

## Project Details



**Project Name:** RG 255

**Date:** Wed Aug 14 2024

**Location:** 9GX2+QJH Stonyford, CA, USA

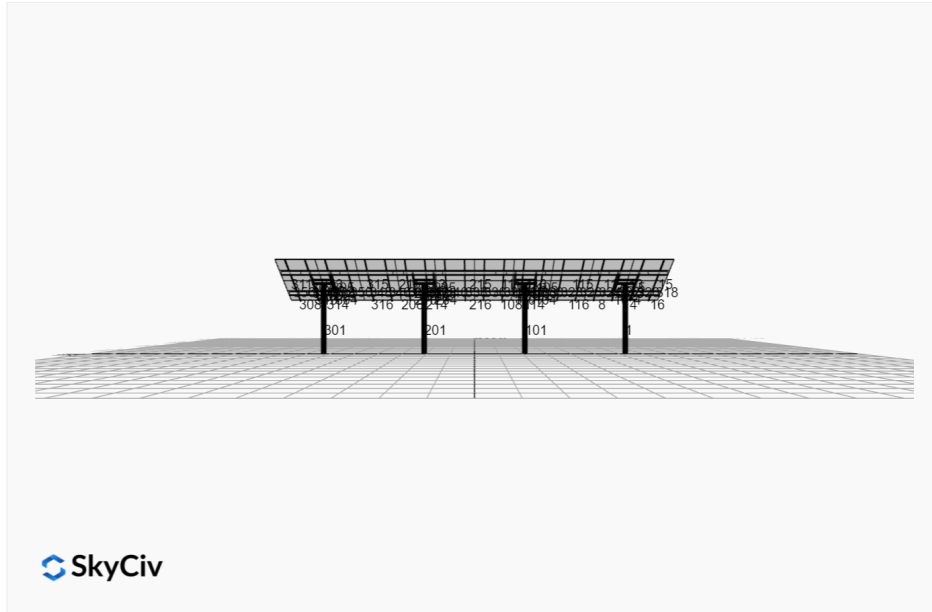
**Number of Modules:** 40

**Unique ID:** 4P-19.75-10TOP-XD-45-L-4Hx10W-2EFF

**Number of Poles:** 4

**Dealer:** \_\_\_\_\_

**Date Sold:** \_\_\_\_\_



Array Dimensions N/S	15.03 ft
Array Dimensions E/W	75.17 ft
Winter Tilt Angle	30
Front Edge Clearance	10 ft

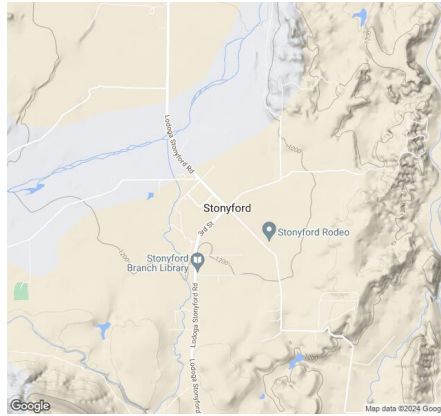
### MT Solar Bill of Materials (4P-19.75-10TOP-XD-45-L-4Hx10W-2EFF)

Part	Short Description	BOM Qty
MTS-PC-10	10IN Pole Cap Assembly	4
MTS-HF-XD	H-Frame Assembly-XD	4
MTS-XD-Wing-45	45IN XD Wing	4
MTS-XD-Splice-90	90IN XD Splice	6
MTS-XD-Splice-57	57IN XD Splice	6
MTS-CLAMP-HOOK-4PK	Hook Clamp	10

### Rail Bill of Materials

Part	Qty
Rails (178in)	20
Rail Attachment	40
Module Mid Clamp	60
Module End Clamp	40
Ground Lug	10

## Site Details:



**Site Address:** 9GX2+QJH Stonyford, CA, USA

### Array Specification

<b>Duty Classification:</b>	XD
<b>Module Width:</b>	44.60 in
<b>Module Length:</b>	89.20in
<b>Number of Rows:</b>	4
<b>Number of Columns:</b>	10
<b>Total Number of Modules:</b>	40
<b>Winter Tilt Angle:</b>	30
<b>Front Edge Clearance:</b>	10
<b>Total Array Height at Tilt:</b>	17.52 ft
<b>Total Frame Length:</b>	74.25 ft
<b>Frame Weight:</b>	5948 lbs
<b>Array Dimensions N/S:</b>	15.03 ft
<b>Array Dimensions E/W:</b>	75.17 ft
<b>Rail Length:</b>	180.40 in
<b>Rail Spacing:</b>	3.76 ft

### Support Specifications

<b>Pole Size:</b>	10in Pipe Sch 40
<b>Pole Length above Grade:</b>	13.76 ft
<b>Number of Poles:</b>	4
<b>Pole Spacing:</b>	19.75 ft

### Foundation Specifications

<b>Foundation Type:</b>	Square
<b>Foundation Dimensions:</b>	48 x 48 in
<b>Foundation Depth (below grade):</b>	Pile 1: 7.00 ft Pile 2: 7.25 ft Pile 3: 7.25 ft Pile 4: 7.00 ft
<b>Foundation Volume:</b>	16.889 y <sup>3</sup>

### Site Info

<b>Risk Category:</b>	I
<b>Exposure:</b>	C
<b>Soil Classification:</b>	sand
<b>Site Location:</b>	9GX2+QJH Stonyford, CA, USA
<b>Wind Speed:</b>	100 mph

<b>Snow Load:</b>	24 psf
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#### **Design Disclaimer**

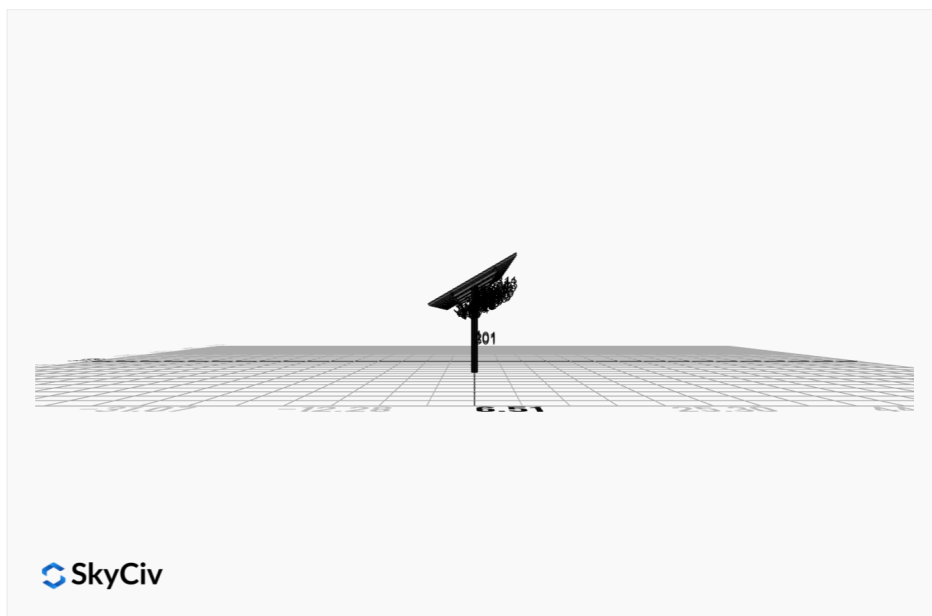
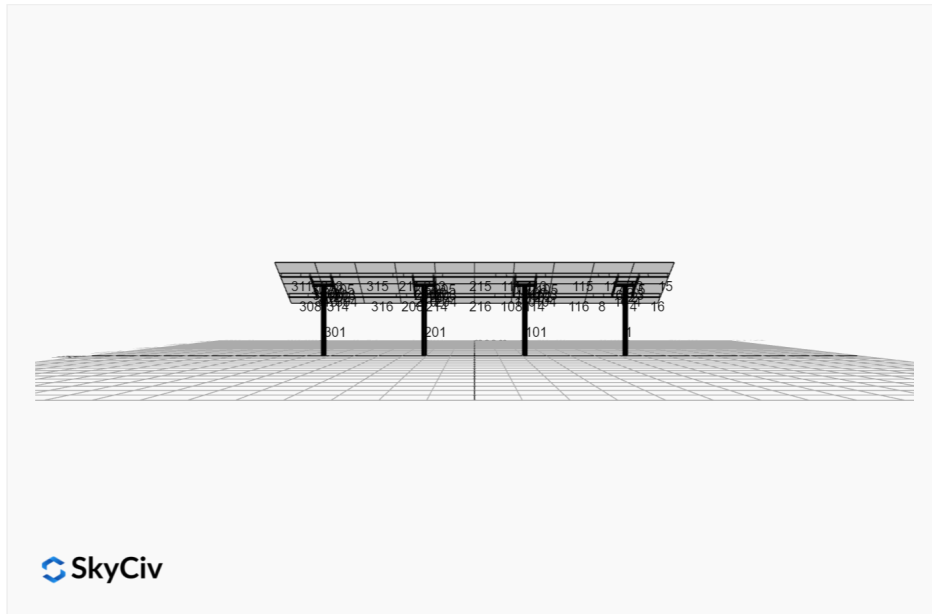
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

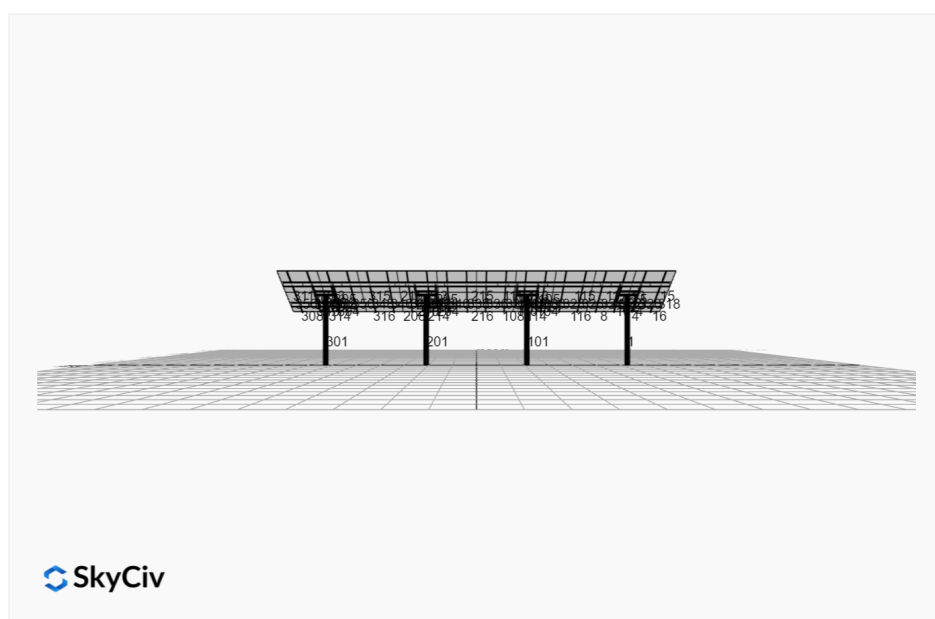
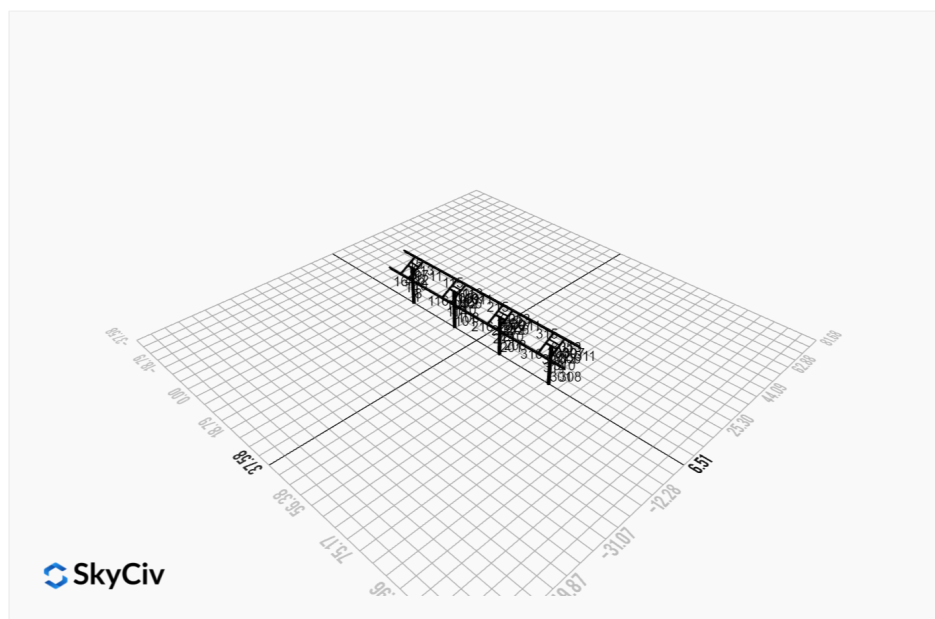
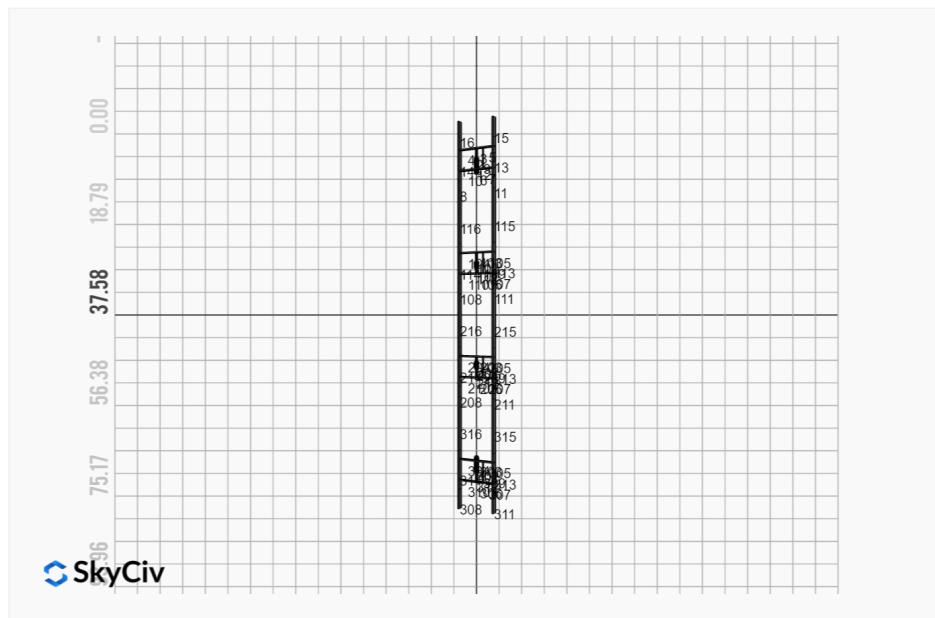
## AutoDesigner Input

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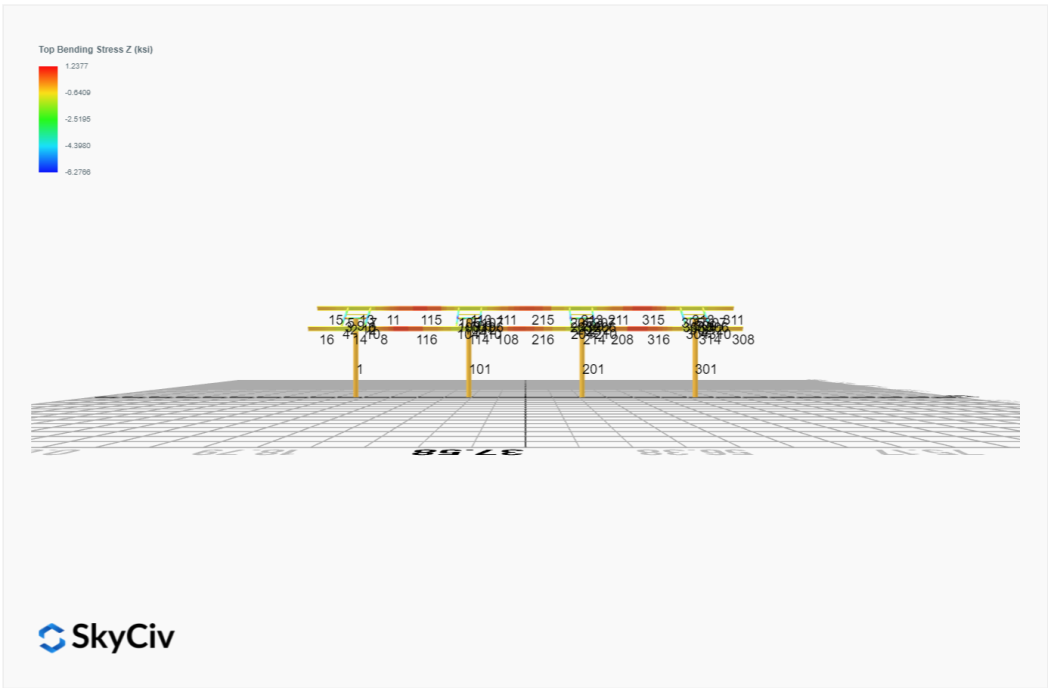
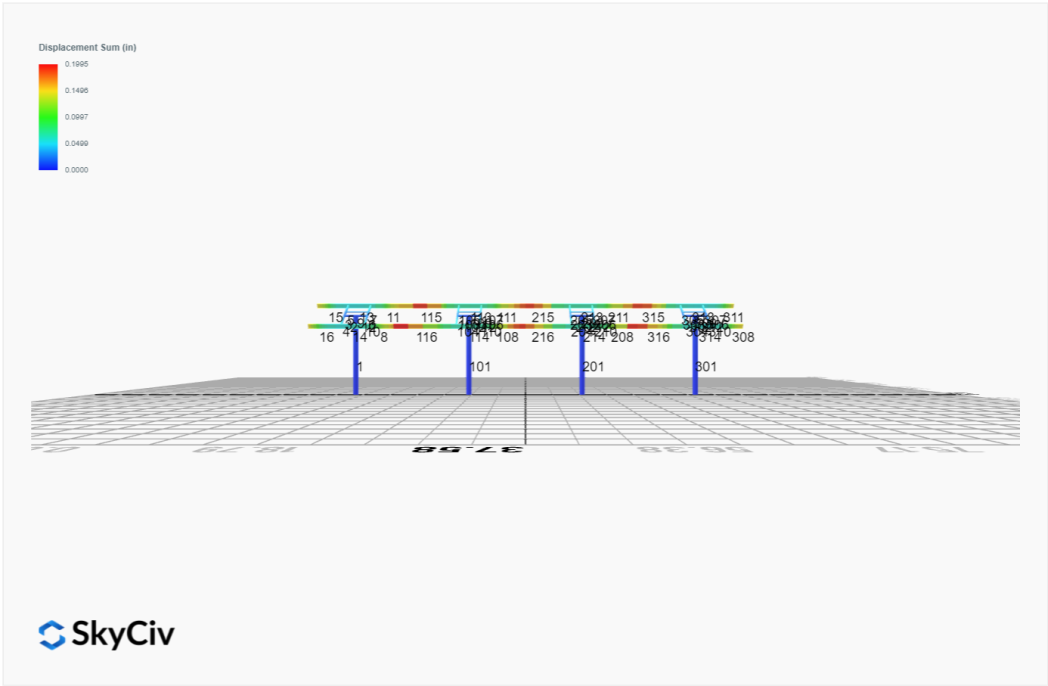
### Design Notes:

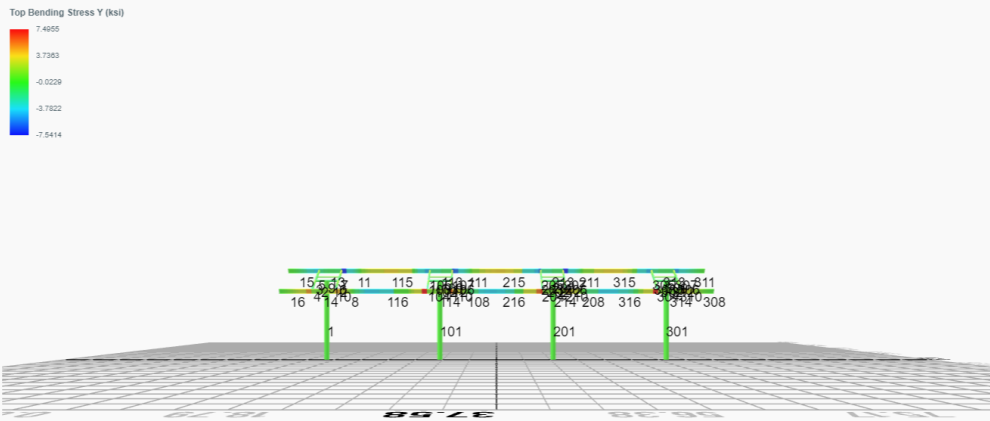
- AISC Deflection checks are set to L/1 due to structure design intent
- Foundation Soil Parameters used in this Autodesign are all estimates, proper geotechnical reports are required to confirm soil profiles
- Wind speeds, snow loads and other site specific results are based on ASCE 7 2016
- Steel frame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



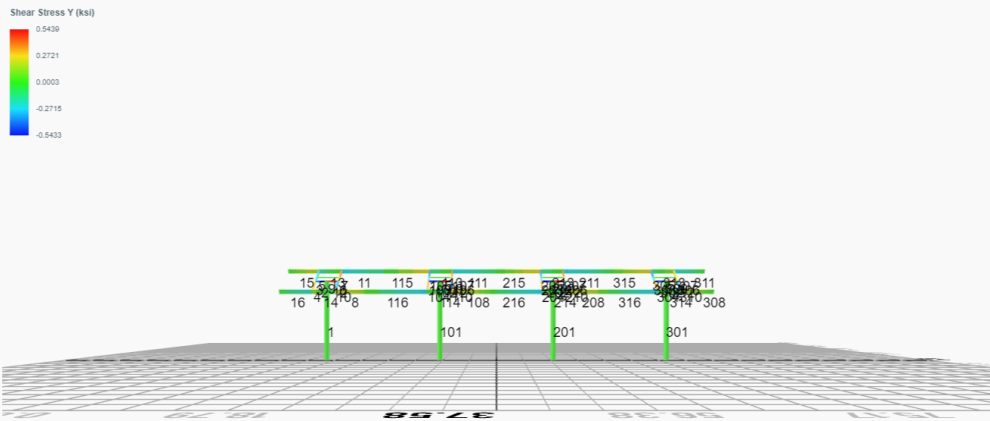


# FEM Results (Envelope Worst Case for each member)





 SkyCiv



 SkyCiv





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

### ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	0.0067	2.4322	0.0219	0.0888	-0.0046	-0.0585
ULS: 2. D + L	0.0067	2.4322	0.0219	0.0888	-0.0046	-0.0585
ULS: 3. D + (S or Lr or R)	0.0166	4.8014	0.0544	0.2212	-0.0121	-0.1847
ULS: 3. D + (S or Lr or R)	0.0067	2.4322	0.0219	0.0888	-0.0046	-0.0585
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0141	4.2091	0.0463	0.1881	-0.0102	-0.1531
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0067	2.4322	0.0219	0.0888	-0.0046	-0.0585
ULS: 5b. D + 0.7E	0.0067	2.4322	0.0219	0.0888	-0.0046	-0.0585
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0141	4.2091	0.0463	0.1881	-0.0102	-0.1531
ULS: 8. 0.6D + 0.7E	0.0040	1.4593	0.0131	0.0533	-0.0028	-0.0351
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.5093	6.7547	0.1051	0.4047	-0.3039	35.1540
ULS: 5a. D + 0.6W_Wind downforce Case B only	-2.5093	6.7547	0.1051	0.4047	-0.3039	35.1540
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.1616	-1.2716	-0.0479	-0.1755	0.2463	-29.4355
ULS: 5a. D + 0.6W_Wind uplift Case B only	1.8138	-0.6620	-0.0455	-0.1664	0.2426	-33.5928
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.8728	7.4509	0.1087	0.4251	-0.2347	26.2562
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.8728	7.4509	0.1087	0.4251	-0.2347	26.2562
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.6303	1.4312	-0.0060	-0.0101	0.1779	-22.1860
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.3695	1.8884	-0.0043	-0.0033	0.1752	-25.3039
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.8803	5.6741	0.0843	0.3257	-0.2290	26.3509
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.8803	5.6741	0.0843	0.3257	-0.2290	26.3509
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.6229	-0.3456	-0.0305	-0.1094	0.1836	-22.0913
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.3620	0.1116	-0.0287	-0.1026	0.1808	-25.2092
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.5119	5.7818	0.0964	0.3692	-0.3020	35.1774
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-2.5119	5.7818	0.0964	0.3692	-0.3020	35.1774
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.1590	-2.2445	-0.0566	-0.2110	0.2481	-29.4122
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	1.8111	-1.6349	-0.0543	-0.2019	0.2445	-33.5694

### Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	11.3079
Shear X	-4.1932
Shear Z	0.1821
Moment X	0.7031
Moment Y (Twist)	0.5110
Moment Z	59.0869

### Worst Case Reactions ASD

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

Result	Value (kip, kip-ft)
Axial	7.4509
Shear X	-2.5119
Shear Z	0.1087
Moment X	0.4251
Moment Y (Twist)	0.3039
Moment Z	35.1774

## 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	-0.0066	2.6783	-0.0021	-0.0092	0.0059	0.1172
ULS: 2. D + L	-0.0066	2.6783	-0.0021	-0.0092	0.0059	0.1172
ULS: 3. D + (S or Lr or R)	-0.0165	5.4114	-0.0053	-0.0229	0.0146	0.2543
ULS: 3. D + (S or Lr or R)	-0.0066	2.6783	-0.0021	-0.0092	0.0059	0.1172
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0140	4.7281	-0.0045	-0.0194	0.0124	0.2201

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0066	2.6783	-0.0021	-0.0092	0.0059	0.1172
ULS: 5b. D + 0.7E	-0.0066	2.6783	-0.0021	-0.0092	0.0059	0.1172
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0140	4.7281	-0.0045	-0.0194	0.0124	0.2201
ULS: 8. 0.6D + 0.7E	-0.0040	1.6070	-0.0013	-0.0055	0.0035	0.0703
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.8587	7.6533	0.0036	0.0084	-0.0362	39.9005
ULS: 5a. D + 0.6W_Wind downforce Case B only	-2.8587	7.6533	0.0036	0.0084	-0.0362	39.9005
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.4395	-1.5871	-0.0061	-0.0210	0.0381	-32.9996
ULS: 5a. D + 0.6W_Wind uplift Case B only	2.0205	-0.8685	-0.0109	-0.0394	0.0577	-37.4175
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.1530	8.4594	-0.0003	-0.0063	-0.0191	30.0575
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.1530	8.4594	-0.0003	-0.0063	-0.0191	30.0575
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.8206	1.5291	-0.0075	-0.0283	0.0366	-24.6176
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.5064	2.0680	-0.0111	-0.0421	0.0513	-27.9310
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.1456	6.4096	0.0021	0.0040	-0.0257	29.9547
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.1456	6.4096	0.0021	0.0040	-0.0257	29.9547
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.8280	-0.5207	-0.0051	-0.0180	0.0300	-24.7204
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.5138	0.0182	-0.0087	-0.0318	0.0447	-28.0338
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.8560	6.5820	0.0044	0.0120	-0.0385	39.8536
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-2.8560	6.5820	0.0044	0.0120	-0.0385	39.8536
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.4422	-2.6584	-0.0053	-0.0173	0.0357	-33.0465
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	2.0232	-1.9398	-0.0100	-0.0357	0.0553	-37.4644

### Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	12.8716
Shear X	-4.7654
Shear Z	-0.0192
Moment X	-0.0698
Moment Y (Twist)	0.1001
Moment Z	67.1586

### 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	8.4594
Shear X	-2.8587
Shear Z	-0.0111
Moment X	-0.0421
Moment Y (Twist)	0.0577
Moment Z	39.9005

## 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	-0.0068	2.6790	0.0023	0.0085	-0.0051	0.1200
ULS: 2. D + L	-0.0068	2.6790	0.0023	0.0085	-0.0051	0.1200
ULS: 3. D + (S or Lr or R)	-0.0170	5.4129	0.0057	0.0212	-0.0128	0.2612
ULS: 3. D + (S or Lr or R)	-0.0068	2.6790	0.0023	0.0085	-0.0051	0.1200
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0145	4.7294	0.0049	0.0180	-0.0109	0.2259
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0068	2.6790	0.0023	0.0085	-0.0051	0.1200
ULS: 5b. D + 0.7E	-0.0068	2.6790	0.0023	0.0085	-0.0051	0.1200
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0145	4.7294	0.0049	0.0180	-0.0109	0.2259
ULS: 8. 0.6D + 0.7E	-0.0041	1.6074	0.0014	0.0051	-0.0031	0.0720
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.8600	7.6563	-0.0032	-0.0128	0.0334	39.9189
ULS: 5a. D + 0.6W_Wind downforce Case B only	-2.8600	7.6563	-0.0032	-0.0128	0.0334	39.9189
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.4403	-1.5885	0.0061	0.0234	-0.0344	-33.0096
ULS: 5a. D + 0.6W_Wind uplift Case B only	2.0211	-0.8696	0.0109	0.0412	-0.0542	-37.4272

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	-2.1544	8.4625	0.0008	0.0020	0.0180	30.0751
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.1544	8.4625	0.0008	0.0020	0.0180	30.0751
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.8209	1.5288	0.0078	0.0292	-0.0328	-24.6213
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.5065	2.0680	0.0113	0.0425	-0.0477	-27.9345
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-2.1467	6.4120	-0.0018	-0.0075	0.0237	29.9692
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-2.1467	6.4120	-0.0018	-0.0075	0.0237	29.9692
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.8285	-0.5216	0.0052	0.0197	-0.0271	-24.7272
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.5141	0.0176	0.0087	0.0330	-0.0420	-28.0404
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.8573	6.5848	-0.0041	-0.0162	0.0354	39.8709
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-2.8573	6.5848	-0.0041	-0.0162	0.0354	39.8709
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.4431	-2.6601	0.0052	0.0200	-0.0323	-33.0576
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	2.0238	-1.9412	0.0099	0.0377	-0.0522	-37.4752

### Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	12.8768
Shear X	-4.7677
Shear Z	0.0192
Moment X	0.0729
Moment Y (Twist)	0.0940
Moment Z	67.1904

### 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	8.4625
Shear X	-2.8600
Shear Z	0.0113
Moment X	0.0425
Moment Y (Twist)	0.0542
Moment Z	39.9189

## 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	0.0068	2.4320	-0.0220	-0.0907	0.0026	-0.0600
ULS: 2. D + L	0.0068	2.4320	-0.0220	-0.0907	0.0026	-0.0600
ULS: 3. D + (S or Lr or R)	0.0169	4.8007	-0.0548	-0.2259	0.0071	-0.1885
ULS: 3. D + (S or Lr or R)	0.0068	2.4320	-0.0220	-0.0907	0.0026	-0.0600
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0144	4.2085	-0.0466	-0.1921	0.0059	-0.1564
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0068	2.4320	-0.0220	-0.0907	0.0026	-0.0600
ULS: 5b. D + 0.7E	0.0068	2.4320	-0.0220	-0.0907	0.0026	-0.0600
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0144	4.2085	-0.0466	-0.1921	0.0059	-0.1564
ULS: 8. 0.6D + 0.7E	0.0041	1.4592	-0.0132	-0.0544	0.0015	-0.0360
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.5086	6.7533	-0.1055	-0.4120	0.3005	35.1450
ULS: 5a. D + 0.6W_Wind downforce Case B only	-2.5086	6.7533	-0.1055	-0.4120	0.3005	35.1450
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.1613	-1.2709	0.0479	0.1781	-0.2471	-29.4309
ULS: 5a. D + 0.6W_Wind uplift Case B only	1.8135	-0.6615	0.0455	0.1684	-0.2439	-33.5878
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.8722	7.4495	-0.1092	-0.4331	0.2294	26.2474
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.8722	7.4495	-0.1092	-0.4331	0.2294	26.2474
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.6302	1.4313	0.0058	0.0095	-0.1813	-22.1846
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.3694	1.8884	0.0040	0.0022	-0.1789	-25.3022
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.8798	5.6730	-0.0846	-0.3317	0.2260	26.3438
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.8798	5.6730	-0.0846	-0.3317	0.2260	26.3438
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.6227	-0.3452	0.0304	0.1109	-0.1847	-22.0882
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.3619	0.1119	0.0286	0.1036	-0.1823	-25.2059

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.5113	5.7805	-0.0967	-0.3757	0.2995	35.1690
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-2.5113	5.7805	-0.0967	-0.3757	0.2995	35.1690
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.1586	-2.2437	0.0567	0.2144	-0.2481	-29.4069
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	1.8108	-1.6343	0.0543	0.2047	-0.2449	-33.5638

### Worst Case Reactions LRFD

These calculations are taken directly from the FEA via SkyCiv and are used in the Concrete Checks of the Foundation Module.

Note: Worst case values are assumed as downforce wind load cases.

Result	Value (kip, kip-ft)
Axial	11.3056
Shear X	-4.1923
Shear Z	-0.1828
Moment X	-0.7157
Moment Y (Twist)	0.5049
Moment Z	59.0718

### Worst Case Reactions ASD

These results are taken from the worst case values in the above table and are used in the Soil Checks in the Foundation Module.

Note: Worst case values are assumed as downforce wind load cases.

Result	Value (kip, kip-ft)
Axial	7.4495
Shear X	-2.5113
Shear Z	-0.1092
Moment X	-0.4331
Moment Y (Twist)	0.3005
Moment Z	35.1690

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			
$\Phi_t$	$\Phi_c$	$\Phi_b$	$\Phi_v$
0.9	0.9	0.9	0.9

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

Section Dimensions								
ID	Name	d (in)	$t_w$ (in)					
3	2in Pipe Sch 120	2.38	0.25					
6	4in Pipe Sch 120	4.50	0.44					
11	10in Pipe Sch 40	10.75	0.36					
ID	Name	d (in)	b (in)	$t_w$ (in)	$t_b$ (in)	r (in)		
17	HSS5x3x1/4	5.00	3.00	0.23	0.23	0.23		
ID	Name	d (in)	$t_w$ (in)	$b_t$ (in)	$b_b$ (in)	$t_t$ (in)	$t_b$ (in)	r (in)
20	W10x12	9.87	0.19	3.96	3.96	0.21	0.21	0.30

Section Properties								
ID	Name	A (in <sup>2</sup> )	J (in <sup>4</sup> )	$I_{yp}$ (in <sup>4</sup> )	$I_{zp}$ (in <sup>4</sup> )	$I_w$ (in <sup>6</sup> )	$S_{yp}$ (in <sup>3</sup> )	$S_{zp}$ (in <sup>3</sup> )
-	-	-	-	-	-	-	-	-



113	20	4.88	4.00	7.5 0	1.04,1.04,1.04,1.04,1.04,1.04,1.05,1.05,1.06,1.06,1.05,1.05,1.06,1.06,1.05,1.05,1.04,1.02,1.05,1.05,1.0 6,1.07,1.05,1.05,1.05,1.06	30 0	20 0	1
114	20	4.88	4.00	7.5 0	1.04,1.04,1.04,1.04,1.04,1.04,1.05,1.05,1.05,3.89,1.05,1.05,1.05,1.05,1.05,1.05,1.04,1.05,1.05,1.0 5,1.50,1.05,1.05,1.05,1.05	30 0	20 0	1
115	20	10.2 0	10.2 0	10. 20	1.20,1.20,1.20,1.20,1.20,1.20,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.17,1.19,1.19,1.26,2.06,1.18,1.18,1.1 6,1.16,1.18,1.18,1.18,1.17	30 0	20 0	1
116	20	10.2 0	10.2 0	10. 20	1.20,1.20,1.20,1.20,1.20,1.20,1.20,1.20,1.20,1.17,1.20,1.20,1.20,1.26,1.20,1.20,1.21,1.20,1.20,1.2 0,1.19,1.20,1.20,1.20,1.23	30 0	20 0	1
201	11	28.8 9	28.8 9	13. 76	-	30 0	20 0	1
202	6	1.30	1.30	2.0 0	-	30 0	20 0	1
203	17	0.92	0.92	1.4 2	1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.19,1.74,1.18,1.18,1.1 7,1.17,1.18,1.18,1.18,1.18	30 0	20 0	1
204	17	2.44	2.44	3.7 5	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.66,1.72,1.67,1.67,1.66,1.55,1.67,1.67,1.69,1.68,1.67,1.67,1.6 5,1.72,1.67,1.67,1.66,1.63	30 0	20 0	1
205	17	1.52	1.52	2.3 3	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.68,1.11,1.67,1.67,1.6 5,1.66,1.67,1.67,1.66,1.66	30 0	20 0	1
206	17	0.92	0.92	1.4 2	1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.18,1.18,1.19,1.30,1.18,1.18,1.1 7,1.17,1.18,1.18,1.18,1.18	30 0	20 0	1
207	17	1.52	1.52	2.3 3	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.68,1.84,1.67,1.67,1.6 5,1.66,1.67,1.67,1.66,1.66	30 0	20 0	1
208	20	1.33	1.33	2.0 5	2.06,2.06,2.06,2.06,2.06,2.06,2.06,2.06,2.06,1.75,2.06,2.06,2.06,2.31,2.06,2.06,2.08,2.06,2.06,2.0 5,1.90,2.06,2.06,2.06,2.11	30 0	20 0	1
209	3	2.60	2.60	4.0 0	-	30 0	20 0	1
210	17	2.44	2.44	3.7 5	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.66,1.72,1.67,1.67,1.66,1.53,1.67,1.67,1.69,1.68,1.67,1.67,1.6 5,1.72,1.67,1.67,1.66,1.63	30 0	20 0	1
211	20	1.33	1.33	2.0 5	2.06,2.06,2.06,2.06,2.06,2.06,1.84,1.84,1.68,1.68,1.82,1.82,1.73,1.72,1.93,1.93,2.32,1.12,1.86,1.86,1.6 3,1.65,1.82,1.82,1.75,1.73	30 0	20 0	1
212	6	1.30	1.30	2.0 0	-	30 0	20 0	1
213	20	4.88	4.00	7.5 0	1.04,1.04,1.04,1.04,1.04,1.04,1.05,1.05,1.06,1.06,1.05,1.05,1.05,1.06,1.05,1.05,1.04,1.02,1.05,1.05,1.0 6,1.07,1.05,1.05,1.05,1.06	30 0	20 0	1
214	20	4.88	4.00	7.5 0	1.04,1.04,1.04,1.04,1.04,1.04,1.05,1.05,1.05,3.89,1.05,1.05,1.05,1.05,1.05,1.05,1.04,1.05,1.05,1.0 5,1.50,1.05,1.05,1.05,1.05	30 0	20 0	1
215	20	10.2 0	10.2 0	10. 20	1.17,1.17,1.17,1.17,1.17,1.17,1.16,1.16,1.15,1.15,1.15,1.15,1.15,1.15,1.16,1.16,1.22,1.01,1.16,1.16,1.1 4,1.14,1.15,1.15,1.15,1.15	30 0	20 0	1
216	20	10.2 0	10.2 0	10. 20	1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.16,1.17,1.17,1.17,1.20,1.17,1.17,1.17,1.17,1.17,1.1 7,1.16,1.17,1.17,1.17,1.18	30 0	20 0	1
301	11	28.8 9	28.8 9	13. 76	-	30 0	20 0	1
302	6	1.30	1.30	2.0 0	-	30 0	20 0	1
303	17	0.92	0.92	1.4 2	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.19,1.05,1.18,1.18,1.1 7,1.17,1.18,1.18,1.18,1.18	30 0	20 0	1
304	17	2.44	2.44	3.7 5	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.66,1.73,1.67,1.67,1.66,1.57,1.67,1.67,1.70,1.68,1.67,1.67,1.6 4,1.73,1.67,1.67,1.66,1.63	30 0	20 0	1
305	17	1.52	1.52	2.3 3	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.68,1.45,1.67,1.67,1.6 5,1.66,1.67,1.67,1.66,1.66	30 0	20 0	1
306	17	0.92	0.92	1.4 2	1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.19,1.68,1.18,1.18,1.1 6,1.17,1.18,1.18,1.17,1.17	30 0	20 0	1
307	17	1.52	1.52	2.3 3	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.68,2.93,1.67,1.67,1.6 5,1.66,1.67,1.67,1.66,1.66	30 0	20 0	1
308	20	7.88	7.88	3.7 5	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 3,2.33,2.33,2.33,2.33,2.33	30 0	20 0	1
309	3	2.60	2.60	4.0 0	-	30 0	20 0	1
310	17	2.44	2.44	3.7 5	1.69,1.68,1.69,1.68,1.69,1.69,1.67,1.67,1.66,1.71,1.67,1.67,1.66,1.19,1.67,1.67,1.70,1.68,1.67,1.67,1.6 4,1.72,1.67,1.67,1.66,1.60	30 0	20 0	1
311	20	7.88	7.88	3.7 5	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 3,2.33,2.33,2.33,2.33,2.33	30 0	20 0	1
312	6	4.20	4.20	2.0 0	-	30 0	20 0	1
313	20	4.88	4.00	7.5 0	1.11,1.11,1.11,1.11,1.11,1.11,1.10,1.10,1.10,1.12,1.10,1.10,1.10,1.12,1.11,1.11,1.14,2.33,1.10,1.10,1.0 9,1.12,1.10,1.10,1.10,1.12	30 0	20 0	1
314	20	4.88	4.00	7.5 0	1.11,1.11,1.11,1.11,1.11,1.11,1.11,1.11,1.10,2.51,1.11,1.11,1.10,1.17,1.11,1.11,1.12,1.14,1.11,1.11,1.1 0,1.42,1.11,1.11,1.11,1.11	30 0	20 0	1

315	20	10.2 0	10.2 0	10. 20	1.12,1.12,1.12,1.12,1.12,1.12,1.13,1.13,1.14,1.14,1.13,1.13,1.13,1.14,1.12,1.12,1.12,2.23,1.13,1.13,1.14,1.14,1.13,1.13,1.14	30 0	20 0	1
316	20	10.2 0	10.2 0	10. 20	1.11,1.11,1.11,1.11,1.11,1.11,1.12,1.12,1.12,1.18,1.12,1.12,1.12,1.09,1.11,1.11,1.11,1.12,1.12,1.12,1.12,1.15,1.12,1.12,1.12,1.10	30 0	20 0	1

## Member Design Capacity

Member ID	$\Phi_t P_n$ (kip)	$\Phi_c P_n$ (kip)	$\Phi_b M_{zn}$ (k-ft)	$\Phi_b M_{yn}$ (k-ft)	$\Phi_v V_{yn}$ (kip)	$\Phi_v V_{zn}$ (kip)
1	535.87	279.42	147.68	147.68	160.76	160.76
2	251.01	229.64	27.16	27.16	75.30	75.30
3	151.65	150.70	20.17	14.14	54.12	28.95
4	151.65	145.15	20.17	14.14	54.12	28.95
5	151.65	149.10	20.17	14.14	54.12	28.95
6	151.65	150.70	20.17	14.14	54.12	28.95
7	151.65	149.10	20.17	14.14	54.12	28.95
8	159.30	140.46	46.90	6.46	56.26	44.91
9	75.10	66.32	4.25	4.25	22.53	22.53
10	151.65	145.15	20.17	14.14	54.12	28.95
11	159.30	140.46	46.90	6.46	56.26	44.91
12	251.01	248.88	27.16	27.16	75.30	75.30
13	159.30	97.43	33.45	6.46	56.26	44.91
14	159.30	97.43	33.66	6.46	56.26	44.91
15	159.30	55.15	46.90	6.46	56.26	44.91
16	159.30	55.15	46.90	6.46	56.26	44.91
101	535.87	279.42	147.68	147.68	160.76	160.76
102	251.01	248.88	27.16	27.16	75.30	75.30
103	151.65	150.70	20.17	14.14	54.12	28.95
104	151.65	145.15	20.17	14.14	54.12	28.95
105	151.65	149.10	20.17	14.14	54.12	28.95
106	151.65	150.70	20.17	14.14	54.12	28.95
107	151.65	149.10	20.17	14.14	54.12	28.95
108	159.30	140.46	46.90	6.46	56.26	44.91
109	75.10	66.32	4.25	4.25	22.53	22.53
110	151.65	145.15	20.17	14.14	54.12	28.95
111	159.30	140.46	46.90	6.46	56.26	44.91
112	251.01	248.88	27.16	27.16	75.30	75.30
113	159.30	97.43	31.29	6.46	56.26	44.91
114	159.30	97.43	31.89	6.46	56.26	44.91
115	159.30	32.87	22.39	6.46	56.26	44.91
116	159.30	32.87	22.57	6.46	56.26	44.91
201	535.87	279.42	147.68	147.68	160.76	160.76
202	251.01	248.88	27.16	27.16	75.30	75.30
203	151.65	150.70	20.17	14.14	54.12	28.95
204	151.65	145.15	20.17	14.14	54.12	28.95
205	151.65	149.10	20.17	14.14	54.12	28.95
206	151.65	150.70	20.17	14.14	54.12	28.95
207	151.65	149.10	20.17	14.14	54.12	28.95
208	159.30	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	240.00	27.10	27.10	75.30	75.30
213	159.30	97.43	31.31	6.46	56.26	44.91
214	159.30	97.43	31.86	6.46	56.26	44.91
215	159.30	32.87	19.36	6.46	56.26	44.91
216	159.30	32.87	22.29	6.46	56.26	44.91
301	535.87	279.42	147.68	147.68	160.76	160.76
302	251.01	248.88	27.16	27.16	75.30	75.30
303	151.65	150.70	20.17	14.14	54.12	28.95
304	151.65	145.15	20.17	14.14	54.12	28.95
305	151.65	149.10	20.17	14.14	54.12	28.95
306	151.65	150.70	20.17	14.14	54.12	28.95
307	151.65	149.10	20.17	14.14	54.12	28.95
308	159.30	55.15	46.90	6.46	56.26	44.91
309	75.10	66.32	4.25	4.25	22.53	22.53
310	151.65	145.15	20.17	14.14	54.12	28.95
311	159.30	55.15	46.90	6.46	56.26	44.91
312	251.01	229.64	27.16	27.16	75.30	75.30
313	159.30	97.43	33.45	6.46	56.26	44.91
314	159.30	97.43	33.67	6.46	56.26	44.91
315	159.30	32.87	21.52	6.46	56.26	44.91
316	159.30	32.87	21.05	6.46	56.26	44.91

## Design Ratio

Member ID	P	M <sub>z</sub>	M <sub>y</sub>	V <sub>y</sub>	V <sub>z</sub>	(P,M <sub>z</sub> ,M <sub>y</sub> )	Worst LC	KL/r	δ	Status
1	0.040	0.400	0.012	0.026	0.001	0.425	#13	0.472	Not Required	Pass
2	0.002	0.300	0.140	0.066	0.027	0.440	#13	0.116	Not Required	Pass
3	0.004	0.487	0.022	0.048	0.002	0.500	#13	0.046	Not Required	Pass
4	0.004	0.486	0.072	0.049	0.016	0.522	#13	0.082	Not Required	Pass
5	0.004	0.302	0.069	0.048	0.018	0.309	#13	0.076	Not Required	Pass
6	0.006	0.555	0.043	0.056	0.009	0.582	#13	0.046	Not Required	Pass
7	0.006	0.344	0.098	0.055	0.025	0.358	#13	0.076	Not Required	Pass
8	0.001	0.062	0.105	0.034	0.011	0.109	#24	0.102	Not Required	Pass
9	0.007	0.055	0.040	0.001	0.001	0.096	#13	0.206	Not Required	Pass
10	0.006	0.544	0.095	0.054	0.021	0.566	#13	0.082	Not Required	Pass
11	0.001	0.059	0.106	0.035	0.011	0.110	#24	0.102	Not Required	Pass
12	0.001	0.366	0.159	0.076	0.029	0.525	#13	0.054	Not Required	Pass
13	0.003	0.163	0.266	0.045	0.015	0.355	#21	0.306	Not Required	Pass
14	0.005	0.162	0.264	0.044	0.015	0.346	#21	0.204	Not Required	Pass
15	0.000	0.048	0.090	0.021	0.007	0.130	#21	Not Required	Not Required	Pass
16	0.000	0.048	0.090	0.021	0.007	0.130	#21	Not Required	Not Required	Pass
101	0.046	0.455	0.001	0.030	0.000	0.478	#13	0.472	Not Required	Pass
102	0.002	0.380	0.169	0.081	0.031	0.550	#13	0.036	Not Required	Pass
103	0.006	0.591	0.036	0.059	0.005	0.614	#13	0.046	Not Required	Pass
104	0.006	0.597	0.095	0.060	0.021	0.636	#13	0.082	Not Required	Pass
105	0.006	0.367	0.098	0.058	0.025	0.381	#13	0.076	Not Required	Pass
106	0.006	0.597	0.035	0.060	0.006	0.616	#13	0.046	Not Required	Pass
107	0.006	0.370	0.095	0.059	0.025	0.384	#13	0.076	Not Required	Pass
108	0.002	0.046	0.098	0.035	0.011	0.119	#21	0.102	Not Required	Pass
109	0.009	0.053	0.034	0.001	0.000	0.088	#13	0.206	Not Required	Pass
110	0.006	0.596	0.092	0.060	0.020	0.631	#13	0.082	Not Required	Pass

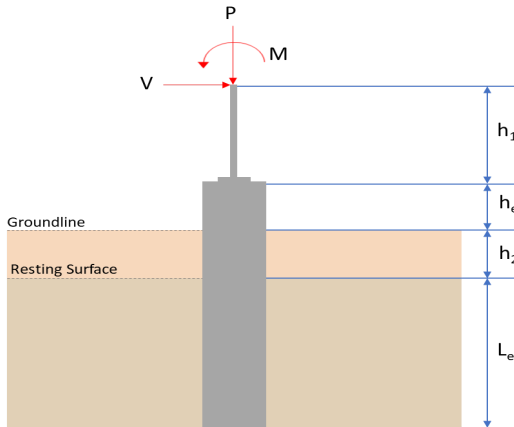
111	0.002	0.053	0.100	0.035	0.011	0.118	#21	0.102	Not Required	Pass
112	0.002	0.382	0.171	0.081	0.032	0.554	#13	0.036	Not Required	Pass
113	0.003	0.168	0.268	0.045	0.015	0.391	#21	0.306	Not Required	Pass
114	0.006	0.183	0.266	0.046	0.015	0.397	#21	0.306	Not Required	Pass
115	0.006	0.233	0.141	0.035	0.011	0.337	#21	0.780	Not Required	Pass
116	0.003	0.230	0.142	0.036	0.011	0.332	#21	0.780	Not Required	Pass
201	0.046	0.455	0.001	0.030	0.000	0.478	#13	0.472	Not Required	Pass
202	0.002	0.382	0.171	0.081	0.032	0.554	#13	0.036	Not Required	Pass
203	0.006	0.597	0.035	0.060	0.006	0.616	#13	0.046	Not Required	Pass
204	0.006	0.596	0.092	0.060	0.020	0.631	#13	0.082	Not Required	Pass
205	0.006	0.370	0.095	0.059	0.025	0.384	#13	0.076	Not Required	Pass
206	0.006	0.591	0.035	0.059	0.005	0.614	#13	0.046	Not Required	Pass
207	0.006	0.367	0.098	0.059	0.025	0.381	#13	0.076	Not Required	Pass
208	0.001	0.052	0.107	0.036	0.012	0.126	#21	0.102	Not Required	Pass
209	0.009	0.053	0.034	0.001	0.000	0.088	#13	0.206	Not Required	Pass
210	0.006	0.597	0.095	0.060	0.021	0.636	#13	0.082	Not Required	Pass
211	0.001	0.057	0.108	0.035	0.011	0.123	#21	0.102	Not Required	Pass
212	0.002	0.380	0.169	0.081	0.031	0.550	#13	0.036	Not Required	Pass
213	0.003	0.168	0.268	0.045	0.015	0.392	#21	0.306	Not Required	Pass
214	0.006	0.183	0.266	0.046	0.015	0.398	#21	0.306	Not Required	Pass
215	0.007	0.229	0.141	0.035	0.011	0.330	#21	0.780	Not Required	Pass
216	0.005	0.214	0.142	0.035	0.011	0.319	#21	0.780	Not Required	Pass
301	0.040	0.400	0.012	0.026	0.001	0.425	#13	0.472	Not Required	Pass
302	0.001	0.366	0.158	0.076	0.029	0.525	#13	0.054	Not Required	Pass
303	0.006	0.555	0.043	0.056	0.009	0.582	#13	0.046	Not Required	Pass
304	0.006	0.543	0.095	0.054	0.021	0.566	#13	0.082	Not Required	Pass
305	0.006	0.344	0.098	0.055	0.025	0.358	#13	0.076	Not Required	Pass
306	0.004	0.487	0.022	0.048	0.002	0.500	#13	0.046	Not Required	Pass
307	0.004	0.302	0.069	0.048	0.018	0.309	#13	0.076	Not Required	Pass
308	0.000	0.048	0.090	0.021	0.007	0.130	#21	Not Required	Not Required	Pass
309	0.007	0.055	0.040	0.001	0.001	0.096	#13	0.206	Not Required	Pass
310	0.004	0.486	0.072	0.049	0.016	0.522	#13	0.082	Not Required	Pass
311	0.000	0.048	0.090	0.021	0.007	0.130	#21	Not Required	Not Required	Pass
312	0.002	0.300	0.140	0.066	0.027	0.441	#13	0.116	Not Required	Pass
313	0.003	0.163	0.265	0.044	0.015	0.355	#21	0.204	Not Required	Pass
314	0.005	0.162	0.264	0.044	0.015	0.345	#21	0.306	Not Required	Pass
315	0.006	0.247	0.139	0.035	0.011	0.342	#21	0.780	Not Required	Pass
316	0.003	0.242	0.140	0.034	0.011	0.339	#21	0.780	Not Required	Pass

## Definitions

$\Phi_t$	Safety factor for tensile
$\Phi_c$	Safety factor for compression
$\Phi_b$	Safety factor for flexure
$\Phi_v$	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
$\delta$	Design ratio in case of member deflection
OK	Capacity is provided
NG	Capacity is not provided



REFERENCES	CALCULATIONS	RESULTS																										
	<div><div>SkyCiv Foundation Design</div><div>Pile Foundation</div><div>Design Information :</div><div>Design code : IBC 2021 (International Building Code)</div><div>Unit System : Imperial</div></div>																											
	<div><div>Pile Input</div><div></div><div>Geometry</div><div>Pile shape: rectangular b = 48 in - Pile width D = 48 in - Pile depth L = 7 ft - Total pile length h1 = 0 ft - Lateral load height from the top of the pile, h2 = 0 ft - Depth to resisting surface he = 0 ft - Length of pile above the ground</div><div>Tabulation of Soil Parameters</div><table><thead><tr><th>Layer</th><th>Label</th><th>Allowable Bearing Pressure (qa) (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 &amp; clayey gravel</td><td>2000.000</td><td>150.000</td></tr></tbody></table><div>Tabulation of Loads</div><table><thead><tr><th>Load Component</th><th>ASD</th><th>LRFD</th></tr></thead><tbody><tr><td>P (kip)</td><td>7.451</td><td>11.308</td></tr><tr><td>Vx (kip)</td><td>-2.512</td><td>-4.193</td></tr><tr><td>Vz (kip)</td><td>0.109</td><td>0.182</td></tr><tr><td>Mx (kipft)</td><td>0.425</td><td>0.703</td></tr><tr><td>Mz (kipft)</td><td>35.177</td><td>59.087</td></tr></tbody></table><div>Material Properties</div><div>f'ck = 2.5 ksi - Concrete strength,</div></div>	Layer	Label	Allowable Bearing Pressure (qa) (psf)	Allowable Lateral Pressure (R) (psf/ft)	1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000	Load Component	ASD	LRFD	P (kip)	7.451	11.308	Vx (kip)	-2.512	-4.193	Vz (kip)	0.109	0.182	Mx (kipft)	0.425	0.703	Mz (kipft)	35.177	59.087	
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	<div><div>Required depth to resist lateral loads (ASD)</div><div>H - Point of application of the lateral load</div><div><div><div><div><div><math display="block">H = h_1 + h_2 + h_e</math></div><div><math display="block">H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})</math></div><div><math display="block">H = 0 \text{ ft}</math></div></div></div><div>Considering x-direction:</div><div>Ho - Lateral force per length of pile,</div><div><div><div><math display="block">H_o = \frac{V_x}{1.57 D}</math></div><div><math display="block">H_o = \frac{(-2.512 \text{ kip})}{1.57 \times (48 \text{ in})}</math></div><div><math display="block">H_o = -0.4 \text{ kip/ft}</math></div></div></div></div></div></div>																											

	<p><math>M_o</math> - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$ $M_o = \frac{(35.177 \text{ kipft}) + ((-2.512 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 5.6014 \text{ kipft/ft}$ <p>Required depth of embedment in earth:</p> $L_x^3 - \left( 14.14 \times \frac{H_o \times L_x}{R} \right) - \left( 18.85 \times \frac{M_o}{R} \right) = 0$ <p>Solving the cubic equation:  <math>L_{e,x} = 6.6143 \text{ ft}</math> - Required depth in x-direction,</p> <p><b>Considering z-direction:</b></p> <p><math>H_o</math> - Lateral force per length of pile,</p> $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(0.109 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = 0.017357 \text{ kip/ft}$ <p><math>M_o</math> - Moment per length of pile,</p> $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(0.425 \text{ kipft}) + ((0.109 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.067675 \text{ kipft/ft}$ <p>Required depth of embedment in earth:</p> $L_z^3 - \left( 14.14 \times \frac{H_o \times L_z}{R} \right) - \left( 18.85 \times \frac{M_o}{R} \right) = 0$ <p>Solving the cubic equation:  <math>L_{e,z} = 1.953 \text{ ft}</math> - Required depth in z-direction,</p> <p><b>Minimum embedded depth required:</b></p> <p><math>L_{e,req}</math> - Depth of pile required,</p> $L_{e,req} = \text{MAX}[L_{e,x}, L_{e,z}]$ $L_{e,req} = \text{MAX}[(6.6143 \text{ ft}), (1.953 \text{ ft})]$ $L_{e,req} = 6.614 \text{ ft}$ <p><math>L_e</math> - Actual embedded length of pile,</p> $L_e = L - h_e - h_2$ $L_e = (7 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 7 \text{ ft}$ <p><b>Ratio</b> - Embedded depth</p> $\text{Ratio} = \frac{L_{e,req}}{L_e}$ $\text{Ratio} = \frac{(6.614 \text{ ft})}{(7 \text{ ft})}$ $\text{Ratio} = 0.94486$	<p>Status: <b>PASS</b> Ratio: <b>0.940</b></p>
	<p><b>End-bearing Capacity (ASD)</b></p> <p><math>A</math> - Pile cross-section area</p> $A = b D$ $A = (48 \text{ in}) \times (48 \text{ in})$ $A = 16 \text{ ft}^2$ <p><math>q</math> - End-bearing pressure</p>	

	$q = \frac{P_v}{A}$ $q = \frac{(7.451 \text{ kip})}{(16 \text{ ft}^2)}$ $q = 0.46569 \text{ kip/ft}^2$ <p><b>Check bearing capacity ratio:</b></p> <p>Ratio - Capacity</p> $\text{Ratio} = \frac{q}{q_a}$ $\text{Ratio} = \frac{(0.46569 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $\text{Ratio} = 0.23284$	Status: <b>PASS</b> Ratio: <b>0.230</b>
Czerniak	<p><b>Lateral Soil Pressure (ASD):</b></p> <p><math>L/D</math> - Length to least lateral dimension ratio,</p> $L/D = \frac{L}{D}$ $L/D = \frac{(7 \text{ ft})}{(48 \text{ in})}$ $L/D = 1.75$ <p>Since <math>L/D \leq 10</math>,</p> <p>Pile is short.</p> <p><b>Considering x-direction:</b></p> <p><math>H_o = -0.4 \text{ kip/ft}</math> - Lateral force per length of pile,  <math>M_o = 5.6014 \text{ kipft/ft}</math> - Overturning moment per length of pile,  <math>a</math> - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (5.6014 \text{ kipft/ft}) \times (7 \text{ ft})) + (3 \times (-0.4 \text{ kip/ft}) \times (7 \text{ ft})^2)}{(6 \times (5.6014 \text{ kipft/ft})) + (4 \times (-0.4 \text{ kip/ft}) \times (7 \text{ ft}))}$ $a = 4.8125 \text{ ft}$ <p><math>p</math> - Earth pressure against the pile at distance <math>a/2</math> from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (5.6014 \text{ kipft/ft})) + (3 \times (-0.4 \text{ kip/ft}) \times (7 \text{ ft}))]^2}{(7 \text{ ft})^2 \times [(3 \times (5.6014 \text{ kipft/ft})) + (2 \times (-0.4 \text{ kip/ft}) \times (7 \text{ ft}))]}$ $p = 0.26797 \text{ kip/ft}^2$ <p><math>s</math> - Earth pressure against the pile at distance <math>L_e</math>,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (5.6014 \text{ kipft/ft})) + ((-0.4 \text{ kip/ft}) \times (7 \text{ ft}))]}{(7 \text{ ft})^2}$ $s = 1.0289 \text{ kip/ft}^2$ <p><b>Check lateral soil pressure capacity:</b></p> <p><math>p_a</math> - Allowable lateral soil pressure at depth <math>a/2</math>,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.8125 \text{ ft})}{2}$ $p_a = 0.36094 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p>	

	$Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.26797 \text{ kip/ft}^2)}{(0.36094 \text{ kip/ft}^2)}$ $Ratio = 0.74244$ <p><math>p_s</math> - Allowable lateral soil pressure at depth <math>L_e</math>,</p> $p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (7 \text{ ft})$ $p_s = 1.05 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $Ratio = \frac{s}{p_s}$ $Ratio = \frac{(1.0289 \text{ kip/ft}^2)}{(1.05 \text{ kip/ft}^2)}$ $Ratio = 0.97993$	<p>Status: <b>PASS</b> Ratio: <b>0.740</b></p> <p>Status: <b>PASS</b> Ratio: <b>0.980</b></p>
	<p><b>Considering z-direction:</b></p> <p><math>H_o = 0.017357 \text{ kip/ft}</math> - Lateral force per length of pile,  <math>M_o = 0.067675 \text{ kipft/ft}</math> - Overturning moment per length of pile,  <math>a</math> - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.067675 \text{ kipft/ft}) \times (7 \text{ ft})) + (3 \times (0.017357 \text{ kip/ft}) \times (7 \text{ ft})^2)}{(6 \times (0.067675 \text{ kipft/ft})) + (4 \times (0.017357 \text{ kip/ft}) \times (7 \text{ ft}))}$ $a = 4.9845 \text{ ft}$ <p><math>p</math> - Earth pressure against the pile at distance <math>a/2</math> from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.067675 \text{ kipft/ft})) + (3 \times (0.017357 \text{ kip/ft}) \times (7 \text{ ft}))]^2}{(7 \text{ ft})^2 \times [(3 \times (0.067675 \text{ kipft/ft})) + (2 \times (0.017357 \text{ kip/ft}) \times (7 \text{ ft}))]}$ $p = 0.013846 \text{ kip/ft}^2$ <p><math>s</math> - Earth pressure against the pile at distance <math>L_e</math>,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.067675 \text{ kipft/ft})) + ((0.017357 \text{ kip/ft}) \times (7 \text{ ft}))]}{(7 \text{ ft})^2}$ $s = 0.031451 \text{ kip/ft}^2$ <p><b>Check lateral soil pressure capacity:</b></p> <p><math>p_a</math> - Allowable lateral soil pressure at depth <math>a/2</math>,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.9845 \text{ ft})}{2}$ $p_a = 0.37384 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.013846 \text{ kip/ft}^2)}{(0.37384 \text{ kip/ft}^2)}$	



$$Ratio = 0.037037$$

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

$p_s$  - Allowable lateral soil pressure at depth  $L_e$ ,

$$p_s = R L_e$$

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

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

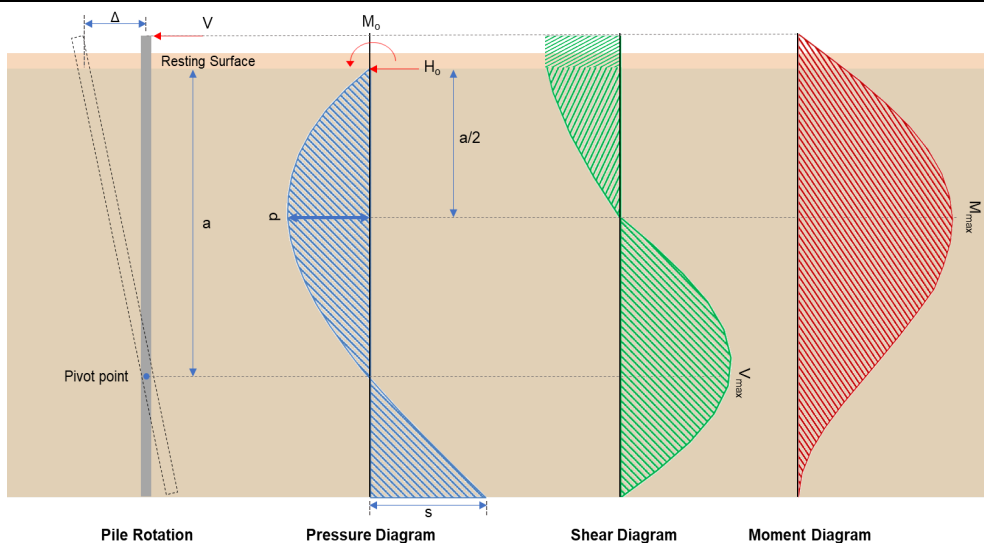
Ratio - Lateral soil capacity

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

$$Ratio = \frac{(0.031451 \text{ kip/ft}^2)}{(1.05 \text{ kip/ft}^2)}$$

$$Ratio = 0.029953$$

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



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

$H_o$  - Lateral force per length of pile,

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

$$H_o = \frac{(-4.193 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.66768 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

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

$$M_o = \frac{(59.087 \text{ kipft}) + ((-4.193 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 9.4088 \text{ kipft/ft}$$

$E$  - Distance from lateral load to resisting surface,

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

$$E = \frac{(9.4088 \text{ kipft/ft})}{(-0.66768 \text{ kip/ft})}$$

$$E = 14.092 \text{ ft}$$

$a$  - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (9.4088 \text{ kipft/ft}) \times (7 \text{ ft})) + (3 \times (-0.66768 \text{ kip/ft}) \times (7 \text{ ft})^2)}{(6 \times (9.4088 \text{ kipft/ft})) + (4 \times (-0.66768 \text{ kip/ft}) \times (7 \text{ ft}))}$$

$$a = \frac{(-0.66768 \text{ kip/ft}) \times (48 \text{ in})}{(6 \times (9.4088 \text{ kip/ft})) + (4 \times (-0.66768 \text{ kip/ft}) \times (7 \text{ ft}))}$$

$$a = 4.8118 \text{ ft}$$

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

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

$$V_{max} = ((-0.66768 \text{ kip/ft}) \times (48 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (14.092 \text{ ft})}{(7 \text{ ft})} + 3 \right) \times \left( \frac{(4.8118 \text{ ft})}{(7 \text{ ft})} \right)^2 \right] + \left[ 4 \times \left( \frac{3 \times (14.092 \text{ ft})}{(7 \text{ ft})} + 2 \right) \times \left( \frac{(4.8118 \text{ ft})}{(7 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 11.277 \text{ kip}$$

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

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

$$M_{max} = ((-0.66768 \text{ kip/ft}) \times (48 \text{ in}) \times (7 \text{ ft})) \times \left[ \left( \frac{(14.092 \text{ ft})}{(7 \text{ ft})} + \frac{(4.8118 \text{ ft})}{2 \times (7 \text{ ft})} \right) - \left[ \left( \frac{4 \times (14.092 \text{ ft})}{(7 \text{ ft})} + 3 \right) \times \left( \frac{(4.8118 \text{ ft})}{2 \times (7 \text{ ft})} \right)^3 \right] + \left[ \left( \frac{3 \times (14.092 \text{ ft})}{(7 \text{ ft})} + 2 \right) \times \left( \frac{(4.8118 \text{ ft})}{2 \times (7 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 37.769 \text{ kipft}$$

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

$H_o$  - Lateral force per length of pile,

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

$$H_o = \frac{(0.182 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.028981 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

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

$$M_o = \frac{(0.703 \text{ kipft}) + ((0.182 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.11194 \text{ kipft/ft}$$

$E$  - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.11194 \text{ kipft/ft})}{(0.028981 \text{ kip/ft})}$$

$$E = 3.8626 \text{ ft}$$

$a$  - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.11194 \text{ kipft/ft}) \times (7 \text{ ft})) + (3 \times (0.028981 \text{ kip/ft}) \times (7 \text{ ft})^2)}{(6 \times (0.11194 \text{ kipft/ft})) + (4 \times (0.028981 \text{ kip/ft}) \times (7 \text{ ft}))}$$

$$a = 4.9858 \text{ ft}$$

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

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

$$V_{max} = ((0.028981 \text{ kip/ft}) \times (48 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (3.8626 \text{ ft})}{(7 \text{ ft})} + 3 \right) \times \left( \frac{(4.9858 \text{ ft})}{(7 \text{ ft})} \right)^2 \right] \right. \\ \left. + \left[ 4 \times \left( \frac{3 \times (3.8626 \text{ ft})}{(7 \text{ ft})} + 2 \right) \times \left( \frac{(4.9858 \text{ ft})}{(7 \text{ ft})} \right)^3 \right] \right] \\ V_{max} = 0.19031 \text{ kip}$$

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

$$M_{max} = (H_o \ b \ L_e) \left[ \left( \frac{E}{L_e} + \frac{a}{2 \ L_e} \right) \right. \\ \left. - \left[ \left( \frac{4 \ E}{L_e} + 3 \right) \left( \frac{a}{2 \ L_e} \right)^3 \right] + \left[ \left( \frac{3 \ E}{L_e} + 2 \right) \left( \frac{a}{2 \ L_e} \right)^4 \right] \right] \\ M_{max} = ((0.028981 \text{ kip/ft}) \times (48 \text{ in}) \times (7 \text{ ft})) \times \left[ \left( \frac{(3.8626 \text{ ft})}{(7 \text{ ft})} + \frac{(4.9858 \text{ ft})}{2 \times (7 \text{ ft})} \right) \right. \\ \left. - \left[ \left( \frac{4 \times (3.8626 \text{ ft})}{(7 \text{ ft})} + 3 \right) \times \left( \frac{(4.9858 \text{ ft})}{2 \times (7 \text{ ft})} \right)^3 \right] + \left[ \left( \frac{3 \times (3.8626 \text{ ft})}{(7 \text{ ft})} + 2 \right) \times \left( \frac{(4.9858 \text{ ft})}{2 \times (7 \text{ ft})} \right)^4 \right] \right] \\ M_{max} = 0.59362 \text{ kipft}$$

#### Minimum Reinforcement Check (LRFD)

##### Parameters:

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

##### Longitudinal reinforcement:

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

$A_{st,required}$

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

$$A_{st,required} = Min \left[ \frac{\left( \frac{(11.308 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2)) \right)}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$$

$$A_{st,required} = -84.22 \text{ in}^2$$

$A_{min}$  - Governing minimum reinforcement area,

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

$$A_{min} = Max [(-84.22 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$$

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

$n_{rebar}$  - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

$A_{st}$  - Actual total reinforcement area,

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

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

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

Ratio - Capacity

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

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

Table 22.4.2.1

22.4.2.2, 10.6.1.1

<p>25.2.3</p>	<p><math>s_{rebar} = 0.96556</math></p> <p><math>s_{rebar}</math> - Minimum spacing of reinforcement,</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><b>Ties:</b></p> <p>25.7.2.2 Since longitudinal reinforcement is <math>\leq</math> No. 10ø: Use #3(0.375 in)</p> <p>25.7.2.1 <math>s_{ties}</math> - Maximum spacing of ties,</p> $s_{ties} = Min[(16 d_{bar}), (48 d_{ties}), Min(D, b)]$ $s_{ties} = Min[(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), Min((48 \text{ in}), (48 \text{ in}))]$ $s_{ties} = 10 \text{ in}$ <p><b>Summary:</b></p> <p>Main reinforcement: <b>14 - #5 (0.625 in)</b> Ties: <b>#3(0.375 in) - 10 in</b></p>	<p>Status: <b>PASS</b> Ratio: <b>0.970</b></p>
<p>22.4.2.2</p>	<p><b>Axial Compression Strength (ACI 318-19, LRFD)</b></p> <p><math>\phi P_N</math> - Allowable axial compressive strength</p> $\phi P_N = \phi 0.80 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st})]$ $\phi P_N = (0.65) \times 0.80 \times [(0.85 \times (2.5 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2))]$ $\phi P_N = 2675.2 \text{ kip}$ <p><math>Ratio</math> - Capacity</p> $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(11.308 \text{ kip})}{(2675.2 \text{ kip})}$ $Ratio = 0.004227$	<p>Status: <b>PASS</b> Ratio: <b>0.000</b></p>
<p>22.5.2.2</p> <p>22.5.1.3</p> <p>22.5.1.1</p>	<p><b>Shear Strength (ACI 318-19, LRFD)</b></p> <p><b>Parameters:</b></p> <p><math>b_w = 48 \text{ in}</math> - Effective width, <math>d</math> - Effective depth</p> $d = 0.80 D$ $d = 0.80 \times (48 \text{ in})$ $d = 38.4 \text{ in}$ <p><math>\lambda_s</math> - size effect modification factor</p> $\lambda_s = MIN \left[ \sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = MIN \left[ \sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.64282$ <p>The following variables were converted to be consistent with empirical formula <math>f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}</math>,</p> <p><math>V_{c,max}</math> - Max shear strength of concrete</p> $V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$ $V_{c,max} = 5 \times (0.64282) \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$	

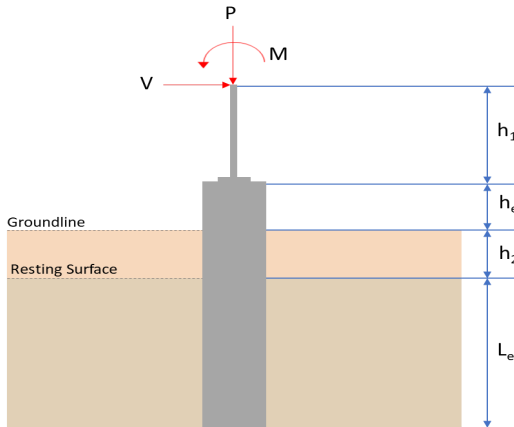
		$V_{c,max} = 296.21 \text{ kip}$	
22.5.5.1.1(a)	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$ , $P = 11.308 \text{ kip} \rightarrow 11308 \text{ lbf}$ , $V_{c,a}$ - Shear strength of concrete (a)	$V_{c,a} = \left[ 2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[ 2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(11308 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 120 \text{ kip}$	
22.5.5.1.2	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$ , $V_{c,b}$ - Shear strength of concrete (b)	$V_{c,b} = \left[ 2 \lambda_s \sqrt{f'_{ck}} + (0.05 f'_{ck}) \right] b_w d$ $V_{c,b} = \left[ 2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + (0.05 \times (2500 \text{ psi})) \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,b} = 348.89 \text{ kip}$	
	$V_c$ - Governing shear strength of concrete	$V_c = \text{Min}[V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = \text{Min}[(296.21 \text{ kip}), (120 \text{ kip}), (348.89 \text{ kip})]$ $V_c = 120 \text{ kip}$	
22.5.5.1.2	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$ , $V_{s,a}$ - Shear strength of steel (a)	$V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$ $V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{s,a} = 737.28 \text{ kip}$	
	$A_v$ - Ties rebar area,	$A_v = \frac{\pi d_{ties}^2}{4}$ $A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$ $A_v = 0.11045 \text{ in}^2$	
22.5.8.5.3	$V_{s,b}$ - Shear strength of steel (b)	$V_{s,b} = \frac{2 A_v f_{yw} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$	
	$V_s$ - Governing shear strength of steel	$V_s = \text{MIN}[V_{s,a}, V_{s,b}]$ $V_s = \text{MIN}[(737.28 \text{ kip}), (50.894 \text{ kip})]$ $V_s = 50.894 \text{ kip}$	
22.5.1.1	$\phi V_n$ - Allowable shear strength	$\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((120 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 111.08 \text{ kip}$	
	Considering x-direction: $V_{max} = 11.277 \text{ kip}$ - Maximum shear force in the x-direction, $Ratio$ - Capacity	$Ratio = \frac{V_{max}}{\phi V_n}$	

	$Ratio = \frac{(11.277 \text{ kip})}{(111.08 \text{ kip})}$ $Ratio = 0.10152$ <p><b>Considering z-direction:</b></p> <p><math>V_{max} = 0.19031 \text{ kip}</math> - Maximum shear force in the z-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.19031 \text{ kip})}{(111.08 \text{ kip})}$ $Ratio = 0.0017133$ <p>Status: <b>PASS</b> Ratio: <b>0.100</b></p>	
14.5.2.1b	<p><b>Flexural Strength (ACI 318-19, LRFD)</b></p> <p><math>S_m</math> - Section modulus</p> $S_m = \frac{b D^2}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$ <p><math>\lambda = 1</math> - Concrete modification factor (Normal concrete),  Allowable flexural strength:  <math>M_n</math> shall be the lesser of:  <math>\phi M_{n,1}</math></p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 \text{ ksi})} \times 18432.001 \text{ in}^3$ $\phi M_{n,1} = 249.600 \text{ kipft}$ <p><math>\phi M_{n,2}</math></p> $\phi M_{n,2} = \phi \times 0.85 \times f'_c \times S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (18432 \text{ in}^3)$ $\phi M_{n,2} = 2121.6 \text{ kipft}$ <p>Therefore,  <math>\phi M_n</math> - Allowable flexural strength,</p> $\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = MIN[(249.6 \text{ kipft}), (2121.6 \text{ kipft})]$ $\phi M_n = 249.6 \text{ kipft}$ <p><b>Considering x-direction:</b></p> <p><math>M_{max} = 37.769 \text{ kipft}</math> - Maximum moment in the x-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(37.769 \text{ kipft})}{(249.6 \text{ kipft})}$ $Ratio = 0.15132$ <p>Status: <b>PASS</b> Ratio: <b>0.150</b></p>	
	<p><b>Considering z-direction:</b></p> <p><math>M_{max} = 0.59362 \text{ kipft}</math> - Maximum moment in the z-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$	

$$Ratio = \frac{(0.59362 \text{ kipft})}{(249.6 \text{ kipft})}$$

$$Ratio = 0.0023783$$

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

REFERENCES	CALCULATIONS	RESULTS																											
	<div>SkyCiv Foundation Design</div> <div>Pile Foundation</div> <div>Design Information :</div> <div>Design code : IBC 2021 (International Building Code)</div> <div>Unit System : Imperial</div>																												
	<div>Pile Input</div> <div></div> <div>Geometry</div> <div>Pile shape: rectangular</div> <div>b = 48 in - Pile width</div> <div>D = 48 in - Pile depth</div> <div>L = 7 ft - Total pile length</div> <div>h1 = 0 ft - Lateral load height from the top of the pile,</div> <div>h2 = 0 ft - Depth to resisting surface</div> <div>he = 0 ft - Length of pile above the ground</div> <div>Tabulation of Soil Parameters</div> <table><tr><th>Layer</th><th>Label</th><th>Allowable Bearing Pressure (qa) (psf)</th><th>Allowable Lateral Pressure (R) (psf/ft)</th></tr><tr><td>1</td><td>Sand, silty sand, clayey sand, silty gravel &amp; clayey gravel</td><td>2000.000</td><td>150.000</td></tr></table> <div>Tabulation of Loads</div> <table><tr><th>Load Component</th><th>ASD</th><th>LRFD</th></tr><tr><td>P (kip)</td><td>7.449</td><td>11.306</td></tr><tr><td>Vx (kip)</td><td>-2.511</td><td>-4.192</td></tr><tr><td>Vz (kip)</td><td>-0.109</td><td>-0.183</td></tr><tr><td>Mx (kipft)</td><td>-0.433</td><td>-0.716</td></tr><tr><td>Mz (kipft)</td><td>35.169</td><td>59.072</td></tr></table> <div>Material Properties</div> <div>f'ck = 2.5 ksi - Concrete strength,</div>	Layer	Label	Allowable Bearing Pressure (qa) (psf)	Allowable Lateral Pressure (R) (psf/ft)	1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000	Load Component	ASD	LRFD	P (kip)	7.449	11.306	Vx (kip)	-2.511	-4.192	Vz (kip)	-0.109	-0.183	Mx (kipft)	-0.433	-0.716	Mz (kipft)	35.169	59.072	<div>Required depth to resist lateral loads (ASD)</div> <div>H - Point of application of the lateral load</div> <div><math display="block">H = h_1 + h_2 + h_e</math></div> <div><math display="block">H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})</math></div> <div><math display="block">H = 0 \text{ ft}</math></div> <div>Considering x-direction:</div> <div>Ho - Lateral force per length of pile,</div> <div><math display="block">H_o = \frac{V_x}{1.57 \text{ } D}</math></div> <div><math display="block">H_o = \frac{(-2.511 \text{ kip})}{1.57 \times (48 \text{ in})}</math></div> <div><math display="block">H_o = -0.39984 \text{ kip/ft}</math></div>	
Layer	Label	Allowable Bearing Pressure (qa) (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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Mx (kipft)	-0.433	-0.716																											
Mz (kipft)	35.169	59.072																											



	<p><math>M_o</math> - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$ $M_o = \frac{(35.169 \text{ kipft}) + ((-2.511 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 5.6002 \text{ kipft/ft}$ <p>Required depth of embedment in earth:</p> $L_x^3 - \left( 14.14 \times \frac{H_o \times L_x}{R} \right) - \left( 18.85 \times \frac{M_o}{R} \right) = 0$ <p>Solving the cubic equation:  <math>L_{e,x} = 6.6141 \text{ ft}</math> - Required depth in x-direction,</p> <p><b>Considering z-direction:</b></p> <p><math>H_o</math> - Lateral force per length of pile,</p> $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(-0.109 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.017357 \text{ kip/ft}$ <p><math>M_o</math> - Moment per length of pile,</p> $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(0.433 \text{ kipft}) + ((-0.109 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.068949 \text{ kipft/ft}$ <p>Required depth of embedment in earth:</p> $L_z^3 - \left( 14.14 \times \frac{H_o \times L_z}{R} \right) - \left( 18.85 \times \frac{M_o}{R} \right) = 0$ <p>Solving the cubic equation:  <math>L_{e,z} = 1.5713 \text{ ft}</math> - Required depth in z-direction,</p> <p><b>Minimum embedded depth required:</b></p> <p><math>L_{e,req}</math> - Depth of pile required,</p> $L_{e,req} = \text{MAX}[L_{e,x}, L_{e,z}]$ $L_{e,req} = \text{MAX}[(6.6141 \text{ ft}), (1.5713 \text{ ft})]$ $L_{e,req} = 6.614 \text{ ft}$ <p><math>L_e</math> - Actual embedded length of pile,</p> $L_e = L - h_e - h_2$ $L_e = (7 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 7 \text{ ft}$ <p><b>Ratio</b> - Embedded depth</p> $\text{Ratio} = \frac{L_{e,req}}{L_e}$ $\text{Ratio} = \frac{(6.614 \text{ ft})}{(7 \text{ ft})}$ $\text{Ratio} = 0.94486$	<p>Status: <b>PASS</b>  Ratio: <b>0.940</b></p>
	<p><b>End-bearing Capacity (ASD)</b></p> <p><math>A</math> - Pile cross-section area</p> $A = b D$ $A = (48 \text{ in}) \times (48 \text{ in})$ $A = 16 \text{ ft}^2$ <p><math>q</math> - End-bearing pressure</p>	

	$q = \frac{P_v}{A}$ $q = \frac{(7.449 \text{ kip})}{(16 \text{ ft}^2)}$ $q = 0.46556 \text{ kip/ft}^2$ <p><b>Check bearing capacity ratio:</b></p> <p>Ratio - Capacity</p> $\text{Ratio} = \frac{q}{q_a}$ $\text{Ratio} = \frac{(0.46556 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $\text{Ratio} = 0.23278$	<p>Status: <b>PASS</b> Ratio: <b>0.230</b></p>
Czerniak	<p><b>Lateral Soil Pressure (ASD):</b></p> <p><math>L/D</math> - Length to least lateral dimension ratio,</p> $L/D = \frac{L}{D}$ $L/D = \frac{(7 \text{ ft})}{(48 \text{ in})}$ $L/D = 1.75$ <p>Since <math>L/D \leq 10</math>,</p> <p>Pile is short.</p> <p><b>Considering x-direction:</b></p> <p><math>H_o = -0.39984 \text{ kip/ft}</math> - Lateral force per length of pile,  <math>M_o = 5.6002 \text{ kipft/ft}</math> - Overturning moment per length of pile,  <math>a</math> - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (5.6002 \text{ kipft/ft}) \times (7 \text{ ft})) + (3 \times (-0.39984 \text{ kip/ft}) \times (7 \text{ ft})^2)}{(6 \times (5.6002 \text{ kipft/ft})) + (4 \times (-0.39984 \text{ kip/ft}) \times (7 \text{ ft}))}$ $a = 4.8125 \text{ ft}$ <p><math>p</math> - Earth pressure against the pile at distance <math>a/2</math> from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (5.6002 \text{ kipft/ft})) + (3 \times (-0.39984 \text{ kip/ft}) \times (7 \text{ ft}))]^2}{(7 \text{ ft})^2 \times [(3 \times (5.6002 \text{ kipft/ft})) + (2 \times (-0.39984 \text{ kip/ft}) \times (7 \text{ ft}))]}$ $p = 0.26794 \text{ kip/ft}^2$ <p><math>s</math> - Earth pressure against the pile at distance <math>L_e</math>,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (5.6002 \text{ kipft/ft})) + ((-0.39984 \text{ kip/ft}) \times (7 \text{ ft}))]}{(7 \text{ ft})^2}$ $s = 1.0287 \text{ kip/ft}^2$ <p><b>Check lateral soil pressure capacity:</b></p> <p><math>p_a</math> - Allowable lateral soil pressure at depth <math>a/2</math>,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.8125 \text{ ft})}{2}$ $p_a = 0.36093 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p>	

	$Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.26794 \text{ kip/ft}^2)}{(0.36093 \text{ kip/ft}^2)}$ $Ratio = 0.74236$ <p><math>p_s</math> - Allowable lateral soil pressure at depth <math>L_e</math>,</p> $p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (7 \text{ ft})$ $p_s = 1.05 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $Ratio = \frac{s}{p_s}$ $Ratio = \frac{(1.0287 \text{ kip/ft}^2)}{(1.05 \text{ kip/ft}^2)}$ $Ratio = 0.97976$	<p>Status: <b>PASS</b> Ratio: <b>0.740</b></p> <p>Status: <b>PASS</b> Ratio: <b>0.980</b></p>
	<p><b>Considering z-direction:</b></p> <p><math>H_o = -0.017357 \text{ kip/ft}</math> - Lateral force per length of pile,  <math>M_o = 0.068949 \text{ kipft/ft}</math> - Overturning moment per length of pile,  <math>a</math> - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.068949 \text{ kipft/ft}) \times (7 \text{ ft})) + (3 \times (-0.017357 \text{ kip/ft}) \times (7 \text{ ft})^2)}{(6 \times (0.068949 \text{ kipft/ft})) + (4 \times (-0.017357 \text{ kip/ft}) \times (7 \text{ ft}))}$ $a = 4.9818 \text{ ft}$ <p><math>p</math> - Earth pressure against the pile at distance <math>a/2</math> from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.068949 \text{ kipft/ft})) + (3 \times (-0.017357 \text{ kip/ft}) \times (7 \text{ ft}))]^2}{(7 \text{ ft})^2 \times [(3 \times (0.068949 \text{ kipft/ft})) + (2 \times (-0.017357 \text{ kip/ft}) \times (7 \text{ ft}))]}$ $p = -0.0033311 \text{ kip/ft}^2$ <p><math>s</math> - Earth pressure against the pile at distance <math>L_e</math>,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.068949 \text{ kipft/ft})) + ((-0.017357 \text{ kip/ft}) \times (7 \text{ ft}))]}{(7 \text{ ft})^2}$ $s = 0.0020083 \text{ kip/ft}^2$ <p><b>Check lateral soil pressure capacity:</b></p> <p><math>p_a</math> - Allowable lateral soil pressure at depth <math>a/2</math>,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.9818 \text{ ft})}{2}$ $p_a = 0.37363 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(-0.0033311 \text{ kip/ft}^2)}{(0.37363 \text{ kip/ft}^2)}$	

$$Ratio = -0.0089155$$

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

$p_s$  - Allowable lateral soil pressure at depth  $L_e$ ,

$$p_s = R L_e$$

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

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

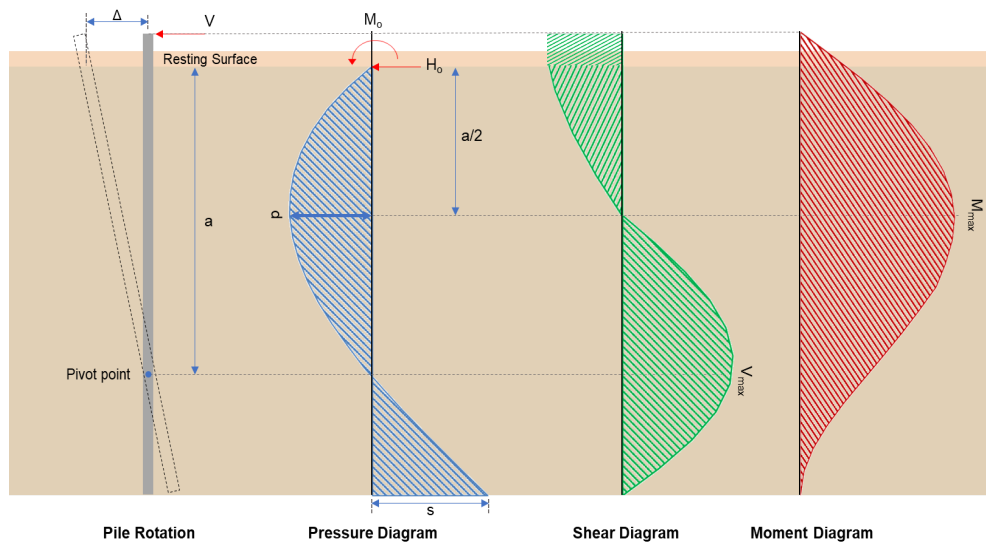
Ratio - Lateral soil capacity

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

$$Ratio = \frac{(0.0020083 \text{ kip/ft}^2)}{(1.05 \text{ kip/ft}^2)}$$

$$Ratio = 0.0019127$$

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



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

$H_o$  - Lateral force per length of pile,

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

$$H_o = \frac{(-4.192 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.66752 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

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

$$M_o = \frac{(59.072 \text{ kipft}) + ((-4.192 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 9.4064 \text{ kipft/ft}$$

$E$  - Distance from lateral load to resisting surface,

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

$$E = \frac{(9.4064 \text{ kipft/ft})}{(-0.66752 \text{ kip/ft})}$$

$$E = 14.092 \text{ ft}$$

$a$  - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (9.4064 \text{ kipft/ft}) \times (7 \text{ ft})) + (3 \times (-0.66752 \text{ kip/ft}) \times (7 \text{ ft})^2)}{(6 \times (9.4064 \text{ kipft/ft})) + (4 \times (-0.66752 \text{ kip/ft}) \times (7 \text{ ft}))}$$

$$a = \frac{(6 \times (9.4064 \text{ kipft/ft})) + (4 \times (-0.66752 \text{ kip/ft}) \times (7 \text{ ft}))}{}$$

$$a = 4.8118 \text{ ft}$$

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

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

$$V_{max} = ((-0.66752 \text{ kip/ft}) \times (48 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (14.092 \text{ ft})}{(7 \text{ ft})} + 3 \right) \times \left( \frac{(4.8118 \text{ ft})}{(7 \text{ ft})} \right)^2 \right] + \left[ 4 \times \left( \frac{3 \times (14.092 \text{ ft})}{(7 \text{ ft})} + 2 \right) \times \left( \frac{(4.8118 \text{ ft})}{(7 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 11.274 \text{ kip}$$

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

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

$$M_{max} = ((-0.66752 \text{ kip/ft}) \times (48 \text{ in}) \times (7 \text{ ft})) \times \left[ \left( \frac{(14.092 \text{ ft})}{(7 \text{ ft})} + \frac{(4.8118 \text{ ft})}{2 \times (7 \text{ ft})} \right) - \left[ \left( \frac{4 \times (14.092 \text{ ft})}{(7 \text{ ft})} + 3 \right) \times \left( \frac{(4.8118 \text{ ft})}{2 \times (7 \text{ ft})} \right)^3 \right] + \left[ \left( \frac{3 \times (14.092 \text{ ft})}{(7 \text{ ft})} + 2 \right) \times \left( \frac{(4.8118 \text{ ft})}{2 \times (7 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 37.759 \text{ kipft}$$

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

$H_o$  - Lateral force per length of pile,

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

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

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

$M_o$  - Moment per length of pile,

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

$$M_o = \frac{(0.716 \text{ kipft}) + ((-0.183 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.11401 \text{ kipft/ft}$$

$E$  - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.11401 \text{ kipft/ft})}{(-0.02914 \text{ kip/ft})}$$

$$E = 3.9126 \text{ ft}$$

$a$  - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.11401 \text{ kipft/ft}) \times (7 \text{ ft})) + (3 \times (-0.02914 \text{ kip/ft}) \times (7 \text{ ft})^2)}{(6 \times (0.11401 \text{ kipft/ft})) + (4 \times (-0.02914 \text{ kip/ft}) \times (7 \text{ ft}))}$$

$$a = 4.984 \text{ ft}$$

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

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

$$V_{max} = ((-0.02914 \text{ kip/ft}) \times (48 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (3.9126 \text{ ft})}{(7 \text{ ft})} + 3 \right) \times \left( \frac{(4.984 \text{ ft})}{(7 \text{ ft})} \right)^2 \right] + \left[ 4 \times \left( \frac{3 \times (3.9126 \text{ ft})}{(7 \text{ ft})} + 2 \right) \times \left( \frac{(4.984 \text{ ft})}{(7 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.19281 \text{ kip}$$

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

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

$$M_{max} = ((-0.02914 \text{ kip/ft}) \times (48 \text{ in}) \times (7 \text{ ft})) \times \left[ \left( \frac{(3.9126 \text{ ft})}{(7 \text{ ft})} + \frac{(4.984 \text{ ft})}{2 \times (7 \text{ ft})} \right) - \left[ \left( \frac{4 \times (3.9126 \text{ ft})}{(7 \text{ ft})} + 3 \right) \times \left( \frac{(4.984 \text{ ft})}{2 \times (7 \text{ ft})} \right)^3 \right] + \left[ \left( \frac{3 \times (3.9126 \text{ ft})}{(7 \text{ ft})} + 2 \right) \times \left( \frac{(4.984 \text{ ft})}{2 \times (7 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.60196 \text{ kipft}$$

#### Minimum Reinforcement Check (LRFD)

##### Parameters:

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

##### Longitudinal reinforcement:

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

$A_{st,required}$

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

$$A_{st,required} = Min \left[ \frac{\left( \frac{(11.306 \text{ kip})}{(0.65) \times (0.8)} \right) - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$$

$$A_{st,required} = -84.22 \text{ in}^2$$

$A_{min}$  - Governing minimum reinforcement area,

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

$$A_{min} = Max [(-84.22 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$$

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

$n_{rebar}$  - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

$A_{st}$  - Actual total reinforcement area,

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

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

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

Ratio - Capacity

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

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

Table 22.4.2.1

22.4.2.2, 10.6.1.1

<p>25.2.3</p>	<p><math>s_{rebar} = 0.96556</math></p> <p><math>s_{rebar}</math> - Minimum spacing of reinforcement,</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><b>Ties:</b></p> <p>25.7.2.2 Since longitudinal reinforcement is <math>\leq</math> No. 10ø: Use #3(0.375 in)</p> <p>25.7.2.1 <math>s_{ties}</math> - Maximum spacing of ties,</p> $s_{ties} = Min[(16 d_{bar}), (48 d_{ties}), Min(D, b)]$ $s_{ties} = Min[(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), Min((48 \text{ in}), (48 \text{ in}))]$ $s_{ties} = 10 \text{ in}$ <p><b>Summary:</b></p> <p>Main reinforcement: <b>14 - #5 (0.625 in)</b> Ties: <b>#3(0.375 in) - 10 in</b></p>	<p>Status: <b>PASS</b> Ratio: <b>0.970</b></p>
<p>22.4.2.2</p>	<p><b>Axial Compression Strength (ACI 318-19, LRFD)</b></p> <p><math>\phi P_N</math> - Allowable axial compressive strength</p> $\phi P_N = \phi 0.80 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st})]$ $\phi P_N = (0.65) \times 0.80 \times [(0.85 \times (2.5 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2))]$ $\phi P_N = 2675.2 \text{ kip}$ <p><math>Ratio</math> - Capacity</p> $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(11.306 \text{ kip})}{(2675.2 \text{ kip})}$ $Ratio = 0.0042263$	<p>Status: <b>PASS</b> Ratio: <b>0.000</b></p>
<p>22.5.2.2</p> <p>22.5.1.3</p> <p>22.5.1.1</p>	<p><b>Shear Strength (ACI 318-19, LRFD)</b></p> <p><b>Parameters:</b></p> <p><math>b_w = 48 \text{ in}</math> - Effective width, <math>d</math> - Effective depth</p> $d = 0.80 D$ $d = 0.80 \times (48 \text{ in})$ $d = 38.4 \text{ in}$ <p><math>\lambda_s</math> - size effect modification factor</p> $\lambda_s = MIN \left[ \sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = MIN \left[ \sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.64282$ <p>The following variables were converted to be consistent with empirical formula <math>f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}</math>,</p> <p><math>V_{c,max}</math> - Max shear strength of concrete</p> $V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$ $V_{c,max} = 5 \times (0.64282) \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$	

		$V_{c,max} = 296.21 \text{ kip}$	
22.5.5.1.1(a)	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$ , $P = 11.306 \text{ kip} \rightarrow 11306 \text{ lbf}$ , $V_{c,a}$ - Shear strength of concrete (a)	$V_{c,a} = \left[ 2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[ 2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(11306 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 120 \text{ kip}$	
22.5.5.1.2	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$ , $V_{c,b}$ - Shear strength of concrete (b)	$V_{c,b} = \left[ 2 \lambda_s \sqrt{f'_{ck}} + (0.05 f'_{ck}) \right] b_w d$ $V_{c,b} = \left[ 2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + (0.05 \times (2500 \text{ psi})) \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,b} = 348.89 \text{ kip}$	
	$V_c$ - Governing shear strength of concrete	$V_c = \text{Min}[V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = \text{Min}[(296.21 \text{ kip}), (120 \text{ kip}), (348.89 \text{ kip})]$ $V_c = 120 \text{ kip}$	
22.5.5.1.2	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$ , $V_{s,a}$ - Shear strength of steel (a)	$V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$ $V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{s,a} = 737.28 \text{ kip}$	
	$A_v$ - Ties rebar area,	$A_v = \frac{\pi d_{ties}^2}{4}$ $A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$ $A_v = 0.11045 \text{ in}^2$	
22.5.8.5.3	$V_{s,b}$ - Shear strength of steel (b)	$V_{s,b} = \frac{2 A_v f_{yw} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$	
	$V_s$ - Governing shear strength of steel	$V_s = \text{MIN}[V_{s,a}, V_{s,b}]$ $V_s = \text{MIN}[(737.28 \text{ kip}), (50.894 \text{ kip})]$ $V_s = 50.894 \text{ kip}$	
22.5.1.1	$\phi V_n$ - Allowable shear strength	$\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((120 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 111.08 \text{ kip}$	
	<b>Considering x-direction:</b> $V_{max} = 11.274 \text{ kip}$ - Maximum shear force in the x-direction, $Ratio$ - Capacity	$Ratio = \frac{V_{max}}{\phi V_n}$	

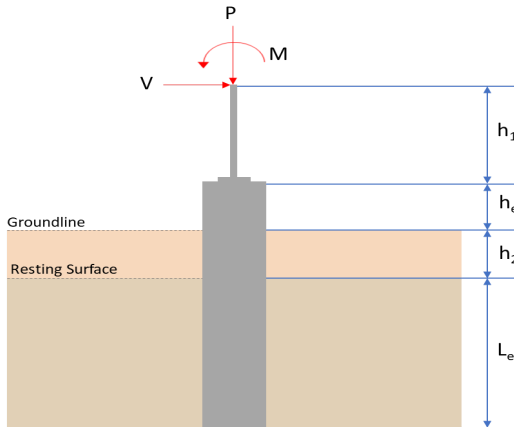


	$Ratio = \frac{(11.274 \text{ kip})}{(111.08 \text{ kip})}$ $Ratio = 0.1015$ <p><b>Considering z-direction:</b></p> <p><math>V_{max} = 0.19281 \text{ kip}</math> - Maximum shear force in the z-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.19281 \text{ kip})}{(111.08 \text{ kip})}$ $Ratio = 0.0017359$	<p>Status: <b>PASS</b> Ratio: <b>0.100</b></p> <p>Status: <b>PASS</b> Ratio: <b>0.000</b></p>
14.5.2.1b	<p><b>Flexural Strength (ACI 318-19, LRFD)</b></p> <p><math>S_m</math> - Section modulus</p> $S_m = \frac{b D^2}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$ <p><math>\lambda = 1</math> - Concrete modification factor (Normal concrete),  Allowable flexural strength:  <math>M_n</math> shall be the lesser of:  <math>\phi M_{n,1}</math></p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 \text{ ksi})} \times 18432.001 \text{ in}^3$ $\phi M_{n,1} = 249.600 \text{ kipft}$ <p><math>\phi M_{n,2}</math></p> $\phi M_{n,2} = \phi \times 0.85 \times f'_c \times S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (18432 \text{ in}^3)$ $\phi M_{n,2} = 2121.6 \text{ kipft}$ <p>Therefore,  <math>\phi M_n</math> - Allowable flexural strength,</p> $\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = MIN[(249.6 \text{ kipft}), (2121.6 \text{ kipft})]$ $\phi M_n = 249.6 \text{ kipft}$ <p><b>Considering x-direction:</b></p> <p><math>M_{max} = 37.759 \text{ kipft}</math> - Maximum moment in the x-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(37.759 \text{ kipft})}{(249.6 \text{ kipft})}$ $Ratio = 0.15128$	<p>Status: <b>PASS</b> Ratio: <b>0.150</b></p>
	<p><b>Considering z-direction:</b></p> <p><math>M_{max} = 0.60196 \text{ kipft}</math> - Maximum moment in the z-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$	

$$Ratio = \frac{(0.60196 \text{ kipft})}{(249.6 \text{ kipft})}$$

$$Ratio = 0.0024117$$

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

REFERENCES	CALCULATIONS	RESULTS																										
	<div>SkyCiv Foundation Design</div> <div>Pile Foundation</div> <div>Design Information :</div> <div>Design code : IBC 2021 (International Building Code)</div> <div>Unit System : Imperial</div>																											
	<div>Pile Input</div> <div></div> <div>Geometry</div> <div>Pile shape: rectangular</div> <div>b = 48 in - Pile width</div> <div>D = 48 in - Pile depth</div> <div>L = 7.25 ft - Total pile length</div> <div>h1 = 0 ft - Lateral load height from the top of the pile,</div> <div>h2 = 0 ft - Depth to resisting surface</div> <div>he = 0 ft - Length of pile above the ground</div> <div>Tabulation of Soil Parameters</div> <table><tr><th>Layer</th><th>Label</th><th>Allowable Bearing Pressure (qa) (psf)</th><th>Allowable Lateral Pressure (R) (psf/ft)</th></tr><tr><td>1</td><td>Sand, silty sand, clayey sand, silty gravel &amp; clayey gravel</td><td>2000.000</td><td>150.000</td></tr></table> <div>Tabulation of Loads</div> <table><tr><th>Load Component</th><th>ASD</th><th>LRFD</th></tr><tr><td>P (kip)</td><td>8.459</td><td>12.872</td></tr><tr><td>Vx (kip)</td><td>-2.859</td><td>-4.765</td></tr><tr><td>Vz (kip)</td><td>-0.011</td><td>-0.019</td></tr><tr><td>Mx (kipft)</td><td>-0.042</td><td>-0.070</td></tr><tr><td>Mz (kipft)</td><td>39.901</td><td>67.159</td></tr></table> <div>Material Properties</div> <div>f'ck = 2.5 ksi - Concrete strength,</div>	Layer	Label	Allowable Bearing Pressure (qa) (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)	8.459	12.872	Vx (kip)	-2.859	-4.765	Vz (kip)	-0.011	-0.019	Mx (kipft)	-0.042	-0.070	Mz (kipft)	39.901	67.159	
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	<div>Required depth to resist lateral loads (ASD)</div> <div>H - Point of application of the lateral load</div> <div><math display="block">H = h_1 + h_2 + h_e</math><math display="block">H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})</math><math display="block">H = 0 \text{ ft}</math></div> <div>Considering x-direction:</div> <div>Ho - Lateral force per length of pile,</div> <div><math display="block">H_o = \frac{V_x}{1.57 \text{ } D}</math><math display="block">H_o = \frac{(-2.859 \text{ kip})}{1.57 \times (48 \text{ in})}</math><math display="block">H_o = -0.45525 \text{ kip/ft}</math></div>																											

	<p><math>M_o</math> - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$ $M_o = \frac{(39.901 \text{ kipft}) + ((-2.859 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 6.3537 \text{ kipft/ft}$ <p>Required depth of embedment in earth:</p> $L_x^3 - \left( 14.14 \times \frac{H_o \times L_x}{R} \right) - \left( 18.85 \times \frac{M_o}{R} \right) = 0$ <p>Solving the cubic equation:  <math>L_{e,x} = 6.8486 \text{ ft}</math> - Required depth in x-direction,</p> <p><b>Considering z-direction:</b></p> <p><math>H_o</math> - Lateral force per length of pile,</p> $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(-0.011 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.0017516 \text{ kip/ft}$ <p><math>M_o</math> - Moment per length of pile,</p> $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(0.042 \text{ kipft}) + ((-0.011 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.0066879 \text{ kipft/ft}$ <p>Required depth of embedment in earth:</p> $L_z^3 - \left( 14.14 \times \frac{H_o \times L_z}{R} \right) - \left( 18.85 \times \frac{M_o}{R} \right) = 0$ <p>Solving the cubic equation:  <math>L_{e,z} = 0.76884 \text{ ft}</math> - Required depth in z-direction,</p> <p><b>Minimum embedded depth required:</b></p> <p><math>L_{e,req}</math> - Depth of pile required,</p> $L_{e,req} = \text{MAX}[L_{e,x}, L_{e,z}]$ $L_{e,req} = \text{MAX}[(6.8486 \text{ ft}), (0.76884 \text{ ft})]$ $L_{e,req} = 6.849 \text{ ft}$ <p><math>L_e</math> - Actual embedded length of pile,</p> $L_e = L - h_e - h_2$ $L_e = (7.25 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 7.25 \text{ ft}$ <p><b>Ratio</b> - Embedded depth</p> $\text{Ratio} = \frac{L_{e,req}}{L_e}$ $\text{Ratio} = \frac{(6.849 \text{ ft})}{(7.25 \text{ ft})}$ $\text{Ratio} = 0.94469$	<p>Status: <b>PASS</b>  Ratio: <b>0.940</b></p>
	<p><b>End-bearing Capacity (ASD)</b></p> <p><math>A</math> - Pile cross-section area</p> $A = b D$ $A = (48 \text{ in}) \times (48 \text{ in})$ $A = 16 \text{ ft}^2$ <p><math>q</math> - End-bearing pressure</p>	

	$q = \frac{P_v}{A}$ $q = \frac{(8.459 \text{ kip})}{(16 \text{ ft}^2)}$ $q = 0.52869 \text{ kip/ft}^2$ <p><b>Check bearing capacity ratio:</b></p> <p>Ratio - Capacity</p> $\text{Ratio} = \frac{q}{q_a}$ $\text{Ratio} = \frac{(0.52869 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $\text{Ratio} = 0.26434$	Status: <b>PASS</b> Ratio: <b>0.260</b>
Czerniak	<p><b>Lateral Soil Pressure (ASD):</b></p> <p><math>L/D</math> - Length to least lateral dimension ratio,</p> $L/D = \frac{L}{D}$ $L/D = \frac{(7.25 \text{ ft})}{(48 \text{ in})}$ $L/D = 1.8125$ <p>Since <math>L/D \leq 10</math>,</p> <p>Pile is short.</p> <p><b>Considering x-direction:</b></p> <p><math>H_o = -0.45525 \text{ kip/ft}</math> - Lateral force per length of pile,  <math>M_o = 6.3537 \text{ kipft/ft}</math> - Overturning moment per length of pile,  <math>a</math> - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (6.3537 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.45525 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (6.3537 \text{ kipft/ft})) + (4 \times (-0.45525 \text{ kip/ft}) \times (7.25 \text{ ft}))}$ $a = 4.9887 \text{ ft}$ <p><math>p</math> - Earth pressure against the pile at distance <math>a/2</math> from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (6.3537 \text{ kipft/ft})) + (3 \times (-0.45525 \text{ kip/ft}) \times (7.25 \text{ ft}))]^2}{(7.25 \text{ ft})^2 \times [(3 \times (6.3537 \text{ kipft/ft})) + (2 \times (-0.45525 \text{ kip/ft}) \times (7.25 \text{ ft}))]}$ $p = 0.27559 \text{ kip/ft}^2$ <p><math>s</math> - Earth pressure against the pile at distance <math>L_e</math>,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (6.3537 \text{ kipft/ft})) + ((-0.45525 \text{ kip/ft}) \times (7.25 \text{ ft}))]}{(7.25 \text{ ft})^2}$ $s = 1.0738 \text{ kip/ft}^2$ <p><b>Check lateral soil pressure capacity:</b></p> <p><math>p_a</math> - Allowable lateral soil pressure at depth <math>a/2</math>,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.9887 \text{ ft})}{2}$ $p_a = 0.37416 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p>	

	$Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.27559 \text{ kip/ft}^2)}{(0.37416 \text{ kip/ft}^2)}$ $Ratio = 0.73656$ <p><math>p_s</math> - Allowable lateral soil pressure at depth <math>L_e</math>,</p> $p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (7.25 \text{ ft})$ $p_s = 1.0875 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $Ratio = \frac{s}{p_s}$ $Ratio = \frac{(1.0738 \text{ kip/ft}^2)}{(1.0875 \text{ kip/ft}^2)}$ $Ratio = 0.98738$	<p>Status: <b>PASS</b> Ratio: <b>0.740</b></p> <p>Status: <b>PASS</b> Ratio: <b>0.990</b></p>
	<p><b>Considering z-direction:</b></p> <p><math>H_o = -0.0017516 \text{ kip/ft}</math> - Lateral force per length of pile,  <math>M_o = 0.0066879 \text{ kipft/ft}</math> - Overturning moment per length of pile,  <math>a</math> - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.0066879 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.0017516 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (0.0066879 \text{ kipft/ft})) + (4 \times (-0.0017516 \text{ kip/ft}) \times (7.25 \text{ ft}))}$ $a = 5.1709 \text{ ft}$ <p><math>p</math> - Earth pressure against the pile at distance <math>a/2</math> from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.0066879 \text{ kipft/ft})) + (3 \times (-0.0017516 \text{ kip/ft}) \times (7.25 \text{ ft}))]^2}{(7.25 \text{ ft})^2 \times [(3 \times (0.0066879 \text{ kipft/ft})) + (2 \times (-0.0017516 \text{ kip/ft}) \times (7.25 \text{ ft}))]}$ $p = -0.00034431 \text{ kip/ft}^2$ <p><math>s</math> - Earth pressure against the pile at distance <math>L_e</math>,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.0066879 \text{ kipft/ft})) + ((-0.0017516 \text{ kip/ft}) \times (7.25 \text{ ft}))]}{(7.25 \text{ ft})^2}$ $s = 0.000077251 \text{ kip/ft}^2$ <p><b>Check lateral soil pressure capacity:</b></p> <p><math>p_a</math> - Allowable lateral soil pressure at depth <math>a/2</math>,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(5.1709 \text{ ft})}{2}$ $p_a = 0.38781 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(-0.00034431 \text{ kip/ft}^2)}{(0.38781 \text{ kip/ft}^2)}$	

$$Ratio = -0.00088782$$

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

$p_s$  - Allowable lateral soil pressure at depth  $L_e$ ,

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (7.25 \text{ ft})$$

$$p_s = 1.0875 \text{ kip/ft}^2$$

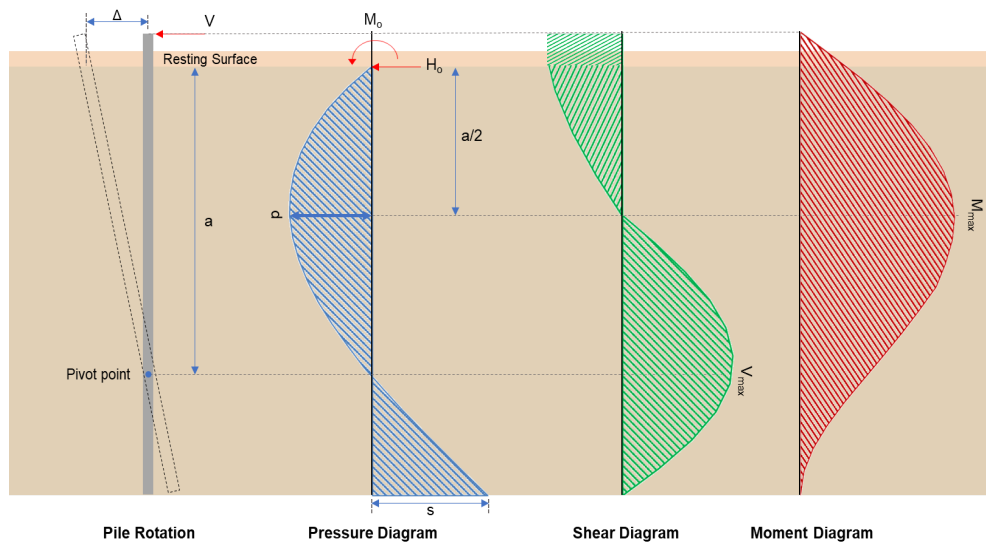
Ratio - Lateral soil capacity

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

$$Ratio = \frac{(0.000077251 \text{ kip/ft}^2)}{(1.0875 \text{ kip/ft}^2)}$$

$$Ratio = 0.000071035$$

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



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

$H_o$  - Lateral force per length of pile,

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

$$H_o = \frac{(-4.765 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.75876 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

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

$$M_o = \frac{(67.159 \text{ kipft}) + ((-4.765 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 10.694 \text{ kipft/ft}$$

$E$  - Distance from lateral load to resisting surface,

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

$$E = \frac{(10.694 \text{ kipft/ft})}{(-0.75876 \text{ kip/ft})}$$

$$E = 14.094 \text{ ft}$$

$a$  - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (10.694 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.75876 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times 10.694 \text{ kipft/ft}) + (4 \times (-0.75876 \text{ kip/ft}) \times 7.25 \text{ ft})}$$

$$a = \frac{6 \times (10.694 \text{ kipft/ft}) + (4 \times (-0.75876 \text{ kip/ft}) \times (7.25 \text{ ft}))}{}$$

$$a = 4.9876 \text{ ft}$$

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

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

$$V_{max} = ((-0.75876 \text{ kip/ft}) \times (48 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (14.094 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left( \frac{(4.9876 \text{ ft})}{(7.25 \text{ ft})} \right)^2 \right] + \left[ 4 \times \left( \frac{3 \times (14.094 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left( \frac{(4.9876 \text{ ft})}{(7.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 12.444 \text{ kip}$$

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

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

$$M_{max} = ((-0.75876 \text{ kip/ft}) \times (48 \text{ in}) \times (7.25 \text{ ft})) \times \left[ \left( \frac{(14.094 \text{ ft})}{(7.25 \text{ ft})} + \frac{(4.9876 \text{ ft})}{2 \times (7.25 \text{ ft})} \right) - \left[ \left( \frac{4 \times (14.094 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left( \frac{(4.9876 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^3 \right] + \left[ \left( \frac{3 \times (14.094 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left( \frac{(4.9876 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 43.108 \text{ kipft}$$

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

$H_o$  - Lateral force per length of pile,

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

$$H_o = \frac{(-0.019 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.0030255 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

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

$$M_o = \frac{(0.07 \text{ kipft}) + ((-0.019 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.011146 \text{ kipft/ft}$$

$E$  - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.011146 \text{ kipft/ft})}{(-0.0030255 \text{ kip/ft})}$$

$$E = 3.6842 \text{ ft}$$

$a$  - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.011146 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.0030255 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (0.011146 \text{ kipft/ft})) + (4 \times (-0.0030255 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 5.1762 \text{ ft}$$

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

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



$$V_{max} = ((-0.0030255 \text{ kip/ft}) \times (48 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (3.6842 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left( \frac{(5.1762 \text{ ft})}{(7.25 \text{ ft})} \right)^2 \right] + \left[ 4 \times \left( \frac{3 \times (3.6842 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left( \frac{(5.1762 \text{ ft})}{(7.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.018943 \text{ kip}$$

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

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

$$M_{max} = ((-0.0030255 \text{ kip/ft}) \times (48 \text{ in}) \times (7.25 \text{ ft})) \times \left[ \left( \frac{(3.6842 \text{ ft})}{(7.25 \text{ ft})} + \frac{(5.1762 \text{ ft})}{2 \times (7.25 \text{ ft})} \right) - \left[ \left( \frac{4 \times (3.6842 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left( \frac{(5.1762 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^3 \right] + \left[ \left( \frac{3 \times (3.6842 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left( \frac{(5.1762 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.060842 \text{ kipft}$$

#### Minimum Reinforcement Check (LRFD)

##### Parameters:

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

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

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

$\alpha = 0.8$  - Alpha factor for axial strength,

$A_g = 2304 \text{ in}^2$  - Gross area of concrete,

##### Longitudinal reinforcement:

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

$A_{st,required}$

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

$$A_{st,required} = Min \left[ \frac{\left( \frac{(12.872 \text{ kip})}{(0.65) \times (0.8)} \right) - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$$

$$A_{st,required} = -84.168 \text{ in}^2$$

$A_{min}$  - Governing minimum reinforcement area,

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

$$A_{min} = Max [(-84.168 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$$

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

$n_{rebar}$  - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

$A_{st}$  - Actual total reinforcement area,

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

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

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

Ratio - Capacity

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

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

Table 22.4.2.1

22.4.2.2, 10.6.1.1

<p>25.2.3</p>	<p><math>s_{rebar} = 0.96556</math></p> <p><math>s_{rebar}</math> - Minimum spacing of reinforcement,</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><b>Ties:</b></p> <p>25.7.2.2 Since longitudinal reinforcement is <math>\leq</math> No. 10ø: Use #3(0.375 in)</p> <p>25.7.2.1 <math>s_{ties}</math> - Maximum spacing of ties,</p> $s_{ties} = Min[(16 d_{bar}), (48 d_{ties}), Min(D, b)]$ $s_{ties} = Min[(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), Min((48 \text{ in}), (48 \text{ in}))]$ $s_{ties} = 10 \text{ in}$ <p><b>Summary:</b></p> <p>Main reinforcement: <b>14 - #5 (0.625 in)</b> Ties: <b>#3(0.375 in) - 10 in</b></p>	<p>Status: <b>PASS</b> Ratio: <b>0.970</b></p>
<p>22.4.2.2</p>	<p><b>Axial Compression Strength (ACI 318-19, LRFD)</b></p> <p><math>\phi P_N</math> - Allowable axial compressive strength</p> $\phi P_N = \phi 0.80 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st})]$ $\phi P_N = (0.65) \times 0.80 \times [(0.85 \times (2.5 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2))]$ $\phi P_N = 2675.2 \text{ kip}$ <p><math>Ratio</math> - Capacity</p> $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(12.872 \text{ kip})}{(2675.2 \text{ kip})}$ $Ratio = 0.0048116$	<p>Status: <b>PASS</b> Ratio: <b>0.000</b></p>
<p>22.5.2.2</p> <p>22.5.1.3</p> <p>22.5.1.1</p>	<p><b>Shear Strength (ACI 318-19, LRFD)</b></p> <p><b>Parameters:</b></p> <p><math>b_w = 48 \text{ in}</math> - Effective width, <math>d</math> - Effective depth</p> $d = 0.80 D$ $d = 0.80 \times (48 \text{ in})$ $d = 38.4 \text{ in}$ <p><math>\lambda_s</math> - size effect modification factor</p> $\lambda_s = MIN \left[ \sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = MIN \left[ \sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.64282$ <p>The following variables were converted to be consistent with empirical formula <math>f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}</math>,</p> <p><math>V_{c,max}</math> - Max shear strength of concrete</p> $V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$ $V_{c,max} = 5 \times (0.64282) \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$	

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

22.5.5.1.1(a) The following variables were converted to be consistent with empirical formula  $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$ ,  $P = 12.872 \text{ kip} \rightarrow 12872 \text{ lbf}$ ,  
 $V_{c,a}$  - Shear strength of concrete (a)

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

$$V_{c,a} = \left[ 2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(12872 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 120.2 \text{ kip}$$

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

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

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

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

$V_c$  - Governing shear strength of concrete

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

$$V_c = \text{Min}[(296.21 \text{ kip}), (120.2 \text{ kip}), (348.89 \text{ kip})]$$

$$V_c = 120.2 \text{ kip}$$

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)

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

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

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

$A_v$  - Ties rebar area,

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

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

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

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

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

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

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

$V_s$  - Governing shear strength of steel

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

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

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

22.5.1.1  $\phi V_n$  - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((120.2 \text{ kip}) + (50.894 \text{ kip}))$$

$$\phi V_n = 111.21 \text{ kip}$$

**Considering x-direction:**

$V_{max} = 12.444 \text{ kip}$  - Maximum shear force in the x-direction,  
 $Ratio$  - Capacity

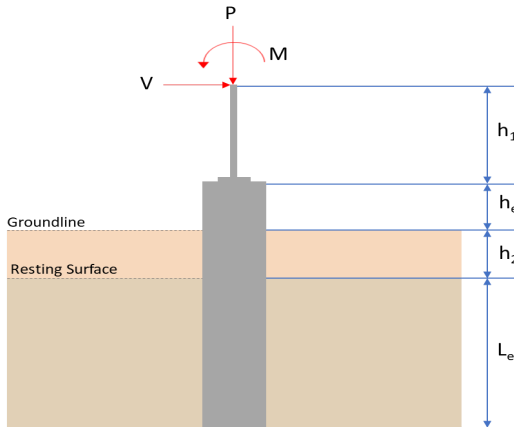
$$Ratio = \frac{V_{max}}{\phi V_n}$$

	$Ratio = \frac{(12.444 \text{ kip})}{(111.21 \text{ kip})}$ $Ratio = 0.11189$ <p><b>Considering z-direction:</b></p> <p><math>V_{max} = 0.018943 \text{ kip}</math> - Maximum shear force in the z-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.018943 \text{ kip})}{(111.21 \text{ kip})}$ $Ratio = 0.00017033$ <p>Status: <b>PASS</b>  Ratio: <b>0.110</b></p>	
14.5.2.1b	<p><b>Flexural Strength (ACI 318-19, LRFD)</b></p> <p><math>S_m</math> - Section modulus</p> $S_m = \frac{b D^2}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$ <p><math>\lambda = 1</math> - Concrete modification factor (Normal concrete),  Allowable flexural strength:  <math>M_n</math> shall be the lesser of:  <math>\phi M_{n,1}</math></p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 \text{ ksi})} \times 18432.001 \text{ in}^3$ $\phi M_{n,1} = 249.600 \text{ kipft}$ <p><math>\phi M_{n,2}</math></p> $\phi M_{n,2} = \phi \times 0.85 \times f'_c \times S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (18432 \text{ in}^3)$ $\phi M_{n,2} = 2121.6 \text{ kipft}$ <p>Therefore,  <math>\phi M_n</math> - Allowable flexural strength,</p> $\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = MIN[(249.6 \text{ kipft}), (2121.6 \text{ kipft})]$ $\phi M_n = 249.6 \text{ kipft}$ <p><b>Considering x-direction:</b></p> <p><math>M_{max} = 43.108 \text{ kipft}</math> - Maximum moment in the x-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(43.108 \text{ kipft})}{(249.6 \text{ kipft})}$ $Ratio = 0.17271$ <p>Status: <b>PASS</b>  Ratio: <b>0.170</b></p>	
	<p><b>Considering z-direction:</b></p> <p><math>M_{max} = 0.060842 \text{ kipft}</math> - Maximum moment in the z-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$	

$$Ratio = \frac{(0.060842 \text{ kipft})}{(249.6 \text{ kipft})}$$

$$Ratio = 0.00024376$$

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

REFERENCES	CALCULATIONS	RESULTS																											
	<div>SkyCiv Foundation Design</div> <div>Pile Foundation</div> <div>Design Information :</div> <div>Design code : IBC 2021 (International Building Code)</div> <div>Unit System : Imperial</div>																												
	<div>Pile Input</div> <div></div> <div>Geometry</div> <div>Pile shape: rectangular</div> <div>b = 48 in - Pile width</div> <div>D = 48 in - Pile depth</div> <div>L = 7.25 ft - Total pile length</div> <div>h1 = 0 ft - Lateral load height from the top of the pile,</div> <div>h2 = 0 ft - Depth to resisting surface</div> <div>he = 0 ft - Length of pile above the ground</div> <div>Tabulation of Soil Parameters</div> <table><tr><th>Layer</th><th>Label</th><th>Allowable Bearing Pressure (qa) (psf)</th><th>Allowable Lateral Pressure (R) (psf/ft)</th></tr><tr><td>1</td><td>Sand, silty sand, clayey sand, silty gravel &amp; clayey gravel</td><td>2000.000</td><td>150.000</td></tr></table> <div>Tabulation of Loads</div> <table><tr><th>Load Component</th><th>ASD</th><th>LRFD</th></tr><tr><td>P (kip)</td><td>8.462</td><td>12.877</td></tr><tr><td>Vx (kip)</td><td>-2.860</td><td>-4.768</td></tr><tr><td>Vz (kip)</td><td>0.011</td><td>0.019</td></tr><tr><td>Mx (kipft)</td><td>0.042</td><td>0.073</td></tr><tr><td>Mz (kipft)</td><td>39.919</td><td>67.190</td></tr></table> <div>Material Properties</div> <div>f'ck = 2.5 ksi - Concrete strength,</div>	Layer	Label	Allowable Bearing Pressure (qa) (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)	8.462	12.877	Vx (kip)	-2.860	-4.768	Vz (kip)	0.011	0.019	Mx (kipft)	0.042	0.073	Mz (kipft)	39.919	67.190	<div>Required depth to resist lateral loads (ASD)</div> <div>H - Point of application of the lateral load</div> <div><math display="block">H = h_1 + h_2 + h_e</math></div> <div><math display="block">H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})</math></div> <div><math display="block">H = 0 \text{ ft}</math></div> <div>Considering x-direction:</div> <div>Ho - Lateral force per length of pile,</div> <div><math display="block">H_o = \frac{V_x}{1.57 \; D}</math></div> <div><math display="block">H_o = \frac{(-2.86 \text{ kip})}{1.57 \times (48 \text{ in})}</math></div> <div><math display="block">H_o = -0.45541 \text{ kip/ft}</math></div>	
Layer	Label	Allowable Bearing Pressure (qa) (psf)	Allowable Lateral Pressure (R) (psf/ft)																										
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Mx (kipft)	0.042	0.073																											
Mz (kipft)	39.919	67.190																											

	<p><math>M_o</math> - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$ $M_o = \frac{(39.92 \text{ kipft}) + ((-2.86 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 6.3565 \text{ kipft/ft}$ <p>Required depth of embedment in earth:</p> $L_x^3 - \left( 14.14 \times \frac{H_o \times L_x}{R} \right) - \left( 18.85 \times \frac{M_o}{R} \right) = 0$ <p>Solving the cubic equation:  <math>L_{e,x} = 6.8496 \text{ ft}</math> - Required depth in x-direction,</p> <p><b>Considering z-direction:</b></p> <p><math>H_o</math> - Lateral force per length of pile,</p> $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(0.011 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = 0.0017516 \text{ kip/ft}$ <p><math>M_o</math> - Moment per length of pile,</p> $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(0.042 \text{ kipft}) + ((0.011 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.0066879 \text{ kipft/ft}$ <p>Required depth of embedment in earth:</p> $L_z^3 - \left( 14.14 \times \frac{H_o \times L_z}{R} \right) - \left( 18.85 \times \frac{M_o}{R} \right) = 0$ <p>Solving the cubic equation:  <math>L_{e,z} = 0.85498 \text{ ft}</math> - Required depth in z-direction,</p> <p><b>Minimum embedded depth required:</b></p> <p><math>L_{e,req}</math> - Depth of pile required,</p> $L_{e,req} = \text{MAX}[L_{e,x}, L_{e,z}]$ $L_{e,req} = \text{MAX}[(6.8496 \text{ ft}), (0.85498 \text{ ft})]$ $L_{e,req} = 6.85 \text{ ft}$ <p><math>L_e</math> - Actual embedded length of pile,</p> $L_e = L - h_e - h_2$ $L_e = (7.25 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 7.25 \text{ ft}$ <p><b>Ratio</b> - Embedded depth</p> $\text{Ratio} = \frac{L_{e,req}}{L_e}$ $\text{Ratio} = \frac{(6.85 \text{ ft})}{(7.25 \text{ ft})}$ $\text{Ratio} = 0.94483$	<p>Status: <b>PASS</b>  Ratio: <b>0.940</b></p>
	<p><b>End-bearing Capacity (ASD)</b></p> <p><math>A</math> - Pile cross-section area</p> $A = b D$ $A = (48 \text{ in}) \times (48 \text{ in})$ $A = 16 \text{ ft}^2$ <p><math>q</math> - End-bearing pressure</p>	

	$q = \frac{P_v}{A}$ $q = \frac{(8.462 \text{ kip})}{(16 \text{ ft}^2)}$ $q = 0.52887 \text{ kip/ft}^2$ <p><b>Check bearing capacity ratio:</b></p> <p>Ratio - Capacity</p> $\text{Ratio} = \frac{q}{q_a}$ $\text{Ratio} = \frac{(0.52887 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $\text{Ratio} = 0.26444$	Status: <b>PASS</b> Ratio: <b>0.260</b>
Czerniak	<p><b>Lateral Soil Pressure (ASD):</b></p> <p><math>L/D</math> - Length to least lateral dimension ratio,</p> $L/D = \frac{L}{D}$ $L/D = \frac{(7.25 \text{ ft})}{(48 \text{ in})}$ $L/D = 1.8125$ <p>Since <math>L/D \leq 10</math>,</p> <p>Pile is short.</p> <p><b>Considering x-direction:</b></p> <p><math>H_o = -0.45541 \text{ kip/ft}</math> - Lateral force per length of pile,  <math>M_o = 6.3565 \text{ kipft/ft}</math> - Overturning moment per length of pile,  <math>a</math> - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (6.3565 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.45541 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (6.3565 \text{ kipft/ft})) + (4 \times (-0.45541 \text{ kip/ft}) \times (7.25 \text{ ft}))}$ $a = 4.9887 \text{ ft}$ <p><math>p</math> - Earth pressure against the pile at distance <math>a/2</math> from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (6.3565 \text{ kipft/ft})) + (3 \times (-0.45541 \text{ kip/ft}) \times (7.25 \text{ ft}))]^2}{(7.25 \text{ ft})^2 \times [(3 \times (6.3565 \text{ kipft/ft})) + (2 \times (-0.45541 \text{ kip/ft}) \times (7.25 \text{ ft}))]}$ $p = 0.27573 \text{ kip/ft}^2$ <p><math>s</math> - Earth pressure against the pile at distance <math>L_e</math>,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (6.3565 \text{ kipft/ft})) + ((-0.45541 \text{ kip/ft}) \times (7.25 \text{ ft}))]}{(7.25 \text{ ft})^2}$ $s = 1.0743 \text{ kip/ft}^2$ <p><b>Check lateral soil pressure capacity:</b></p> <p><math>p_a</math> - Allowable lateral soil pressure at depth <math>a/2</math>,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.9887 \text{ ft})}{2}$ $p_a = 0.37416 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p>	



	$Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.27573 \text{ kip/ft}^2)}{(0.37416 \text{ kip/ft}^2)}$ $Ratio = 0.73695$ <p><math>p_s</math> - Allowable lateral soil pressure at depth <math>L_e</math>,</p> $p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (7.25 \text{ ft})$ $p_s = 1.0875 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $Ratio = \frac{s}{p_s}$ $Ratio = \frac{(1.0743 \text{ kip/ft}^2)}{(1.0875 \text{ kip/ft}^2)}$ $Ratio = 0.98786$	<p>Status: <b>PASS</b> Ratio: <b>0.740</b></p> <p>Status: <b>PASS</b> Ratio: <b>0.990</b></p>
	<p><b>Considering z-direction:</b></p> <p><math>H_o = 0.0017516 \text{ kip/ft}</math> - Lateral force per length of pile,  <math>M_o = 0.0066879 \text{ kipft/ft}</math> - Overturning moment per length of pile,  <math>a</math> - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.0066879 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (0.0017516 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (0.0066879 \text{ kipft/ft})) + (4 \times (0.0017516 \text{ kip/ft}) \times (7.25 \text{ ft}))}$ $a = 5.1709 \text{ ft}$ <p><math>p</math> - Earth pressure against the pile at distance <math>a/2</math> from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.0066879 \text{ kipft/ft})) + (3 \times (0.0017516 \text{ kip/ft}) \times (7.25 \text{ ft}))]^2}{(7.25 \text{ ft})^2 \times [(3 \times (0.0066879 \text{ kipft/ft})) + (2 \times (0.0017516 \text{ kip/ft}) \times (7.25 \text{ ft}))]}$ $p = 0.0013199 \text{ kip/ft}^2$ <p><math>s</math> - Earth pressure against the pile at distance <math>L_e</math>,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.0066879 \text{ kipft/ft})) + ((0.0017516 \text{ kip/ft}) \times (7.25 \text{ ft}))]}{(7.25 \text{ ft})^2}$ $s = 0.0029764 \text{ kip/ft}^2$ <p><b>Check lateral soil pressure capacity:</b></p> <p><math>p_a</math> - Allowable lateral soil pressure at depth <math>a/2</math>,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(5.1709 \text{ ft})}{2}$ $p_a = 0.38781 \text{ kip/ft}^2$ <p>Ratio - Lateral soil capacity</p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.0013199 \text{ kip/ft}^2)}{(0.38781 \text{ kip/ft}^2)}$	

$$Ratio = 0.0034034$$

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

$p_s$  - Allowable lateral soil pressure at depth  $L_e$ ,

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (7.25 \text{ ft})$$

$$p_s = 1.0875 \text{ kip/ft}^2$$

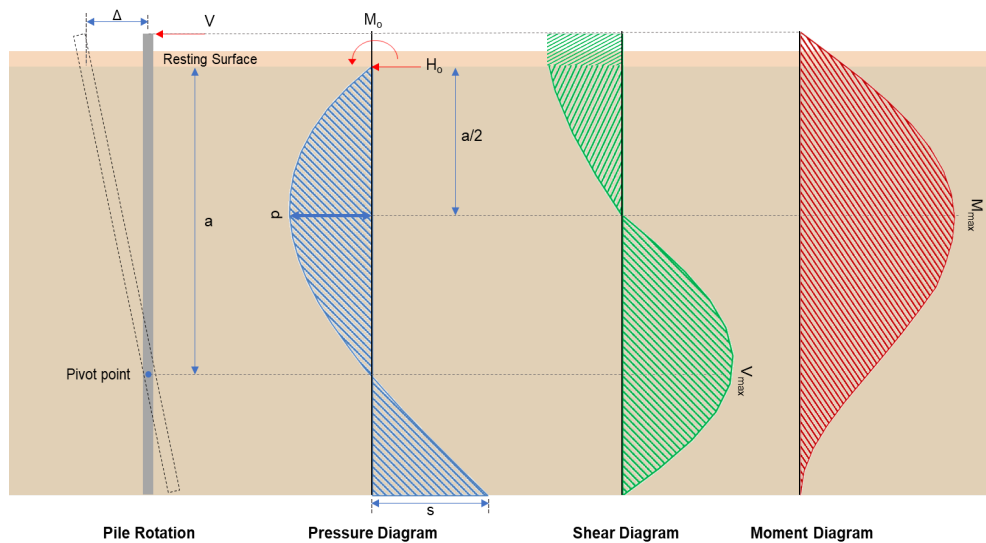
$Ratio$  - Lateral soil capacity

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

$$Ratio = \frac{(0.0029764 \text{ kip/ft}^2)}{(1.0875 \text{ kip/ft}^2)}$$

$$Ratio = 0.002737$$

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



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

$H_o$  - Lateral force per length of pile,

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

$$H_o = \frac{(-4.768 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.75924 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

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

$$M_o = \frac{(67.19 \text{ kipft}) + ((-4.768 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 10.699 \text{ kipft/ft}$$

$E$  - Distance from lateral load to resisting surface,

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

$$E = \frac{(10.699 \text{ kipft/ft})}{(-0.75924 \text{ kip/ft})}$$

$$E = 14.092 \text{ ft}$$

$a$  - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (10.699 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.75924 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (10.699 \text{ kipft/ft})) + (4 \times (-0.75924 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = \frac{(-0.75924 \text{ kip/ft}) \times (48 \text{ in}) \times (7.25 \text{ ft})}{(6 \times (10.699 \text{ kipft/ft})) + (4 \times (-0.75924 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 4.9876 \text{ ft}$$

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

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

$$V_{max} = ((-0.75924 \text{ kip/ft}) \times (48 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (14.092 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left( \frac{(4.9876 \text{ ft})}{(7.25 \text{ ft})} \right)^2 \right] + \left[ 4 \times \left( \frac{3 \times (14.092 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left( \frac{(4.9876 \text{ ft})}{(7.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 12.45 \text{ kip}$$

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

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

$$M_{max} = ((-0.75924 \text{ kip/ft}) \times (48 \text{ in}) \times (7.25 \text{ ft})) \times \left[ \left( \frac{(14.092 \text{ ft})}{(7.25 \text{ ft})} + \frac{(4.9876 \text{ ft})}{2 \times (7.25 \text{ ft})} \right) - \left[ \left( \frac{4 \times (14.092 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left( \frac{(4.9876 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^3 \right] + \left[ \left( \frac{3 \times (14.092 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left( \frac{(4.9876 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 43.128 \text{ kipft}$$

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

$H_o$  - Lateral force per length of pile,

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

$$H_o = \frac{(0.019 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.0030255 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

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

$$M_o = \frac{(0.073 \text{ kipft}) + ((0.019 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.011624 \text{ kipft/ft}$$

$E$  - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.011624 \text{ kipft/ft})}{(0.0030255 \text{ kip/ft})}$$

$$E = 3.8421 \text{ ft}$$

$a$  - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.011624 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (0.0030255 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (0.011624 \text{ kipft/ft})) + (4 \times (0.0030255 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 5.1699 \text{ ft}$$

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

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

$$V_{max} = ((0.0030255 \text{ kip/ft}) \times (48 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (3.8421 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left( \frac{(5.1699 \text{ ft})}{(7.25 \text{ ft})} \right)^2 \right] + \left[ 4 \times \left( \frac{3 \times (3.8421 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left( \frac{(5.1699 \text{ ft})}{(7.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.019405 \text{ kip}$$

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

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

$$M_{max} = ((0.0030255 \text{ kip/ft}) \times (48 \text{ in}) \times (7.25 \text{ ft})) \times \left[ \left( \frac{(3.8421 \text{ ft})}{(7.25 \text{ ft})} + \frac{(5.1699 \text{ ft})}{2 \times (7.25 \text{ ft})} \right) - \left[ \left( \frac{4 \times (3.8421 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left( \frac{(5.1699 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^3 \right] + \left[ \left( \frac{3 \times (3.8421 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left( \frac{(5.1699 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.062509 \text{ kipft}$$

#### Minimum Reinforcement Check (LRFD)

##### Parameters:

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

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

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

$\alpha = 0.8$  - Alpha factor for axial strength,

$A_g = 2304 \text{ in}^2$  - Gross area of concrete,

##### Longitudinal reinforcement:

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

$A_{st,required}$

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

$$A_{st,required} = Min \left[ \frac{\left( \frac{(12.877 \text{ kip})}{(0.65) \times (0.8)} \right) - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$$

$$A_{st,required} = -84.168 \text{ in}^2$$

$A_{min}$  - Governing minimum reinforcement area,

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

$$A_{min} = Max [(-84.168 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$$

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

$n_{rebar}$  - Required number of reinforcement,

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

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

$$n_{rebar} = 14$$

$A_{st}$  - Actual total reinforcement area,

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

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

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

Ratio - Capacity

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

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

Table 22.4.2.1

22.4.2.2, 10.6.1.1

<p>25.2.3</p>	<p><math>s_{rebar} = 0.96556</math></p> <p><math>s_{rebar}</math> - Minimum spacing of reinforcement,</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><b>Ties:</b></p> <p>25.7.2.2 Since longitudinal reinforcement is <math>\leq</math> No. 10ø: Use #3(0.375 in)</p> <p>25.7.2.1 <math>s_{ties}</math> - Maximum spacing of ties,</p> $s_{ties} = Min[(16 d_{bar}), (48 d_{ties}), Min(D, b)]$ $s_{ties} = Min[(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), Min((48 \text{ in}), (48 \text{ in}))]$ $s_{ties} = 10 \text{ in}$ <p><b>Summary:</b></p> <p>Main reinforcement: <b>14 - #5 (0.625 in)</b> Ties: <b>#3(0.375 in) - 10 in</b></p>	<p>Status: <b>PASS</b> Ratio: <b>0.970</b></p>
<p>22.4.2.2</p>	<p><b>Axial Compression Strength (ACI 318-19, LRFD)</b></p> <p><math>\phi P_N</math> - Allowable axial compressive strength</p> $\phi P_N = \phi 0.80 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st})]$ $\phi P_N = (0.65) \times 0.80 \times [(0.85 \times (2.5 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2))]$ $\phi P_N = 2675.2 \text{ kip}$ <p><math>Ratio</math> - Capacity</p> $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(12.877 \text{ kip})}{(2675.2 \text{ kip})}$ $Ratio = 0.0048135$	<p>Status: <b>PASS</b> Ratio: <b>0.000</b></p>
<p>22.5.2.2</p> <p>22.5.1.3</p> <p>22.5.1.1</p>	<p><b>Shear Strength (ACI 318-19, LRFD)</b></p> <p><b>Parameters:</b></p> <p><math>b_w = 48 \text{ in}</math> - Effective width, <math>d</math> - Effective depth</p> $d = 0.80 D$ $d = 0.80 \times (48 \text{ in})$ $d = 38.4 \text{ in}$ <p><math>\lambda_s</math> - size effect modification factor</p> $\lambda_s = MIN \left[ \sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = MIN \left[ \sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.64282$ <p>The following variables were converted to be consistent with empirical formula <math>f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}</math>,</p> <p><math>V_{c,max}</math> - Max shear strength of concrete</p> $V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$ $V_{c,max} = 5 \times (0.64282) \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$	

		$V_{c,max} = 296.21 \text{ kip}$	
22.5.5.1.1(a)	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$ , $P = 12.877 \text{ kip} \rightarrow 12877 \text{ lbf}$ , $V_{c,a}$ - Shear strength of concrete (a)	$V_{c,a} = \left[ 2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[ 2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(12877 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 120.2 \text{ kip}$	
22.5.5.1.2	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$ , $V_{c,b}$ - Shear strength of concrete (b)	$V_{c,b} = \left[ 2 \lambda_s \sqrt{f'_{ck}} + (0.05 f'_{ck}) \right] b_w d$ $V_{c,b} = \left[ 2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + (0.05 \times (2500 \text{ psi})) \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,b} = 348.89 \text{ kip}$	
	$V_c$ - Governing shear strength of concrete	$V_c = \text{Min}[V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = \text{Min}[(296.21 \text{ kip}), (120.2 \text{ kip}), (348.89 \text{ kip})]$ $V_c = 120.2 \text{ kip}$	
22.5.5.1.2	The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$ , $V_{s,a}$ - Shear strength of steel (a)	$V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$ $V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{s,a} = 737.28 \text{ kip}$	
	$A_v$ - Ties rebar area,	$A_v = \frac{\pi d_{ties}^2}{4}$ $A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$ $A_v = 0.11045 \text{ in}^2$	
22.5.8.5.3	$V_{s,b}$ - Shear strength of steel (b)	$V_{s,b} = \frac{2 A_v f_{yw} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$	
	$V_s$ - Governing shear strength of steel	$V_s = \text{MIN}[V_{s,a}, V_{s,b}]$ $V_s = \text{MIN}[(737.28 \text{ kip}), (50.894 \text{ kip})]$ $V_s = 50.894 \text{ kip}$	
22.5.1.1	$\phi V_n$ - Allowable shear strength	$\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((120.2 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 111.21 \text{ kip}$	
	Considering x-direction:		
	$V_{max}$ = 12.45 kip - Maximum shear force in the x-direction, $Ratio$ - Capacity	$Ratio = \frac{V_{max}}{\phi V_n}$	

	$Ratio = \frac{(12.45 \text{ kip})}{(111.21 \text{ kip})}$ $Ratio = 0.11195$ <p><b>Considering z-direction:</b></p> <p><math>V_{max} = 0.019405 \text{ kip}</math> - Maximum shear force in the z-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.019405 \text{ kip})}{(111.21 \text{ kip})}$ $Ratio = 0.00017448$ <p>Status: <b>PASS</b>  Ratio: <b>0.110</b></p>	
14.5.2.1b	<p><b>Flexural Strength (ACI 318-19, LRFD)</b></p> <p><math>S_m</math> - Section modulus</p> $S_m = \frac{b D^2}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$ <p><math>\lambda = 1</math> - Concrete modification factor (Normal concrete),  Allowable flexural strength:  <math>M_n</math> shall be the lesser of:  <math>\phi M_{n,1}</math></p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 \text{ ksi})} \times 18432.001 \text{ in}^3$ $\phi M_{n,1} = 249.600 \text{ kipft}$ <p><math>\phi M_{n,2}</math></p> $\phi M_{n,2} = \phi \times 0.85 \times f'_{ck} \times S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (18432 \text{ in}^3)$ $\phi M_{n,2} = 2121.6 \text{ kipft}$ <p>Therefore,  <math>\phi M_n</math> - Allowable flexural strength,</p> $\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = MIN[(249.6 \text{ kipft}), (2121.6 \text{ kipft})]$ $\phi M_n = 249.6 \text{ kipft}$ <p><b>Considering x-direction:</b></p> <p><math>M_{max} = 43.128 \text{ kipft}</math> - Maximum moment in the x-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(43.128 \text{ kipft})}{(249.6 \text{ kipft})}$ $Ratio = 0.17279$ <p>Status: <b>PASS</b>  Ratio: <b>0.170</b></p>	
	<p><b>Considering z-direction:</b></p> <p><math>M_{max} = 0.062509 \text{ kipft}</math> - Maximum moment in the z-direction,  <i>Ratio</i> - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$	

$$Ratio = \frac{(0.062509 \text{ kipft})}{(249.6 \text{ kipft})}$$

$$Ratio = 0.00025044$$

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