \text{ kipft/ft})) + (4 \times (-0.11033 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.5864 \text{ ft}$$

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

$$p = \frac{1.178 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$$

$$p = \frac{1.178 \times [(4 \times (2.735 \text{ kipft/ft})) + (3 \times (-0.11033 \text{ kip/ft}) \times (6.75 \text{ ft}))]^2}{(6.75 \text{ ft})^2 \times [(3 \times (2.735 \text{ kipft/ft})) + (2 \times (-0.11033 \text{ kip/ft}) \times (6.75 \text{ ft}))]}$$

$$p = 0.29179 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

$$s = \frac{9.425 [(2 M_o) + (H_o L_e)]}{L_e^2}$$

$$s = \frac{9.425 \times [(2 \times (2.735 \text{ kipft/ft})) + ((-0.11033 \text{ kip/ft}) \times (6.75 \text{ ft}))]}{(6.75 \text{ ft})^2}$$

$$s = 0.97746 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(4.5864 \text{ ft})}{2}$$

$$p_a = 0.34398 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.29179 \text{ kip/ft}^2)}{(0.34398 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.84827$$

p_s - Allowable lateral soil pressure at depth L_e ,

$$p_s = R L_e$$

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

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

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.97746 \text{ kip/ft}^2)}{(1.0125 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.96539$$

Status: **PASS**
Ratio: **0.850**

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

Considering z-direction:

$H_o = -0.0043333 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 0.018667 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.018667 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.0043333 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (0.018667 \text{ kipft/ft})) + (4 \times (-0.0043333 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.7874 \text{ ft}$$

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

$$p = \frac{1.178 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$$

$$p = \frac{1.178 \times [(4 \times (0.018667 \text{ kipft/ft})) + (3 \times (-0.0043333 \text{ kip/ft}) \times (6.75 \text{ ft}))]^2}{(6.75 \text{ ft})^2 \times [(3 \times (0.018667 \text{ kipft/ft})) + (2 \times (-0.0043333 \text{ kip/ft}) \times (6.75 \text{ ft}))]}$$

$$p = -0.0017702 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

$$s = \frac{9.425 [(2 M_o) + (H_o L_e)]}{L_e^2}$$

$$s = \frac{9.425 \times [(2 \times (0.018667 \text{ kipft/ft})) + ((-0.0043333 \text{ kip/ft}) \times (6.75 \text{ ft}))]}{(6.75 \text{ ft})^2}$$

$$s = 0.0016721 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(4.7874 \text{ ft})}{2}$$

$$p_a = 0.35905 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(-0.0017702 \text{ kip/ft}^2)}{(0.35905 \text{ kip/ft}^2)}$$

$$(0.0000 \text{ kip/ft}^2)$$

$$\text{Ratio} = -0.0049303$$

p_s - Allowable lateral soil pressure at depth L_e ,

$$p_s = R L_e$$

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

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

Ratio - Lateral soil capacity

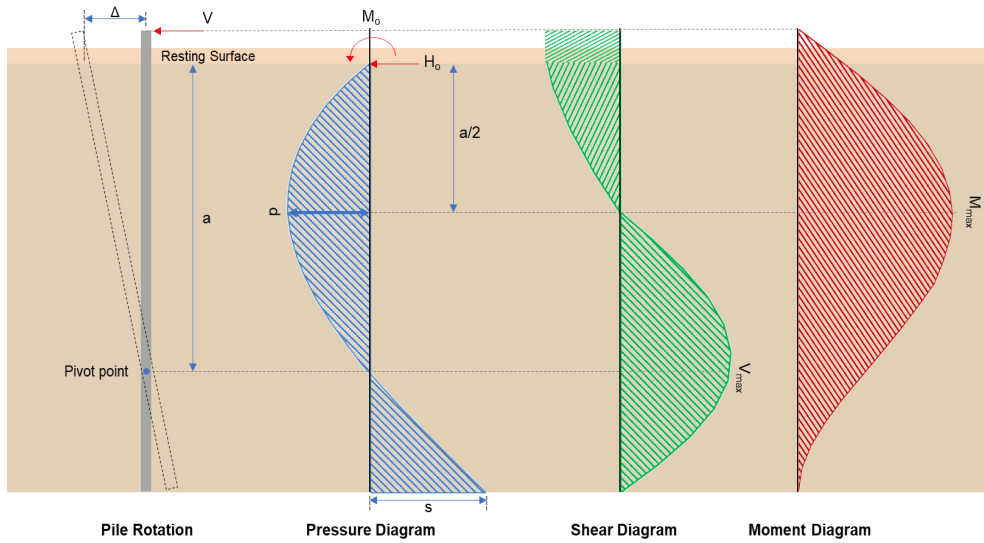
$$\text{Ratio} = \frac{s}{p_s}$$

$$\text{Ratio} = \frac{(0.0016721 \text{ kip/ft}^2)}{(1.0125 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.0016515$$

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

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.554 \text{ kip})}{(36 \text{ in})}$$

$$H_o = -0.18467 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(14.785 \text{ kipft}) + ((-0.554 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 4.9283 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(4.9283 \text{ kipft/ft})}{(-0.18467 \text{ kip/ft})}$$

$$E = 26.688 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (4.9283 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.18467 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (4.9283 \text{ kipft/ft})) + (4 \times (-0.18467 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.5812 \text{ ft}$$

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

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

$$V_{max} = ((-0.18467 \text{ kip/ft}) \times (36 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (26.688 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.5812 \text{ ft})}{(6.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (26.688 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.5812 \text{ ft})}{(6.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 4.2473 \text{ kip}$$

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

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

$$M_{max} = ((-0.18467 \text{ kip/ft}) \times (36 \text{ in}) \times (6.75 \text{ ft})) \times \left[\left(\frac{(26.688 \text{ ft})}{(6.75 \text{ ft})} + \frac{(4.5812 \text{ ft})}{2 \times (6.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (26.688 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.5812 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (26.688 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.5812 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 13.992 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

$$H_o = \frac{V_z}{D}$$

$$H_o = \frac{(-0.022 \text{ kip})}{(36 \text{ in})}$$

$$H_o = -0.0073333 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.095 \text{ kipft}) + ((-0.022 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 0.031667 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.031667 \text{ kipft/ft})}{(-0.0073333 \text{ kip/ft})}$$

$$E = 4.3182 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.031667 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.0073333 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (0.031667 \text{ kipft/ft})) + (4 \times (-0.0073333 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.787 \text{ ft}$$

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

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

$$[\setminus L_e \ / \setminus L_e /]]$$

$$V_{max} = ((-0.0073333 \text{ kip/ft}) \times (36 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (4.3182 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.787 \text{ ft})}{(6.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (4.3182 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.787 \text{ ft})}{(6.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.039509 \text{ kip}$$

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

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

$$M_{max} = ((-0.0073333 \text{ kip/ft}) \times (36 \text{ in}) \times (6.75 \text{ ft})) \times \left[\left(\frac{(4.3182 \text{ ft})}{(6.75 \text{ ft})} + \frac{(4.787 \text{ ft})}{2 \times (6.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (4.3182 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.787 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (4.3182 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.787 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.12005 \text{ kipft}$$

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,

$\alpha = 0.85$ - Alpha factor for axial strength,

$A_g = 1017.9 \text{ in}^2$ - Gross area of concrete,

Longitudinal reinforcement:

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

$A_{st,required}$

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

$$A_{st,required} = \text{Min} \left[\frac{\frac{(13.626 \text{ kip})}{(0.65) \times (0.85)} - (0.85 \times (2.5 \text{ ksi}) \times (1017.9 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (1017.9 \text{ in}^2)) \right]$$

$$A_{st,required} = -36.947 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = \text{Max} [(-36.947 \text{ in}^2), (0.0018 \times (1017.9 \text{ in}^2))]$$

$$A_{min} = 1.8322 \text{ in}^2$$

n_{rebar} - Required number of reinforcement,

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

$$n_{rebar} = \frac{(1.8322 \text{ in}^2)}{(0.3068 \text{ in}^2)}$$

$$n_{rebar} = 6$$

A_{st} - Actual total reinforcement area,

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

$$A_{st} = (6) \times \frac{\pi \times (0.625 \text{ in})^2}{4}$$

$$A_{st} = 1.8408 \text{ in}^2$$

Ratio - Capacity

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

$$= \frac{(1.8322 \text{ in}^2)}{(1.8408 \text{ in}^2)}$$

Table 22.4.2.1

22.4.2.2, 10.6.1.1

<p>25.2.3</p> <p>25.7.2.2</p> <p>25.7.2.1</p>	<p style="text-align: center;">$Ratio = \frac{\lambda}{(1.8408 \text{ in}^2)}$</p> <p style="text-align: center;">$Ratio = 0.99533$</p> <p>$s_{rebar} = Max [1.5, (1.5 d_{bar})]$</p> <p>$s_{rebar} = Max [1.5, (1.5 \times (0.625 \text{ in}))]$</p> <p style="text-align: center;">$s_{rebar} = 1.5 \text{ in}$</p> <p>Ties:</p> <p>Since longitudinal reinforcement is \leq No. 10\emptyset: Use #3(0.375 in)</p> <p>$s_{ties} = Max [16 d_{bar}, (48 d_{ties}), D]$</p> <p>$s_{ties} = Min [(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), (36 \text{ in})]$</p> <p style="text-align: center;">$s_{ties} = 10 \text{ in}$</p> <p>Summary:</p> <p style="text-align: center;">Main reinforcement: 6 - #5 (0.625 in) Ties: #3(0.375 in) - 10 in</p>	<p>Status: PASS Ratio: 1.000</p>
<p>22.4.2.2</p>	<p>Axial Compression Strength (ACI 318-19, LRFD)</p> <p>ϕP_N - Allowable axial compressive strength</p> <p style="text-align: center;">$\phi P_N = \phi 0.85 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st})]$</p> <p style="text-align: center;">$\phi P_N = (0.65) \times 0.85 \times [(0.85 \times (2.5 \text{ ksi}) \times [(1017.9 \text{ in}^2) - (1.8408 \text{ in}^2)]) + ((60 \text{ ksi}) \times (1.8408 \text{ in}^2))]$</p> <p style="text-align: center;">$\phi P_N = 1253.9 \text{ kip}$</p> <p>Ratio - Capacity</p> <p style="text-align: center;">$Ratio = \frac{P}{\phi P_N}$</p> <p style="text-align: center;">$Ratio = \frac{(13.626 \text{ kip})}{(1253.9 \text{ kip})}$</p> <p style="text-align: center;">$Ratio = 0.010867$</p>	<p>Status: PASS Ratio: 0.010</p>
<p>22.5.2.2</p> <p>22.5.5.1.3</p> <p>22.5.5.1.1</p>	<p>Shear Strength (ACI 318-19, LRFD)</p> <p>Parameters:</p> <p>$b_w = 36 \text{ in}$ - Effective width, d - Effective depth</p> <p style="text-align: center;">$d = 0.80 D$</p> <p style="text-align: center;">$d = 0.80 \times (36 \text{ in})$</p> <p style="text-align: center;">$d = 28.8 \text{ in}$</p> <p>λ_s - size effect modification factor</p> <p style="text-align: center;">$\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$</p> <p style="text-align: center;">$\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{(28.8 \text{ in})}{10}}}, 1 \right]$</p> <p style="text-align: center;">$\lambda_s = 0.71796$</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>$V_{c,max}$ - Max shear strength of concrete</p> <p style="text-align: center;">$V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$</p> <p style="text-align: center;">$V_{c,max} = 5 \times (0.71796) \times \sqrt{(2500 \text{ psi})} \times (36 \text{ in}) \times (28.8 \text{ in})$</p>	

$$V_{c,max} = 186.09 \text{ kip}$$

22.5.5.1.1(a) The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 13.626 \text{ kip} \rightarrow 13626 \text{ lbf}$,
 $V_{c,a}$ - Shear strength of concrete (a)

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

$$V_{c,a} = \left[2 \times (0.71796) \times \sqrt{(2500 \text{ psi})} + \frac{(13626 \text{ lbf})}{6 \times (1017.9 \text{ in}^2)} \right] \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{c,a} = 76.751 \text{ kip}$$

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)

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

$$V_{c,b} = \left[2 \times (0.71796) \times \sqrt{(2500 \text{ psi})} + (0.05 \times (2500 \text{ psi})) \right] \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{c,b} = 204.04 \text{ kip}$$

V_c - Governing shear strength of concrete

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

$$V_c = \text{Min}[(186.09 \text{ kip}), (76.751 \text{ kip}), (204.04 \text{ kip})]$$

$$V_c = 76.751 \text{ kip}$$

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

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

$$V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{s,a} = 414.72 \text{ kip}$$

A_v - Ties rebar area,

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

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

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

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

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

$$V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (28.8 \text{ in})}{(10 \text{ in})}$$

$$V_{s,b} = 38.17 \text{ kip}$$

V_s - Governing shear strength of steel

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

$$V_s = \text{MIN}[(414.72 \text{ kip}), (38.17 \text{ kip})]$$

$$V_s = 38.17 \text{ kip}$$

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((76.751 \text{ kip}) + (38.17 \text{ kip}))$$

$$\phi V_n = 74.699 \text{ kip}$$

Considering x-direction:

$V_{max} = 4.2473 \text{ kip}$ - Maximum shear force in the x-direction,

Ratio - Capacity

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

$$Ratio = \frac{(4.2473 \text{ kip})}{(74.699 \text{ kip})}$$

$$Ratio = 0.056859$$

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

Considering z-direction:

$V_{max} = 0.039509 \text{ kip}$ - Maximum shear force in the z-direction,
Ratio - Capacity

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

$$Ratio = \frac{(0.039509 \text{ kip})}{(74.699 \text{ kip})}$$

$$Ratio = 0.00052892$$

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

Flexural Strength (ACI 318-19, LFRD)

S_m - Section modulus

$$S_m = \frac{\pi D^3}{32}$$

$$S_m = \frac{\pi \times (36 \text{ in})^3}{32}$$

$$S_m = 4580.4 \text{ in}^3$$

$\lambda = 1$ - Concrete modification factor (Normal concrete),

Allowable flexural strength:

M_n shall be the lesser of:

$\phi M_{n,1}$

$$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$$

$$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 \text{ ksi})} \times 4580.442 \text{ in}^3$$

$$\phi M_{n,1} = 62.027 \text{ kipft}$$

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

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

$$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (4580.4 \text{ in}^3)$$

$$\phi M_{n,2} = 527.23 \text{ kipft}$$

Therefore,

ϕM_n - Allowable flexural strength,

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

$$\phi M_n = \text{MIN}[(62.027 \text{ kipft}), (527.23 \text{ kipft})]$$

$$\phi M_n = 62.027 \text{ kipft}$$

Considering x-direction:

$M_{max} = 13.992 \text{ kipft}$ - Maximum moment in the x-direction,

Ratio - Capacity

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

$$Ratio = \frac{(13.992 \text{ kipft})}{(62.027 \text{ kipft})}$$

$$Ratio = 0.22558$$

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

Considering z-direction:

$M_{max} = 0.12005 \text{ kipft}$ - Maximum moment in the z-direction,

Ratio - Capacity

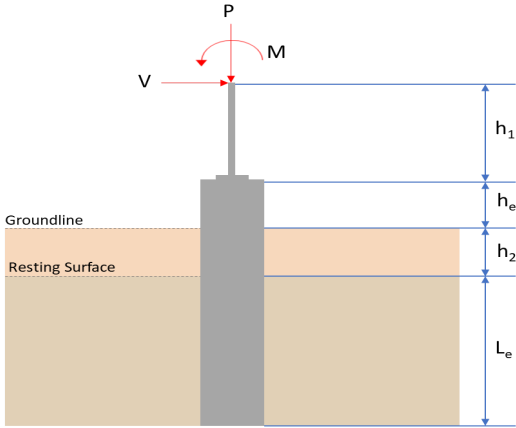
$$Ratio = \frac{M_{max}}{\phi M_n}$$

$$ratio = \frac{1}{\phi M_n}$$

$$Ratio = \frac{(0.12005 \text{ kipft})}{(62.027 \text{ kipft})}$$

$$Ratio = 0.0019355$$

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

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</p> <p>Pile shape: round $D = 36$ in - Pile diameter $L = 6.75$ ft - Total pile length $h_1 = 0$ ft - Lateral load height from the top of the pile, $h_2 = 0$ ft - Depth to resisting surface $h_e = 0$ ft - Length of pile above the ground</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>8.910</td> <td>14.386</td> </tr> <tr> <td>V_x (kip)</td> <td>-0.338</td> <td>-0.565</td> </tr> <tr> <td>V_z (kip)</td> <td>0.009</td> <td>0.014</td> </tr> <tr> <td>M_x (kipft)</td> <td>0.037</td> <td>0.061</td> </tr> <tr> <td>M_z (kipft)</td> <td>8.425</td> <td>15.239</td> </tr> </tbody> </table> <p>Material Properties</p> <p>$f'_{ck} = 2.5$ 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)	8.910	14.386	V_x (kip)	-0.338	-0.565	V_z (kip)	0.009	0.014	M_x (kipft)	0.037	0.061	M_z (kipft)	8.425	15.239	
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M_z (kipft)	8.425	15.239																										
	<p>Required depth to resist lateral loads (ASD)</p> <p>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:</p> <p>H_o - Lateral force per length of pile,</p> $H_o = \frac{V_x}{D}$ $H_o = \frac{(-0.338 \text{ kip})}{(36 \text{ in})}$ $H_o = -0.11267 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p>																											

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

$$M_o = \frac{(8.425 \text{ kipft}) + ((-0.338 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 2.8083 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$L_{e,x} = 6.5667 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

$$H_o = \frac{V_z}{D}$$

$$H_o = \frac{(0.009 \text{ kip})}{(36 \text{ in})}$$

$$H_o = 0.003 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.037 \text{ kipft}) + ((0.009 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 0.012333 \text{ kipft/ft}$$

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:

$L_{e,z} = 1.2385 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = \text{MAX}[(6.5667 \text{ ft}), (1.2385 \text{ ft})]$$

$$L_{e,req} = 6.567 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

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

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

Ratio - Embedded depth

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

$$\text{Ratio} = \frac{(6.567 \text{ ft})}{(6.75 \text{ ft})}$$

$$\text{Ratio} = 0.97289$$

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

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = \pi \left(\frac{D}{2}\right)^2$$

$$A = \pi \times \left(\frac{(36 \text{ in})}{2}\right)^2$$

$$A = 7.0686 \text{ ft}^2$$

q - End-bearing pressure

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

$$q = \frac{(8.91 \text{ kip})}{(7.0686 \text{ ft}^2)}$$

$$q = 1.2605 \text{ kip/ft}^2$$

Check bearing capacity ratio:

Ratio - Capacity

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

$$\text{Ratio} = \frac{(1.2605 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$\text{Ratio} = 0.63025$$

Status: **PASS**
Ratio: **0.630**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(6.75 \text{ ft})}{(36 \text{ in})}$$

$$L/D = 2.25$$

Since $L/D \leq 10$,

Pile is short.

Considering x-direction:

$H_o = -0.11267 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 2.8083 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (2.8083 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.11267 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (2.8083 \text{ kipft/ft})) + (4 \times (-0.11267 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.586 \text{ ft}$$

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

$$p = \frac{1.178 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$$

$$p = \frac{1.178 \times [(4 \times (2.8083 \text{ kipft/ft})) + (3 \times (-0.11267 \text{ kip/ft}) \times (6.75 \text{ ft}))]^2}{(6.75 \text{ ft})^2 \times [(3 \times (2.8083 \text{ kipft/ft})) + (2 \times (-0.11267 \text{ kip/ft}) \times (6.75 \text{ ft}))]}$$

$$p = 0.3001 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

$$s = \frac{9.425 [(2 M_o) + (H_o L_e)]}{L_e^2}$$

$$s = \frac{9.425 \times [(2 \times (2.8083 \text{ kipft/ft})) + ((-0.11267 \text{ kip/ft}) \times (6.75 \text{ ft}))]}{(6.75 \text{ ft})^2}$$

$$s = 1.0045 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(4.586 \text{ ft})}{2}$$

$$p_a = 0.34395 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.3001 \text{ kip/ft}^2)}{(0.34395 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.8725$$

p_s - Allowable lateral soil pressure at depth L_e ,

$$p_s = R L_e$$

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

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

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(1.0045 \text{ kip/ft}^2)}{(1.0125 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.99214$$

Status: **PASS**
Ratio: **0.870**

Status: **PASS**
Ratio: **0.990**

Considering z-direction:

$H_o = 0.003 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 0.012333 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.012333 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (0.003 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (0.012333 \text{ kipft/ft})) + (4 \times (0.003 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.794 \text{ ft}$$

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

$$p = \frac{1.178 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$$

$$p = \frac{1.178 \times [(4 \times (0.012333 \text{ kipft/ft})) + (3 \times (0.003 \text{ kip/ft}) \times (6.75 \text{ ft}))]^2}{(6.75 \text{ ft})^2 \times [(3 \times (0.012333 \text{ kipft/ft})) + (2 \times (0.003 \text{ kip/ft}) \times (6.75 \text{ ft}))]}$$

$$p = 0.0040428 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

$$s = \frac{9.425 [(2 M_o) + (H_o L_e)]}{L_e^2}$$

$$s = \frac{9.425 \times [(2 \times (0.012333 \text{ kipft/ft})) + ((0.003 \text{ kip/ft}) \times (6.75 \text{ ft}))]}{(6.75 \text{ ft})^2}$$

$$s = 0.0092914 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(4.794 \text{ ft})}{2}$$

$$p_a = 0.35955 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.0040428 \text{ kip/ft}^2)}{(0.35955 \text{ kip/ft}^2)}$$

$$(0.0000 \text{ kip/ft}^2)$$

$$\text{Ratio} = 0.011244$$

p_s - Allowable lateral soil pressure at depth L_e ,

$$p_s = R L_e$$

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

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

Ratio - Lateral soil capacity

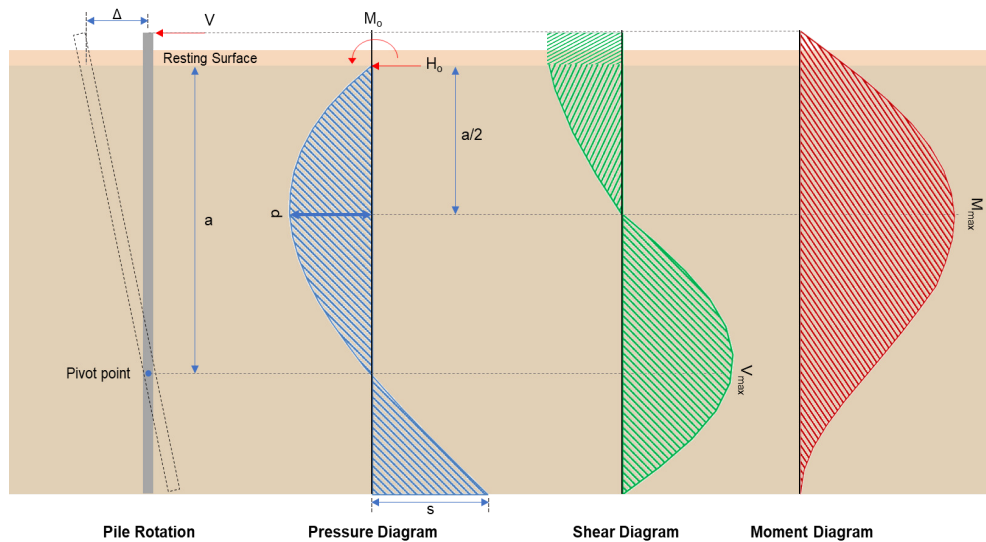
$$\text{Ratio} = \frac{s}{p_s}$$

$$\text{Ratio} = \frac{(0.0092914 \text{ kip/ft}^2)}{(1.0125 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.0091767$$

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

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.565 \text{ kip})}{(36 \text{ in})}$$

$$H_o = -0.18833 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(15.239 \text{ kipft}) + ((-0.565 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 5.0797 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(5.0797 \text{ kipft/ft})}{(-0.18833 \text{ kip/ft})}$$

$$E = 26.972 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.0797 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.18833 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (5.0797 \text{ kipft/ft})) + (4 \times (-0.18833 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.5804 \text{ ft}$$

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

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

$$V_{max} = ((-0.18833 \text{ kip/ft}) \times (36 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (26.972 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{4.5804 \text{ ft}}{(6.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (26.972 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{4.5804 \text{ ft}}{(6.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 4.3738 \text{ kip}$$

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

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

$$M_{max} = ((-0.18833 \text{ kip/ft}) \times (36 \text{ in}) \times (6.75 \text{ ft})) \times \left[\left(\frac{26.972 \text{ ft}}{(6.75 \text{ ft})} + \frac{4.5804 \text{ ft}}{2 \times (6.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (26.972 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{4.5804 \text{ ft}}{2 \times (6.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (26.972 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{4.5804 \text{ ft}}{2 \times (6.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 14.412 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

$$H_o = \frac{V_z}{D}$$

$$H_o = \frac{(0.014 \text{ kip})}{(36 \text{ in})}$$

$$H_o = 0.0046667 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.061 \text{ kipft}) + ((0.014 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 0.020333 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.020333 \text{ kipft/ft})}{(0.0046667 \text{ kip/ft})}$$

$$E = 4.3571 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.020333 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (0.0046667 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (0.020333 \text{ kipft/ft})) + (4 \times (0.0046667 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.7858 \text{ ft}$$

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

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

$$[\setminus L_e / \setminus L_e /]]$$

$$V_{max} = ((0.0046667 \text{ kip/ft}) \times (36 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (4.3571 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.7858 \text{ ft})}{(6.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (4.3571 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.7858 \text{ ft})}{(6.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.025284 \text{ kip}$$

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

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

$$M_{max} = ((0.0046667 \text{ kip/ft}) \times (36 \text{ in}) \times (6.75 \text{ ft})) \times \left[\left(\frac{(4.3571 \text{ ft})}{(6.75 \text{ ft})} + \frac{(4.7858 \text{ ft})}{2 \times (6.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (4.3571 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.7858 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (4.3571 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.7858 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.076875 \text{ kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

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

$f_{yk} = 60 \text{ ksi}$ - Longitudinal reinforcement strength,

$\phi = 0.65$ - Reduction factor for axial strength,

Table 22.4.2.1

$\alpha = 0.85$ - Alpha factor for axial strength,

$A_g = 1017.9 \text{ in}^2$ - Gross area of concrete,

Longitudinal reinforcement:

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

22.4.2.2, 10.6.1.1

$A_{st,required}$

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

$$A_{st,required} = \text{Min} \left[\frac{(14.386 \text{ kip})}{(0.65) \times (0.85)} - (0.85 \times (2.5 \text{ ksi}) \times (1017.9 \text{ in}^2)), \frac{(14.386 \text{ kip})}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (1017.9 \text{ in}^2)) \right]$$

$$A_{st,required} = -36.924 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = \text{Max} [(-36.924 \text{ in}^2), (0.0018 \times (1017.9 \text{ in}^2))]$$

$$A_{min} = 1.8322 \text{ in}^2$$

n_{rebar} - Required number of reinforcement,

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

$$n_{rebar} = \frac{(1.8322 \text{ in}^2)}{(0.3068 \text{ in}^2)}$$

$$n_{rebar} = 6$$

A_{st} - Actual total reinforcement area,

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

$$A_{st} = (6) \times \frac{\pi \times (0.625 \text{ in})^2}{4}$$

$$A_{st} = 1.8408 \text{ in}^2$$

Ratio - Capacity

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

$$= \frac{1.8322 \text{ in}^2}{1.8408 \text{ in}^2}$$

<p>25.2.3</p> <p>25.7.2.2</p> <p>25.7.2.1</p>	<p style="text-align: center;">$Ratio = \frac{\quad}{(1.8408 \text{ in}^2)}$</p> <p style="text-align: center;">$Ratio = 0.99533$</p> <p>$s_{rebar} = Max [1.5, (1.5 d_{bar})]$</p> <p>$s_{rebar} = Max [1.5, (1.5 \times (0.625 \text{ in}))]$</p> <p style="text-align: center;">$s_{rebar} = 1.5 \text{ in}$</p> <p>Ties:</p> <p>Since longitudinal reinforcement is \leq No. 10\emptyset: Use #3(0.375 in)</p> <p>$s_{ties} = Max [16 d_{bar}, (48 d_{ties}), D]$</p> <p>$s_{ties} = Min [(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), (36 \text{ in})]$</p> <p style="text-align: center;">$s_{ties} = 10 \text{ in}$</p> <p>Summary:</p> <p style="text-align: center;">Main reinforcement: 6 - #5 (0.625 in) Ties: #3(0.375 in) - 10 in</p>	<p>Status: PASS Ratio: 1.000</p>
<p>22.4.2.2</p>	<p>Axial Compression Strength (ACI 318-19, LRFD)</p> <p>ϕP_N - Allowable axial compressive strength</p> <p style="text-align: center;">$\phi P_N = \phi 0.85 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st})]$</p> <p style="text-align: center;">$\phi P_N = (0.65) \times 0.85 \times [(0.85 \times (2.5 \text{ ksi}) \times [(1017.9 \text{ in}^2) - (1.8408 \text{ in}^2)]) + ((60 \text{ ksi}) \times (1.8408 \text{ in}^2))]$</p> <p style="text-align: center;">$\phi P_N = 1253.9 \text{ kip}$</p> <p><i>Ratio - Capacity</i></p> <p style="text-align: center;">$Ratio = \frac{P}{\phi P_N}$</p> <p style="text-align: center;">$Ratio = \frac{(14.386 \text{ kip})}{(1253.9 \text{ kip})}$</p> <p style="text-align: center;">$Ratio = 0.011473$</p>	<p>Status: PASS Ratio: 0.010</p>
<p>22.5.2.2</p> <p>22.5.5.1.3</p> <p>22.5.5.1.1</p>	<p>Shear Strength (ACI 318-19, LRFD)</p> <p>Parameters:</p> <p>$b_w = 36 \text{ in}$ - Effective width, d - Effective depth</p> <p style="text-align: center;">$d = 0.80 D$</p> <p style="text-align: center;">$d = 0.80 \times (36 \text{ in})$</p> <p style="text-align: center;">$d = 28.8 \text{ in}$</p> <p>λ_s - size effect modification factor</p> <p style="text-align: center;">$\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$</p> <p style="text-align: center;">$\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{(28.8 \text{ in})}{10}}}, 1 \right]$</p> <p style="text-align: center;">$\lambda_s = 0.71796$</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>$V_{c,max}$ - Max shear strength of concrete</p> <p style="text-align: center;">$V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$</p> <p style="text-align: center;">$V_{c,max} = 5 \times (0.71796) \times \sqrt{(2500 \text{ psi})} \times (36 \text{ in}) \times (28.8 \text{ in})$</p>	

$$V_{c,max} = 186.09 \text{ kip}$$

22.5.5.1.1(a) The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 14.386 \text{ kip} \rightarrow 14386 \text{ lbf}$,
 $V_{c,a}$ - Shear strength of concrete (a)

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

$$V_{c,a} = \left[2 \times (0.71796) \times \sqrt{(2500 \text{ psi})} + \frac{(14386 \text{ lbf})}{6 \times (1017.9 \text{ in}^2)} \right] \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{c,a} = 76.88 \text{ kip}$$

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)

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

$$V_{c,b} = \left[2 \times (0.71796) \times \sqrt{(2500 \text{ psi})} + (0.05 \times (2500 \text{ psi})) \right] \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{c,b} = 204.04 \text{ kip}$$

V_c - Governing shear strength of concrete

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

$$V_c = \text{Min}[(186.09 \text{ kip}), (76.88 \text{ kip}), (204.04 \text{ kip})]$$

$$V_c = 76.88 \text{ kip}$$

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

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

$$V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{s,a} = 414.72 \text{ kip}$$

A_v - Ties rebar area,

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

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

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

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

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

$$V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (28.8 \text{ in})}{(10 \text{ in})}$$

$$V_{s,b} = 38.17 \text{ kip}$$

V_s - Governing shear strength of steel

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

$$V_s = \text{MIN}[(414.72 \text{ kip}), (38.17 \text{ kip})]$$

$$V_s = 38.17 \text{ kip}$$

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((76.88 \text{ kip}) + (38.17 \text{ kip}))$$

$$\phi V_n = 74.783 \text{ kip}$$

Considering x-direction:

$V_{max} = 4.3738 \text{ kip}$ - Maximum shear force in the x-direction,

$Ratio$ - Capacity

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

$$Ratio = \frac{(4.3738 \text{ kip})}{(74.783 \text{ kip})}$$

$$Ratio = 0.058487$$

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

Considering z-direction:

$V_{max} = 0.025284 \text{ kip}$ - Maximum shear force in the z-direction,
Ratio - Capacity

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

$$Ratio = \frac{(0.025284 \text{ kip})}{(74.783 \text{ kip})}$$

$$Ratio = 0.0003381$$

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

Flexural Strength (ACI 318-19, LRFD)

S_m - Section modulus

$$S_m = \frac{\pi D^3}{32}$$

$$S_m = \frac{\pi \times (36 \text{ in})^3}{32}$$

$$S_m = 4580.4 \text{ in}^3$$

$\lambda = 1$ - Concrete modification factor (Normal concrete),

Allowable flexural strength:

M_n shall be the lesser of:

$\phi M_{n,1}$

$$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$$

$$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 \text{ ksi})} \times 4580.442 \text{ in}^3$$

$$\phi M_{n,1} = 62.027 \text{ kipft}$$

14.5.2.1b

$\phi M_{n,2}$

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

$$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (4580.4 \text{ in}^3)$$

$$\phi M_{n,2} = 527.23 \text{ kipft}$$

Therefore,

ϕM_n - Allowable flexural strength,

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

$$\phi M_n = \text{MIN}[(62.027 \text{ kipft}), (527.23 \text{ kipft})]$$

$$\phi M_n = 62.027 \text{ kipft}$$

Considering x-direction:

$M_{max} = 14.412 \text{ kipft}$ - Maximum moment in the x-direction,

Ratio - Capacity

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

$$Ratio = \frac{(14.412 \text{ kipft})}{(62.027 \text{ kipft})}$$

$$Ratio = 0.23235$$

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

Considering z-direction:

$M_{max} = 0.076875 \text{ kipft}$ - Maximum moment in the z-direction,

Ratio - Capacity

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

$$ratio = \frac{1}{\phi M_n}$$

$$Ratio = \frac{(0.076875 \text{ kipft})}{(62.027 \text{ kipft})}$$

$$Ratio = 0.0012394$$

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

REFERENCES	CALCULATIONS	RESULTS
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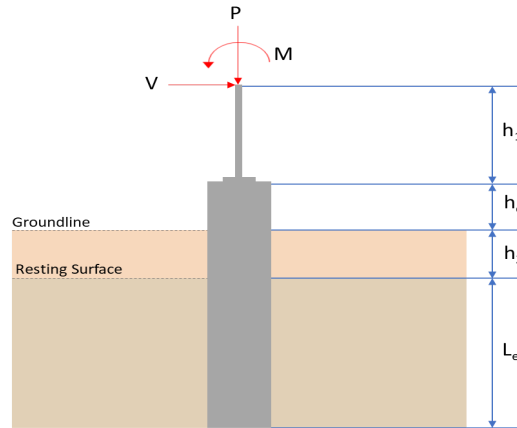
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: round

$D = 36$ in - Pile diameter

$L = 6.75$ ft - Total pile length

$h_1 = 0$ ft - Lateral load height from the top of the pile,

$h_2 = 0$ ft - Depth to resisting surface

$h_e = 0$ ft - Length of pile above the ground

Tabulation of Soil Parameters

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

Tabulation of Loads

Load Component	ASD	LRFD
P (kip)	8.910	14.386
V_x (kip)	-0.338	-0.565
V_z (kip)	-0.009	-0.014
M_x (kipft)	-0.037	-0.061
M_z (kipft)	8.425	15.239

Material Properties

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

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

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

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

Considering x-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.338 \text{ kip})}{(36 \text{ in})}$$

$$H_o = -0.11267 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(8.425 \text{ kipft}) + ((-0.338 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 2.8083 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$L_{e,x} = 6.5667 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

$$H_o = \frac{V_z}{D}$$

$$H_o = \frac{(-0.009 \text{ kip})}{(36 \text{ in})}$$

$$H_o = -0.003 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.037 \text{ kipft}) + ((-0.009 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 0.012333 \text{ kipft/ft}$$

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:

$L_{e,z} = 1.0758 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = \text{MAX}[(6.5667 \text{ ft}), (1.0758 \text{ ft})]$$

$$L_{e,req} = 6.567 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

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

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

Ratio - Embedded depth

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

$$\text{Ratio} = \frac{(6.567 \text{ ft})}{(6.75 \text{ ft})}$$

$$\text{Ratio} = 0.97289$$

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

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = \pi \left(\frac{D}{2}\right)^2$$

$$A = \pi \times \left(\frac{(36 \text{ in})}{2}\right)^2$$

$$A = 7.0686 \text{ ft}^2$$

q - End-bearing pressure

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

$$q = \frac{(8.91 \text{ kip})}{(7.0686 \text{ ft}^2)}$$

$$q = 1.2605 \text{ kip/ft}^2$$

Check bearing capacity ratio:

Ratio - Capacity

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

$$\text{Ratio} = \frac{(1.2605 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$\text{Ratio} = 0.63025$$

Status: **PASS**
Ratio: **0.630**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(6.75 \text{ ft})}{(36 \text{ in})}$$

$$L/D = 2.25$$

Since $L/D \leq 10$,

Pile is short.

Considering x-direction:

$H_o = -0.11267 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 2.8083 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (2.8083 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.11267 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (2.8083 \text{ kipft/ft})) + (4 \times (-0.11267 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.586 \text{ ft}$$

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

$$p = \frac{1.178 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$$

$$p = \frac{1.178 \times [(4 \times (2.8083 \text{ kipft/ft})) + (3 \times (-0.11267 \text{ kip/ft}) \times (6.75 \text{ ft}))]^2}{(6.75 \text{ ft})^2 \times [(3 \times (2.8083 \text{ kipft/ft})) + (2 \times (-0.11267 \text{ kip/ft}) \times (6.75 \text{ ft}))]}$$

$$p = 0.3001 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

$$s = \frac{9.425 [(2 M_o) + (H_o L_e)]}{L_e^2}$$

$$s = \frac{9.425 \times [(2 \times (2.8083 \text{ kipft/ft})) + ((-0.11267 \text{ kip/ft}) \times (6.75 \text{ ft}))]}{(6.75 \text{ ft})^2}$$

$$s = 1.0045 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(4.586 \text{ ft})}{2}$$

$$p_a = 0.34395 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.3001 \text{ kip/ft}^2)}{(0.34395 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.8725$$

p_s - Allowable lateral soil pressure at depth L_e .

$$p_s = R L_e$$

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

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

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(1.0045 \text{ kip/ft}^2)}{(1.0125 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.99214$$

Status: **PASS**
Ratio: **0.870**

Status: **PASS**
Ratio: **0.990**

Considering z-direction:

$H_o = -0.003 \text{ kip/ft}$ - Lateral force per length of pile.

$M_o = 0.012333 \text{ kipft/ft}$ - Overturning moment per length of pile.

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.012333 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.003 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (0.012333 \text{ kipft/ft})) + (4 \times (-0.003 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.794 \text{ ft}$$

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

$$p = \frac{1.178 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$$

$$p = \frac{1.178 \times [(4 \times (0.012333 \text{ kipft/ft})) + (3 \times (-0.003 \text{ kip/ft}) \times (6.75 \text{ ft}))]^2}{(6.75 \text{ ft})^2 \times [(3 \times (0.012333 \text{ kipft/ft})) + (2 \times (-0.003 \text{ kip/ft}) \times (6.75 \text{ ft}))]}$$

$$p = -0.00096283 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

$$s = \frac{9.425 [(2 M_o) + (H_o L_e)]}{L_e^2}$$

$$s = \frac{9.425 \times [(2 \times (0.012333 \text{ kipft/ft})) + ((-0.003 \text{ kip/ft}) \times (6.75 \text{ ft}))]}{(6.75 \text{ ft})^2}$$

$$s = 0.00091363 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(4.794 \text{ ft})}{2}$$

$$p_a = 0.35955 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(-0.00096283 \text{ kip/ft}^2)}{(0.35955 \text{ kip/ft}^2)}$$

$$(0.0009 \text{ kip/ft}^2)$$

$$\text{Ratio} = -0.0026779$$

p_s - Allowable lateral soil pressure at depth L_e ,

$$p_s = R L_e$$

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

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

Ratio - Lateral soil capacity

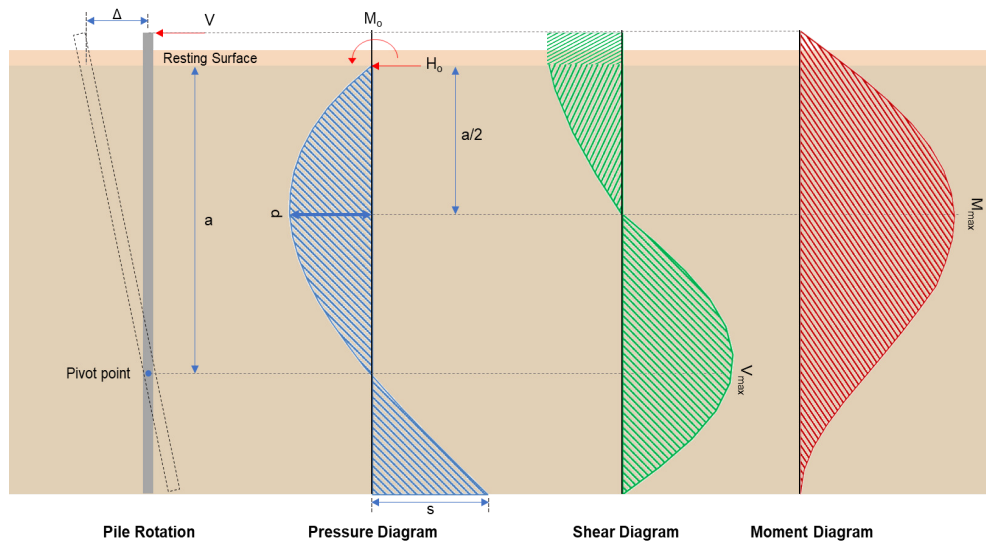
$$\text{Ratio} = \frac{s}{p_s}$$

$$\text{Ratio} = \frac{(0.00091363 \text{ kip/ft}^2)}{(1.0125 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.00090235$$

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

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.565 \text{ kip})}{(36 \text{ in})}$$

$$H_o = -0.18833 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(15.239 \text{ kipft}) + ((-0.565 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 5.0797 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(5.0797 \text{ kipft/ft})}{(-0.18833 \text{ kip/ft})}$$

$$E = 26.972 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.0797 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.18833 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (5.0797 \text{ kipft/ft})) + (4 \times (-0.18833 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.5804 \text{ ft}$$

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

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

$$V_{max} = ((-0.18833 \text{ kip/ft}) \times (36 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (26.972 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.5804 \text{ ft})}{(6.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (26.972 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.5804 \text{ ft})}{(6.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 4.3738 \text{ kip}$$

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

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

$$M_{max} = ((-0.18833 \text{ kip/ft}) \times (36 \text{ in}) \times (6.75 \text{ ft})) \times \left[\left(\frac{(26.972 \text{ ft})}{(6.75 \text{ ft})} + \frac{(4.5804 \text{ ft})}{2 \times (6.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (26.972 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.5804 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (26.972 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.5804 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 14.412 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

$$H_o = \frac{V_z}{D}$$

$$H_o = \frac{(-0.014 \text{ kip})}{(36 \text{ in})}$$

$$H_o = -0.0046667 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.061 \text{ kipft}) + ((-0.014 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 0.020333 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.020333 \text{ kipft/ft})}{(-0.0046667 \text{ kip/ft})}$$

$$E = 4.3571 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.020333 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.0046667 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (0.020333 \text{ kipft/ft})) + (4 \times (-0.0046667 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.7858 \text{ ft}$$

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

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

$$\left[\frac{L_e}{L_e} \right]$$

$$V_{max} = ((-0.0046667 \text{ kip/ft}) \times (36 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (4.3571 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.7858 \text{ ft})}{(6.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (4.3571 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.7858 \text{ ft})}{(6.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.025284 \text{ kip}$$

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

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

$$M_{max} = ((-0.0046667 \text{ kip/ft}) \times (36 \text{ in}) \times (6.75 \text{ ft})) \times \left[\left(\frac{(4.3571 \text{ ft})}{(6.75 \text{ ft})} + \frac{(4.7858 \text{ ft})}{2 \times (6.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (4.3571 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.7858 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (4.3571 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.7858 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.076875 \text{ kipft}$$

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,

$\alpha = 0.85$ - Alpha factor for axial strength,

$A_g = 1017.9 \text{ in}^2$ - Gross area of concrete,

Longitudinal reinforcement:

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

$A_{st,required}$

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

$$A_{st,required} = \text{Min} \left[\frac{\frac{(14.386 \text{ kip})}{(0.65) \times (0.85)} - (0.85 \times (2.5 \text{ ksi}) \times (1017.9 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (1017.9 \text{ in}^2)) \right]$$

$$A_{st,required} = -36.924 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = \text{Max} [(-36.924 \text{ in}^2), (0.0018 \times (1017.9 \text{ in}^2))]$$

$$A_{min} = 1.8322 \text{ in}^2$$

n_{rebar} - Required number of reinforcement,

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

$$n_{rebar} = \frac{(1.8322 \text{ in}^2)}{(0.3068 \text{ in}^2)}$$

$$n_{rebar} = 6$$

A_{st} - Actual total reinforcement area,

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

$$A_{st} = (6) \times \frac{\pi \times (0.625 \text{ in})^2}{4}$$

$$A_{st} = 1.8408 \text{ in}^2$$

Ratio - Capacity

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

$$= \frac{(1.8322 \text{ in}^2)}{(1.8408 \text{ in}^2)}$$

Table 22.4.2.1

22.4.2.2, 10.6.1.1

<p>25.2.3</p> <p>25.7.2.2</p> <p>25.7.2.1</p>	<p style="text-align: center;">$Ratio = \frac{\quad}{(1.8408 \text{ in}^2)}$</p> <p style="text-align: center;">$Ratio = 0.99533$</p> <p>s_{rebar} - Minimum spacing of reinforcement,</p> <p style="text-align: center;">$s_{rebar} = Max [1.5, (1.5 d_{bar})]$</p> <p style="text-align: center;">$s_{rebar} = Max [1.5, (1.5 \times (0.625 \text{ in}))]$</p> <p style="text-align: center;">$s_{rebar} = 1.5 \text{ in}$</p> <p>Ties:</p> <p>Since longitudinal reinforcement is \leq No. 10\emptyset: Use #3(0.375 in)</p> <p>s_{ties} - Maximum center-to-center spacing of ties,</p> <p style="text-align: center;">$s_{ties} = Min [(16 d_{bar}), (48 d_{ties}), D]$</p> <p style="text-align: center;">$s_{ties} = Min [(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), (36 \text{ in})]$</p> <p style="text-align: center;">$s_{ties} = 10 \text{ in}$</p> <p>Summary:</p> <p style="text-align: center;">Main reinforcement: 6 - #5 (0.625 in) Ties: #3(0.375 in) - 10 in</p>	<p>Status: PASS Ratio: 1.000</p>
<p>22.4.2.2</p>	<p>Axial Compression Strength (ACI 318-19, LRFD)</p> <p>ϕP_N - Allowable axial compressive strength</p> <p style="text-align: center;">$\phi P_N = \phi 0.85 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st})]$</p> <p style="text-align: center;">$\phi P_N = (0.65) \times 0.85 \times [(0.85 \times (2.5 \text{ ksi}) \times [(1017.9 \text{ in}^2) - (1.8408 \text{ in}^2)]) + ((60 \text{ ksi}) \times (1.8408 \text{ in}^2))]$</p> <p style="text-align: center;">$\phi P_N = 1253.9 \text{ kip}$</p> <p><i>Ratio</i> - Capacity</p> <p style="text-align: center;">$Ratio = \frac{P}{\phi P_N}$</p> <p style="text-align: center;">$Ratio = \frac{(14.386 \text{ kip})}{(1253.9 \text{ kip})}$</p> <p style="text-align: center;">$Ratio = 0.011473$</p>	<p>Status: PASS Ratio: 0.010</p>
<p>22.5.2.2</p> <p>22.5.5.1.3</p> <p>22.5.5.1.1</p>	<p>Shear Strength (ACI 318-19, LRFD)</p> <p>Parameters:</p> <p>$b_w = 36 \text{ in}$ - Effective width, d - Effective depth</p> <p style="text-align: center;">$d = 0.80 D$</p> <p style="text-align: center;">$d = 0.80 \times (36 \text{ in})$</p> <p style="text-align: center;">$d = 28.8 \text{ in}$</p> <p>λ_s - size effect modification factor</p> <p style="text-align: center;">$\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$</p> <p style="text-align: center;">$\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{(28.8 \text{ in})}{10}}}, 1 \right]$</p> <p style="text-align: center;">$\lambda_s = 0.71796$</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>$V_{c,max}$ - Max shear strength of concrete</p> <p style="text-align: center;">$V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$</p> <p style="text-align: center;">$V_{c,max} = 5 \times (0.71796) \times \sqrt{(2500 \text{ psi})} \times (36 \text{ in}) \times (28.8 \text{ in})$</p>	

$$V_{c,max} = 186.09 \text{ kip}$$

22.5.5.1.1(a) The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 14.386 \text{ kip} \rightarrow 14386 \text{ lbf}$,
 $V_{c,a}$ - Shear strength of concrete (a)

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

$$V_{c,a} = \left[2 \times (0.71796) \times \sqrt{(2500 \text{ psi})} + \frac{(14386 \text{ lbf})}{6 \times (1017.9 \text{ in}^2)} \right] \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{c,a} = 76.88 \text{ kip}$$

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)

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

$$V_{c,b} = \left[2 \times (0.71796) \times \sqrt{(2500 \text{ psi})} + (0.05 \times (2500 \text{ psi})) \right] \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{c,b} = 204.04 \text{ kip}$$

V_c - Governing shear strength of concrete

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

$$V_c = \text{Min} [(186.09 \text{ kip}), (76.88 \text{ kip}), (204.04 \text{ kip})]$$

$$V_c = 76.88 \text{ kip}$$

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

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

$$V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{s,a} = 414.72 \text{ kip}$$

A_v - Ties rebar area,

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

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

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

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

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

$$V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (28.8 \text{ in})}{(10 \text{ in})}$$

$$V_{s,b} = 38.17 \text{ kip}$$

V_s - Governing shear strength of steel

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

$$V_s = \text{MIN} [(414.72 \text{ kip}), (38.17 \text{ kip})]$$

$$V_s = 38.17 \text{ kip}$$

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((76.88 \text{ kip}) + (38.17 \text{ kip}))$$

$$\phi V_n = 74.783 \text{ kip}$$

Considering x-direction:

$V_{max} = 4.3738 \text{ kip}$ - Maximum shear force in the x-direction,

Ratio - Capacity

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

$$Ratio = \frac{(4.3738 \text{ kip})}{(74.783 \text{ kip})}$$

$$Ratio = 0.058487$$

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

Considering z-direction:

$V_{max} = 0.025284 \text{ kip}$ - Maximum shear force in the z-direction,
Ratio - Capacity

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

$$Ratio = \frac{(0.025284 \text{ kip})}{(74.783 \text{ kip})}$$

$$Ratio = 0.0003381$$

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

Flexural Strength (ACI 318-19, LRFD)

S_m - Section modulus

$$S_m = \frac{\pi D^3}{32}$$

$$S_m = \frac{\pi \times (36 \text{ in})^3}{32}$$

$$S_m = 4580.4 \text{ in}^3$$

$\lambda = 1$ - Concrete modification factor (Normal concrete),

Allowable flexural strength:

M_n shall be the lesser of:

$\phi M_{n,1}$

$$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$$

$$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 \text{ ksi})} \times 4580.442 \text{ in}^3$$

$$\phi M_{n,1} = 62.027 \text{ kipft}$$

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

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

$$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (4580.4 \text{ in}^3)$$

$$\phi M_{n,2} = 527.23 \text{ kipft}$$

Therefore,

ϕM_n - Allowable flexural strength,

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

$$\phi M_n = \text{MIN}[(62.027 \text{ kipft}), (527.23 \text{ kipft})]$$

$$\phi M_n = 62.027 \text{ kipft}$$

Considering x-direction:

$M_{max} = 14.412 \text{ kipft}$ - Maximum moment in the x-direction,

Ratio - Capacity

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

$$Ratio = \frac{(14.412 \text{ kipft})}{(62.027 \text{ kipft})}$$

$$Ratio = 0.23235$$

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

Considering z-direction:

$M_{max} = 0.076875 \text{ kipft}$ - Maximum moment in the z-direction,

Ratio - Capacity

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

$$ratio = \frac{1}{\phi M_n}$$

$$Ratio = \frac{(0.076875 \text{ kipft})}{(62.027 \text{ kipft})}$$

$$Ratio = 0.0012394$$

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

REFERENCES	CALCULATIONS	RESULTS
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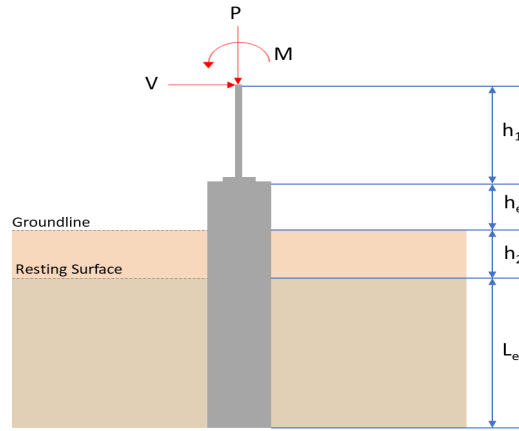
SkyCiv Foundation Design

Pile Foundation

Design Information :

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

Pile Input



Geometry

Pile shape: round

$D = 36$ in - Pile diameter

$L = 6.75$ ft - Total pile length

$h_1 = 0$ ft - Lateral load height from the top of the pile,

$h_2 = 0$ ft - Depth to resisting surface

$h_e = 0$ ft - Length of pile above the ground

Tabulation of Soil Parameters

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

Tabulation of Loads

Load Component	ASD	LRFD
P (kip)	8.448	13.626
V_x (kip)	-0.331	-0.554
V_z (kip)	0.013	0.022
M_x (kipft)	0.056	0.095
M_z (kipft)	8.205	14.786

Material Properties

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

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

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

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

Considering x-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.331 \text{ kip})}{(36 \text{ in})}$$

$$H_o = -0.11033 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(8.205 \text{ kipft}) + ((-0.331 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 2.735 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$L_{e,x} = 6.5107 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

$$H_o = \frac{V_z}{D}$$

$$H_o = \frac{(0.013 \text{ kip})}{(36 \text{ in})}$$

$$H_o = 0.0043333 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.056 \text{ kipft}) + ((0.013 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 0.018667 \text{ kipft/ft}$$

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:

$L_{e,z} = 1.431 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = \text{MAX}[(6.5107 \text{ ft}), (1.431 \text{ ft})]$$

$$L_{e,req} = 6.511 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

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

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

Ratio - Embedded depth

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

$$\text{Ratio} = \frac{(6.511 \text{ ft})}{(6.75 \text{ ft})}$$

$$\text{Ratio} = 0.96459$$

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

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = \pi \left(\frac{D}{2}\right)^2$$

$$A = \pi \times \left(\frac{(36 \text{ in})}{2}\right)^2$$

$$A = 7.0686 \text{ ft}^2$$

q - End-bearing pressure

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

$$q = \frac{(8.448 \text{ kip})}{(7.0686 \text{ ft}^2)}$$

$$q = 1.1951 \text{ kip/ft}^2$$

Check bearing capacity ratio:

Ratio - Capacity

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

$$\text{Ratio} = \frac{(1.1951 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$\text{Ratio} = 0.59757$$

Status: **PASS**
Ratio: **0.600**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(6.75 \text{ ft})}{(36 \text{ in})}$$

$$L/D = 2.25$$

Since $L/D \leq 10$,

Pile is short.

Considering x-direction:

$H_o = -0.11033 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 2.735 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (2.735 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.11033 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (2.735 \text{ kipft/ft})) + (4 \times (-0.11033 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.5864 \text{ ft}$$

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

$$p = \frac{1.178 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$$

$$p = \frac{1.178 \times [(4 \times (2.735 \text{ kipft/ft})) + (3 \times (-0.11033 \text{ kip/ft}) \times (6.75 \text{ ft}))]^2}{(6.75 \text{ ft})^2 \times [(3 \times (2.735 \text{ kipft/ft})) + (2 \times (-0.11033 \text{ kip/ft}) \times (6.75 \text{ ft}))]}$$

$$p = 0.29179 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

$$s = \frac{9.425 [(2 M_o) + (H_o L_e)]}{L_e^2}$$

$$s = \frac{9.425 \times [(2 \times (2.735 \text{ kipft/ft})) + ((-0.11033 \text{ kip/ft}) \times (6.75 \text{ ft}))]}{(6.75 \text{ ft})^2}$$

$$s = 0.97746 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(4.5864 \text{ ft})}{2}$$

$$p_a = 0.34398 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.29179 \text{ kip/ft}^2)}{(0.34398 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.84827$$

p_s - Allowable lateral soil pressure at depth L_e ,

$$p_s = R L_e$$

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

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

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.97746 \text{ kip/ft}^2)}{(1.0125 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.96539$$

Status: **PASS**
Ratio: **0.850**

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

Considering z-direction:

$H_o = 0.0043333 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 0.018667 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.018667 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (0.0043333 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (0.018667 \text{ kipft/ft})) + (4 \times (0.0043333 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.7874 \text{ ft}$$

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

$$p = \frac{1.178 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$$

$$p = \frac{1.178 \times [(4 \times (0.018667 \text{ kipft/ft})) + (3 \times (0.0043333 \text{ kip/ft}) \times (6.75 \text{ ft}))]^2}{(6.75 \text{ ft})^2 \times [(3 \times (0.018667 \text{ kipft/ft})) + (2 \times (0.0043333 \text{ kip/ft}) \times (6.75 \text{ ft}))]}$$

$$p = 0.0059565 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

$$s = \frac{9.425 [(2 M_o) + (H_o L_e)]}{L_e^2}$$

$$s = \frac{9.425 \times [(2 \times (0.018667 \text{ kipft/ft})) + ((0.0043333 \text{ kip/ft}) \times (6.75 \text{ ft}))]}{(6.75 \text{ ft})^2}$$

$$s = 0.013773 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(4.7874 \text{ ft})}{2}$$

$$p_a = 0.35905 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.0059565 \text{ kip/ft}^2)}{(0.35905 \text{ kip/ft}^2)}$$

$$(0.0000 \text{ kip/ft}^2)$$

$$\text{Ratio} = 0.01659$$

p_s - Allowable lateral soil pressure at depth L_e ,

$$p_s = R L_e$$

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

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

Ratio - Lateral soil capacity

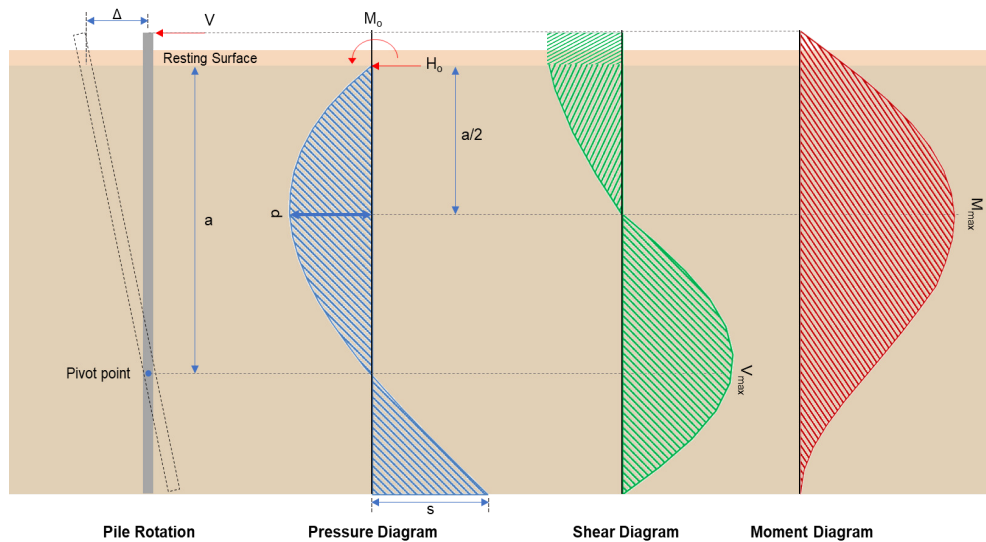
$$\text{Ratio} = \frac{s}{p_s}$$

$$\text{Ratio} = \frac{(0.013773 \text{ kip/ft}^2)}{(1.0125 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.013603$$

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

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.554 \text{ kip})}{(36 \text{ in})}$$

$$H_o = -0.18467 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(14.786 \text{ kipft}) + ((-0.554 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 4.9287 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(4.9287 \text{ kipft/ft})}{(-0.18467 \text{ kip/ft})}$$

$$E = 26.69 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (4.9287 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.18467 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (4.9287 \text{ kipft/ft})) + (4 \times (-0.18467 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.5812 \text{ ft}$$

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

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

$$V_{max} = ((-0.18467 \text{ kip/ft}) \times (36 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (26.69 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.5812 \text{ ft})}{(6.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (26.69 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.5812 \text{ ft})}{(6.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 4.2475 \text{ kip}$$

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

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

$$M_{max} = ((-0.18467 \text{ kip/ft}) \times (36 \text{ in}) \times (6.75 \text{ ft})) \times \left[\left(\frac{(26.69 \text{ ft})}{(6.75 \text{ ft})} + \frac{(4.5812 \text{ ft})}{2 \times (6.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (26.69 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.5812 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (26.69 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.5812 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 13.993 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

$$H_o = \frac{V_z}{D}$$

$$H_o = \frac{(0.022 \text{ kip})}{(36 \text{ in})}$$

$$H_o = 0.0073333 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.095 \text{ kipft}) + ((0.022 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 0.031667 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.031667 \text{ kipft/ft})}{(0.0073333 \text{ kip/ft})}$$

$$E = 4.3182 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.031667 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (0.0073333 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (0.031667 \text{ kipft/ft})) + (4 \times (0.0073333 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.787 \text{ ft}$$

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

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

$$\left[\frac{L_e}{L_e} \right]$$

$$V_{max} = ((0.0073333 \text{ kip/ft}) \times (36 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (4.3182 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.787 \text{ ft})}{(6.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (4.3182 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.787 \text{ ft})}{(6.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.039509 \text{ kip}$$

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

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

$$M_{max} = ((0.0073333 \text{ kip/ft}) \times (36 \text{ in}) \times (6.75 \text{ ft})) \times \left[\left(\frac{(4.3182 \text{ ft})}{(6.75 \text{ ft})} + \frac{(4.787 \text{ ft})}{2 \times (6.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (4.3182 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.787 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (4.3182 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.787 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.12005 \text{ kipft}$$

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,

$\alpha = 0.85$ - Alpha factor for axial strength,

$A_g = 1017.9 \text{ in}^2$ - Gross area of concrete,

Longitudinal reinforcement:

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

$A_{st,required}$

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

$$A_{st,required} = \text{Min} \left[\frac{\frac{(13.626 \text{ kip})}{(0.65) \times (0.85)} - (0.85 \times (2.5 \text{ ksi}) \times (1017.9 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (1017.9 \text{ in}^2)) \right]$$

$$A_{st,required} = -36.947 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = \text{Max} [(-36.947 \text{ in}^2), (0.0018 \times (1017.9 \text{ in}^2))]$$

$$A_{min} = 1.8322 \text{ in}^2$$

n_{rebar} - Required number of reinforcement,

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

$$n_{rebar} = \frac{(1.8322 \text{ in}^2)}{(0.3068 \text{ in}^2)}$$

$$n_{rebar} = 6$$

A_{st} - Actual total reinforcement area,

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

$$A_{st} = (6) \times \frac{\pi \times (0.625 \text{ in})^2}{4}$$

$$A_{st} = 1.8408 \text{ in}^2$$

Ratio - Capacity

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

$$= \frac{(1.8322 \text{ in}^2)}{(1.8408 \text{ in}^2)}$$

Table 22.4.2.1

22.4.2.2, 10.6.1.1

<p>25.2.3</p> <p>25.7.2.2</p> <p>25.7.2.1</p>	<p style="text-align: center;">$Ratio = \frac{\lambda}{(1.8408 \text{ in}^2)}$</p> <p style="text-align: center;">$Ratio = 0.99533$</p> <p>$s_{rebar} = Max [1.5, (1.5 d_{bar})]$</p> <p>$s_{rebar} = Max [1.5, (1.5 \times (0.625 \text{ in}))]$</p> <p style="text-align: center;">$s_{rebar} = 1.5 \text{ in}$</p> <p>Ties:</p> <p>Since longitudinal reinforcement is \leq No. 10\emptyset: Use #3(0.375 in)</p> <p>$s_{ties} = Max [16 d_{bar}, (48 d_{ties}), D]$</p> <p>$s_{ties} = Min [(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), (36 \text{ in})]$</p> <p style="text-align: center;">$s_{ties} = 10 \text{ in}$</p> <p>Summary:</p> <p style="text-align: center;">Main reinforcement: 6 - #5 (0.625 in) Ties: #3(0.375 in) - 10 in</p>	<p>Status: PASS Ratio: 1.000</p>
<p>22.4.2.2</p>	<p>Axial Compression Strength (ACI 318-19, LRFD)</p> <p>ϕP_N - Allowable axial compressive strength</p> <p style="text-align: center;">$\phi P_N = \phi 0.85 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st})]$</p> <p style="text-align: center;">$\phi P_N = (0.65) \times 0.85 \times [(0.85 \times (2.5 \text{ ksi}) \times [(1017.9 \text{ in}^2) - (1.8408 \text{ in}^2)]) + ((60 \text{ ksi}) \times (1.8408 \text{ in}^2))]$</p> <p style="text-align: center;">$\phi P_N = 1253.9 \text{ kip}$</p> <p>Ratio - Capacity</p> <p style="text-align: center;">$Ratio = \frac{P}{\phi P_N}$</p> <p style="text-align: center;">$Ratio = \frac{(13.626 \text{ kip})}{(1253.9 \text{ kip})}$</p> <p style="text-align: center;">$Ratio = 0.010867$</p>	<p>Status: PASS Ratio: 0.010</p>
<p>22.5.2.2</p> <p>22.5.5.1.3</p> <p>22.5.5.1.1</p>	<p>Shear Strength (ACI 318-19, LRFD)</p> <p>Parameters:</p> <p>$b_w = 36 \text{ in}$ - Effective width, d - Effective depth</p> <p style="text-align: center;">$d = 0.80 D$</p> <p style="text-align: center;">$d = 0.80 \times (36 \text{ in})$</p> <p style="text-align: center;">$d = 28.8 \text{ in}$</p> <p>λ_s - size effect modification factor</p> <p style="text-align: center;">$\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$</p> <p style="text-align: center;">$\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{(28.8 \text{ in})}{10}}}, 1 \right]$</p> <p style="text-align: center;">$\lambda_s = 0.71796$</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>$V_{c,max}$ - Max shear strength of concrete</p> <p style="text-align: center;">$V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$</p> <p style="text-align: center;">$V_{c,max} = 5 \times (0.71796) \times \sqrt{(2500 \text{ psi})} \times (36 \text{ in}) \times (28.8 \text{ in})$</p>	

$$V_{c,max} = 186.09 \text{ kip}$$

22.5.5.1.1(a) The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 13.626 \text{ kip} \rightarrow 13626 \text{ lbf}$,
 $V_{c,a}$ - Shear strength of concrete (a)

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

$$V_{c,a} = \left[2 \times (0.71796) \times \sqrt{(2500 \text{ psi})} + \frac{(13626 \text{ lbf})}{6 \times (1017.9 \text{ in}^2)} \right] \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{c,a} = 76.751 \text{ kip}$$

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)

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

$$V_{c,b} = \left[2 \times (0.71796) \times \sqrt{(2500 \text{ psi})} + (0.05 \times (2500 \text{ psi})) \right] \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{c,b} = 204.04 \text{ kip}$$

V_c - Governing shear strength of concrete

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

$$V_c = \text{Min}[(186.09 \text{ kip}), (76.751 \text{ kip}), (204.04 \text{ kip})]$$

$$V_c = 76.751 \text{ kip}$$

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

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

$$V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{s,a} = 414.72 \text{ kip}$$

A_v - Ties rebar area,

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

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

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

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

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

$$V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (28.8 \text{ in})}{(10 \text{ in})}$$

$$V_{s,b} = 38.17 \text{ kip}$$

V_s - Governing shear strength of steel

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

$$V_s = \text{MIN}[(414.72 \text{ kip}), (38.17 \text{ kip})]$$

$$V_s = 38.17 \text{ kip}$$

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((76.751 \text{ kip}) + (38.17 \text{ kip}))$$

$$\phi V_n = 74.699 \text{ kip}$$

Considering x-direction:

$V_{max} = 4.2475 \text{ kip}$ - Maximum shear force in the x-direction,

$Ratio$ - Capacity

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

$$Ratio = \frac{(4.2475 \text{ kip})}{(74.699 \text{ kip})}$$

$$Ratio = 0.056862$$

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

Considering z-direction:

$V_{max} = 0.039509 \text{ kip}$ - Maximum shear force in the z-direction,
Ratio - Capacity

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

$$Ratio = \frac{(0.039509 \text{ kip})}{(74.699 \text{ kip})}$$

$$Ratio = 0.00052892$$

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

Flexural Strength (ACI 318-19, LRFD)

S_m - Section modulus

$$S_m = \frac{\pi D^3}{32}$$

$$S_m = \frac{\pi \times (36 \text{ in})^3}{32}$$

$$S_m = 4580.4 \text{ in}^3$$

$\lambda = 1$ - Concrete modification factor (Normal concrete),

Allowable flexural strength:

M_n shall be the lesser of:

$\phi M_{n,1}$

$$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$$

$$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 \text{ ksi})} \times 4580.442 \text{ in}^3$$

$$\phi M_{n,1} = 62.027 \text{ kipft}$$

14.5.2.1b

$\phi M_{n,2}$

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

$$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (4580.4 \text{ in}^3)$$

$$\phi M_{n,2} = 527.23 \text{ kipft}$$

Therefore,

ϕM_n - Allowable flexural strength,

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

$$\phi M_n = \text{MIN}[(62.027 \text{ kipft}), (527.23 \text{ kipft})]$$

$$\phi M_n = 62.027 \text{ kipft}$$

Considering x-direction:

$M_{max} = 13.993 \text{ kipft}$ - Maximum moment in the x-direction,

Ratio - Capacity

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

$$Ratio = \frac{(13.993 \text{ kipft})}{(62.027 \text{ kipft})}$$

$$Ratio = 0.22559$$

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

Considering z-direction:

$M_{max} = 0.12005 \text{ kipft}$ - Maximum moment in the z-direction,

Ratio - Capacity

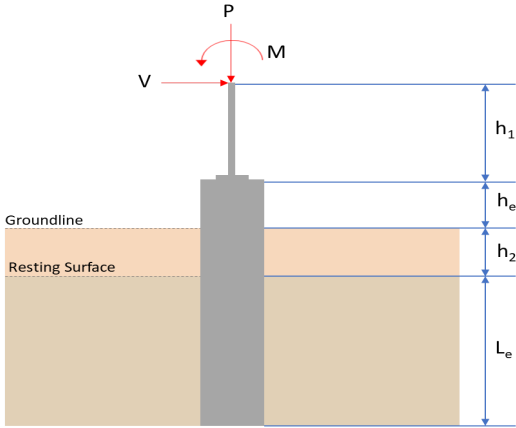
$$Ratio = \frac{M_{max}}{\phi M_n}$$

$$ratio = \frac{1}{\phi M_n}$$

$$Ratio = \frac{(0.12005 \text{ kipft})}{(62.027 \text{ kipft})}$$

$$Ratio = 0.0019355$$

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

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</p> <p>Pile shape: round $D = 36$ in - Pile diameter $L = 7$ ft - Total pile length $h_1 = 0$ ft - Lateral load height from the top of the pile, $h_2 = 0$ ft - Depth to resisting surface $h_e = 0$ ft - Length of pile above the ground</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>9.017</td> <td>14.559</td> </tr> <tr> <td>V_x (kip)</td> <td>-0.343</td> <td>-0.570</td> </tr> <tr> <td>V_z (kip)</td> <td>0.000</td> <td>0.000</td> </tr> <tr> <td>M_x (kipft)</td> <td>0.000</td> <td>0.000</td> </tr> <tr> <td>M_z (kipft)</td> <td>8.506</td> <td>15.372</td> </tr> </tbody> </table> <p>Material Properties</p> <p>$f'_{ck} = 2.5$ 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)	9.017	14.559	V_x (kip)	-0.343	-0.570	V_z (kip)	0.000	0.000	M_x (kipft)	0.000	0.000	M_z (kipft)	8.506	15.372	
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																									
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M_x (kipft)	0.000	0.000																										
M_z (kipft)	8.506	15.372																										
	<p>Required depth to resist lateral loads (ASD)</p> <p>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:</p> <p>H_o - Lateral force per length of pile,</p> $H_o = \frac{V_x}{D}$ $H_o = \frac{(-0.343 \text{ kip})}{(36 \text{ in})}$ $H_o = -0.11433 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p>																											

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

$$M_o = \frac{(8.506 \text{ kipft}) + ((-0.343 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 2.8353 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$L_{e,x} = 6.5836 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

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

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(6.5836 \text{ ft}), (0 \text{ ft})]$$

$$L_{e,req} = 6.584 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

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

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

Ratio - Embedded depth

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

$$Ratio = \frac{(6.584 \text{ ft})}{(7 \text{ ft})}$$

$$Ratio = 0.94057$$

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

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = \pi \left(\frac{D}{2}\right)^2$$

$$A = \pi \times \left(\frac{(36 \text{ in})}{2}\right)^2$$

$$A = 7.0686 \text{ ft}^2$$

q - End-bearing pressure

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

$$q = \frac{(9.017 \text{ kip})}{(7.0686 \text{ ft}^2)}$$

$$q = 1.2756 \text{ kip/ft}^2$$

Check bearing capacity ratio:

Ratio - Capacity

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

$$Ratio = \frac{(1.2756 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$Ratio = 0.63782$$

Status: **PASS**
Ratio: **0.640**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

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

$$L/D = \frac{(7 \text{ ft})}{(36 \text{ in})}$$

$$L/D = 2.3333$$

Since $L/D \leq 10$,

Pile is short.

Considering x-direction:

$H_o = -0.11433$ kip/ft - Lateral force per length of pile,

$M_o = 2.8353$ kipft/ft - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (2.8353 \text{ kipft/ft}) \times (7 \text{ ft})) + (3 \times (-0.11433 \text{ kip/ft}) \times (7 \text{ ft})^2)}{(6 \times (2.8353 \text{ kipft/ft})) + (4 \times (-0.11433 \text{ kip/ft}) \times (7 \text{ ft}))}$$

$$a = 4.7591 \text{ ft}$$

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

$$p = \frac{1.178 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$$

$$p = \frac{1.178 \times [(4 \times (2.8353 \text{ kipft/ft})) + (3 \times (-0.11433 \text{ kip/ft}) \times (7 \text{ ft}))]^2}{(7 \text{ ft})^2 \times [(3 \times (2.8353 \text{ kipft/ft})) + (2 \times (-0.11433 \text{ kip/ft}) \times (7 \text{ ft}))]}$$

$$p = 0.27827 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

$$s = \frac{9.425 [(2 M_o) + (H_o L_e)]}{L_e^2}$$

$$s = \frac{9.425 \times [(2 \times (2.8353 \text{ kipft/ft})) + ((-0.11433 \text{ kip/ft}) \times (7 \text{ ft}))]}{(7 \text{ ft})^2}$$

$$s = 0.93679 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(4.7591 \text{ ft})}{2}$$

$$p_a = 0.35693 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.27827 \text{ kip/ft}^2)}{(0.35693 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.77963$$

p_s - Allowable lateral soil pressure at depth L_e ,

$$p_s = R L_e$$

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

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

Ratio - Lateral soil capacity

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

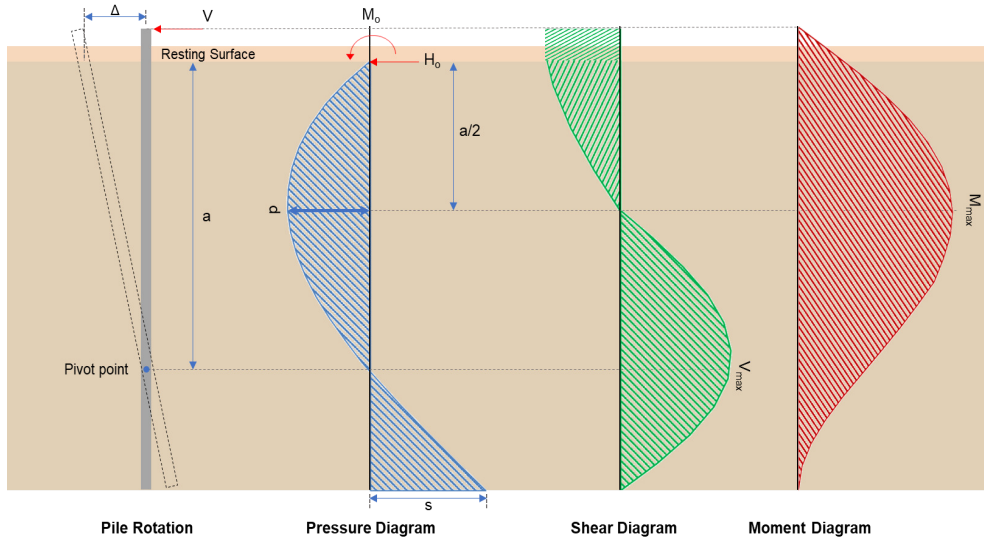
$$= \frac{(0.93679 \text{ kip/ft}^2)}{(1.05 \text{ kip/ft}^2)}$$

Status: **PASS**
Ratio: **0.780**

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

$$\text{Ratio} = 0.89218$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.57 \text{ kip})}{(36 \text{ in})}$$

$$H_o = -0.19 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(15.372 \text{ kipft}) + ((-0.57 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 5.124 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(5.124 \text{ kipft/ft})}{(-0.19 \text{ kip/ft})}$$

$$E = 26.968 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.124 \text{ kipft/ft}) \times (7 \text{ ft})) + (3 \times (-0.19 \text{ kip/ft}) \times (7 \text{ ft})^2)}{(6 \times (5.124 \text{ kipft/ft})) + (4 \times (-0.19 \text{ kip/ft}) \times (7 \text{ ft}))}$$

$$a = 4.7527 \text{ ft}$$

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

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

$$V_{max} = ((-0.19 \text{ kip/ft}) \times (36 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (26.968 \text{ ft})}{(7 \text{ ft})} + 3 \right) \times \left(\frac{(4.7527 \text{ ft})}{(7 \text{ ft})} \right)^2 + 4 \times \left(\frac{3 \times (26.968 \text{ ft})}{(7 \text{ ft})} + 2 \right) \times \left(\frac{(4.7527 \text{ ft})}{(7 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 4.2676 \text{ kip}$$

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

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

$$M_{max} = ((-0.19 \text{ kip/ft}) \times (36 \text{ in}) \times (7 \text{ ft})) \times \left[\left(\frac{(26.968 \text{ ft})}{(7 \text{ ft})} + \frac{(4.7527 \text{ ft})}{2 \times (7 \text{ ft})} \right) - \left[\left(\frac{4 \times (26.968 \text{ ft})}{(7 \text{ ft})} + 3 \right) \times \left(\frac{(4.7527 \text{ ft})}{2 \times (7 \text{ ft})} \right)^3 + \left[\left(\frac{3 \times (26.968 \text{ ft})}{(7 \text{ ft})} + 2 \right) \times \left(\frac{(4.7527 \text{ ft})}{2 \times (7 \text{ ft})} \right)^4 \right] \right] \right]$$

$$M_{max} = 14.571 \text{ kipft}$$

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,

$\alpha = 0.85$ - Alpha factor for axial strength,

$A_g = 1017.9 \text{ in}^2$ - Gross area of concrete,

Longitudinal reinforcement:

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

$A_{st,required}$

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

$$A_{st,required} = \text{Min} \left[\frac{\frac{(14.559 \text{ kip})}{(0.65) \times (0.85)} - (0.85 \times (2.5 \text{ ksi}) \times (1017.9 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (1017.9 \text{ in}^2)) \right]$$

$$A_{st,required} = -36.918 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

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

$$A_{min} = \text{Max} [(-36.918 \text{ in}^2), (0.0018 \times (1017.9 \text{ in}^2))]$$

$$A_{min} = 1.8322 \text{ in}^2$$

n_{rebar} - Required number of reinforcement,

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

$$n_{rebar} = \frac{(1.8322 \text{ in}^2)}{(0.3068 \text{ in}^2)}$$

$$n_{rebar} = 6$$

A_{st} - Actual total reinforcement area,

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

$$A_{st} = (6) \times \frac{\pi \times (0.625 \text{ in})^2}{4}$$

$$A_{st} = 1.8408 \text{ in}^2$$

Ratio - Capacity

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

$$\text{Ratio} = \frac{(1.8322 \text{ in}^2)}{(1.8408 \text{ in}^2)}$$

$$\text{Ratio} = 0.99533$$

25.2.3

s_{rebar} - Minimum spacing of reinforcement,

Status: **PASS**
Ratio: **1.000**

<p>25.7.2.2 25.7.2.1</p>	$s_{rebar} = Max[1.5, (1.5 d_{bar})]$ $s_{rebar} = Max[1.5, (1.5 \times (0.625 \text{ in}))]$ $s_{rebar} = 1.5 \text{ in}$ <p>Ties: Since longitudinal reinforcement is \leq No. 10: Use #3(0.375 in) s_{ties} - Maximum center-to-center spacing of ties,</p> $s_{ties} = Min[(16 d_{bar}), (48 d_{ties}), D]$ $s_{ties} = Min[(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), (36 \text{ in})]$ $s_{ties} = 10 \text{ in}$ <p>Summary:</p> <p>Main reinforcement: 6 - #5 (0.625 in) Ties: #3(0.375 in) - 10 in</p>	
<p>22.4.2.2</p>	<p>Axial Compression Strength (ACI 318-19, LRFD)</p> <p>ϕP_N - Allowable axial compressive strength</p> $\phi P_N = \phi 0.85 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st})]$ $\phi P_N = (0.65) \times 0.85 \times [(0.85 \times (2.5 \text{ ksi}) \times [(1017.9 \text{ in}^2) - (1.8408 \text{ in}^2)]) + ((60 \text{ ksi}) \times (1.8408 \text{ in}^2))]$ $\phi P_N = 1253.9 \text{ kip}$ <p>Ratio - Capacity</p> $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(14.559 \text{ kip})}{(1253.9 \text{ kip})}$ $Ratio = 0.011611$	<p>Status: PASS Ratio: 0.010</p>
<p>22.5.2.2 22.5.5.1.3 22.5.5.1.1 22.5.5.1.1(a)</p>	<p>Shear Strength (ACI 318-19, LRFD)</p> <p>Parameters: $b_w = 36 \text{ in}$ - Effective width, d - Effective depth</p> $d = 0.80 D$ $d = 0.80 \times (36 \text{ in})$ $d = 28.8 \text{ in}$ <p>λ_s - size effect modification factor</p> $\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{(28.8 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.71796$ <p>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</p> $V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$ $V_{c,max} = 5 \times (0.71796) \times \sqrt{(2500 \text{ psi})} \times (36 \text{ in}) \times (28.8 \text{ in})$ $V_{c,max} = 186.09 \text{ kip}$ <p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 14.559 \text{ kip} \rightarrow 14559 \text{ lbf}$, $V_{c,a}$ - Shear strength of concrete (a)</p> $V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$	

$$V_{c,a} = \left[2 \times (0.71796) \times \sqrt{(2500 \text{ psi})} + \frac{(14559 \text{ lbf})}{6 \times (1017.9 \text{ in}^2)} \right] \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{c,a} = 76.91 \text{ kip}$$

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)

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

$$V_{c,b} = \left[2 \times (0.71796) \times \sqrt{(2500 \text{ psi})} + (0.05 \times (2500 \text{ psi})) \right] \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{c,b} = 204.04 \text{ kip}$$

V_c - Governing shear strength of concrete

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

$$V_c = \text{Min} [(186.09 \text{ kip}), (76.91 \text{ kip}), (204.04 \text{ kip})]$$

$$V_c = 76.91 \text{ kip}$$

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

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

$$V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{s,a} = 414.72 \text{ kip}$$

A_v - Ties rebar area,

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

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

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

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

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

$$V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (28.8 \text{ in})}{(10 \text{ in})}$$

$$V_{s,b} = 38.17 \text{ kip}$$

V_s - Governing shear strength of steel

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

$$V_s = \text{MIN} [(414.72 \text{ kip}), (38.17 \text{ kip})]$$

$$V_s = 38.17 \text{ kip}$$

22.5.1.1 ϕV_n - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((76.91 \text{ kip}) + (38.17 \text{ kip}))$$

$$\phi V_n = 74.802 \text{ kip}$$

Considering x-direction:

$V_{max} = 4.2676 \text{ kip}$ - Maximum shear force in the x-direction,

Ratio - Capacity

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

$$\text{Ratio} = \frac{(4.2676 \text{ kip})}{(74.802 \text{ kip})}$$

$$\text{Ratio} = 0.057052$$

Status: **PASS**
 Ratio: **0.057**

Flexural Strength (ACI 318-19, LRFD) S_m - Section modulus

$$S_m = \frac{\pi D^3}{32}$$

$$S_m = \frac{\pi \times (36 \text{ in})^3}{32}$$

$$S_m = 4580.4 \text{ in}^3$$

 $\lambda = 1$ - Concrete modification factor (Normal concrete),

Allowable flexural strength:

 M_n shall be the lesser of: $\phi M_{n,1}$

$$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$$

$$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{2.5 \text{ ksi}} \times 4580.442 \text{ in}^3$$

$$\phi M_{n,1} = 62.027 \text{ kipft}$$

14.5.2.1b

 $\phi M_{n,2}$

$$\phi M_{n,2} = \phi \times 0.85 \times f'_c \times S_m$$

$$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (4580.4 \text{ in}^3)$$

$$\phi M_{n,2} = 527.23 \text{ kipft}$$

Therefore,

 ϕM_n - Allowable flexural strength,

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

$$\phi M_n = \text{MIN}[(62.027 \text{ kipft}), (527.23 \text{ kipft})]$$

$$\phi M_n = 62.027 \text{ kipft}$$

Considering x-direction: $M_{max} = 14.571 \text{ kipft}$ - Maximum moment in the x-direction,

Ratio - Capacity

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

$$\text{Ratio} = \frac{(14.571 \text{ kipft})}{(62.027 \text{ kipft})}$$

$$\text{Ratio} = 0.23492$$

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