

Your Project Calculations



Project Name: J BAR L Big House

S3D Model Link:

https://platform.skyciv.com/structural?preload_name=J%20BAR%20L%20Big%20House&preload_path=Shared%20Enterprise%20Folder/MT_Solar_Projects/3_2023

Public Model Link:

https://platform.skyciv.com/structural-viewer?project_id=ZCvXZVApdJH6XEjTYdppCmnVKraghiwZoMbJFPGwdhenDAqKwyYBi601XrmbONIS

Array Specification

Product:	Beam
Unique ID:	4P-22.5-6TOP-HD-12-L-4Hx11W-79GF
Duty Classification:	HD
Module Width:	41.00 in
Module Length:	83.00in
Number of Rows:	4
Number of Columns:	11
Total Number of Modules:	44
Desired Tilt Angle:	34
Front Edge Clearance:	3
Total Array Height at Tilt:	10.69 ft
Total Frame Length:	77.00 ft
Frame Weight:	2920 lbs
Array Dimensions N/S:	13.83 ft
Array Dimensions E/W:	77.00 ft
Rail Length:	166.00 in
Rail Spacing:	3.46 ft
Rail Check:	Not Checked

Support Specifications

Pole Size:	6in Pipe Sch 40
Pole Length above Grade:	6.87 ft
Number of Poles:	4
Pole Spacing:	22.5 ft

Foundation Specifications

Foundation Type:	Square
Foundation Dimensions:	48 x 48 in
Foundation Depth (below grade):	Pile 1: 5.25 ft Pile 2: 5.75 ft Pile 3: 5.75 ft Pile 4: 5.25 ft
Foundation Volume:	13.037 y ³
Foundation Result:	PASSED

Site Info

Risk Category:	I
Exposure:	B
Soil Classification:	sand
Site Location:	303 Crazy D Ln, Melville, MT 59055, USA
Wind Speed:	120 mph
Snow Load:	30 psf
Design Uplift Pressure:	Multiple pressures
Design Downforce Pressure:	Multiple pressures
Design Snow Pressure:	0.009846 ksf



Design Disclaimer

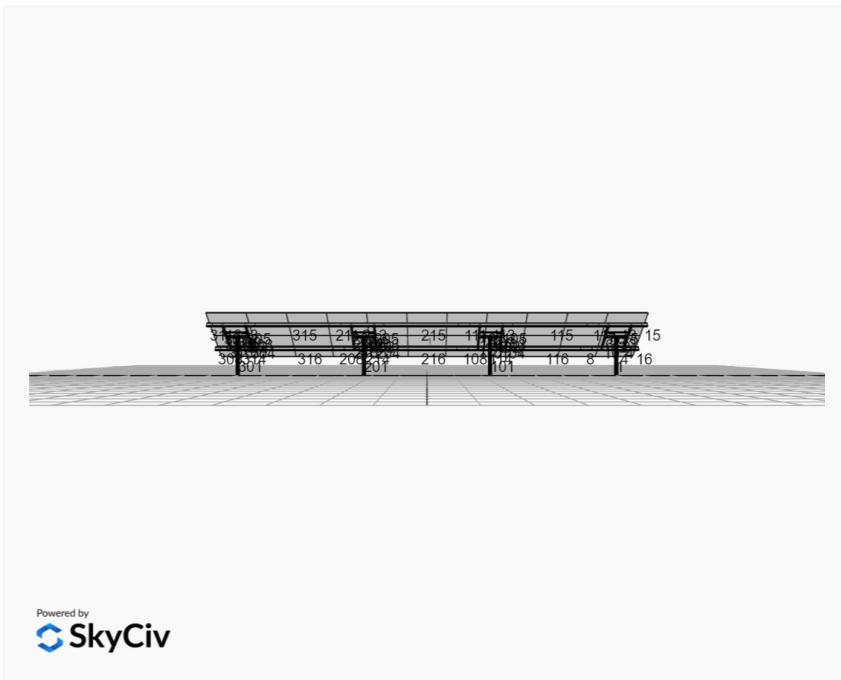
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

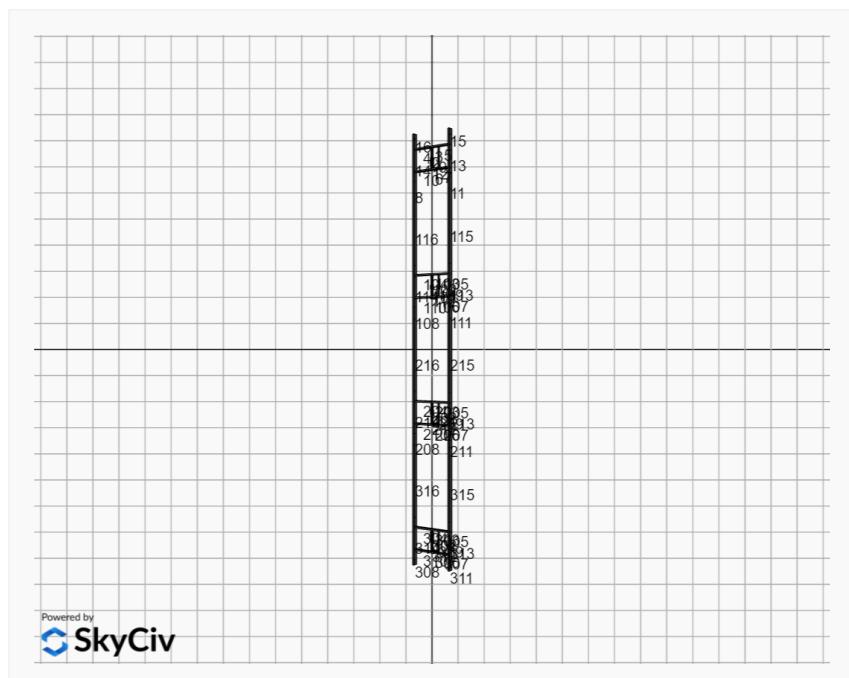
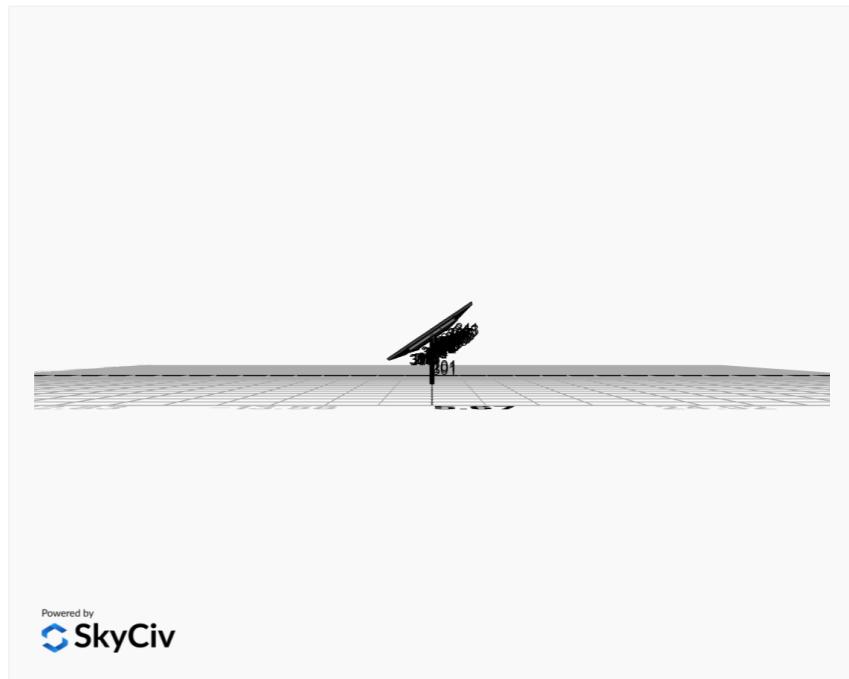
AutoDesigner Input

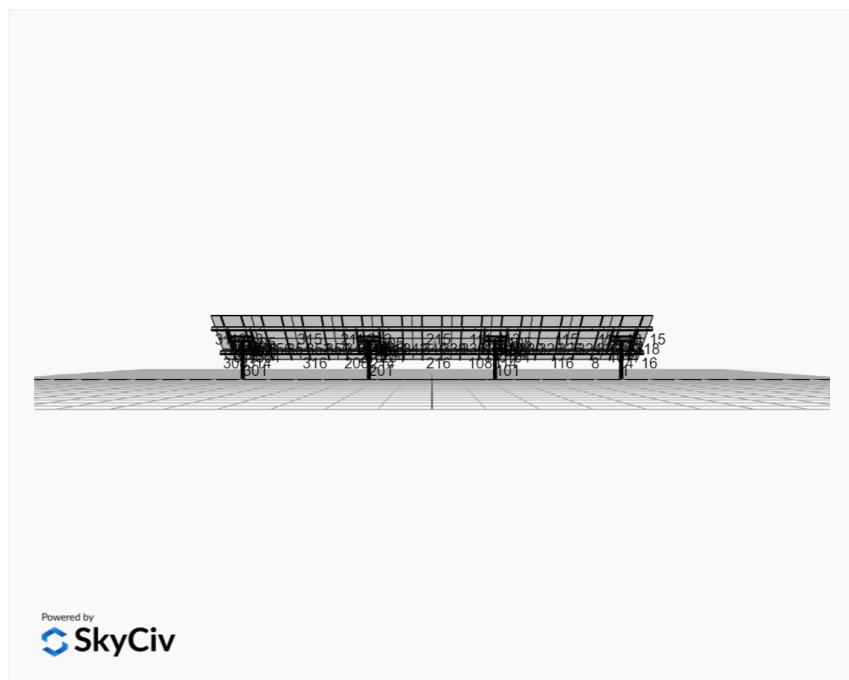
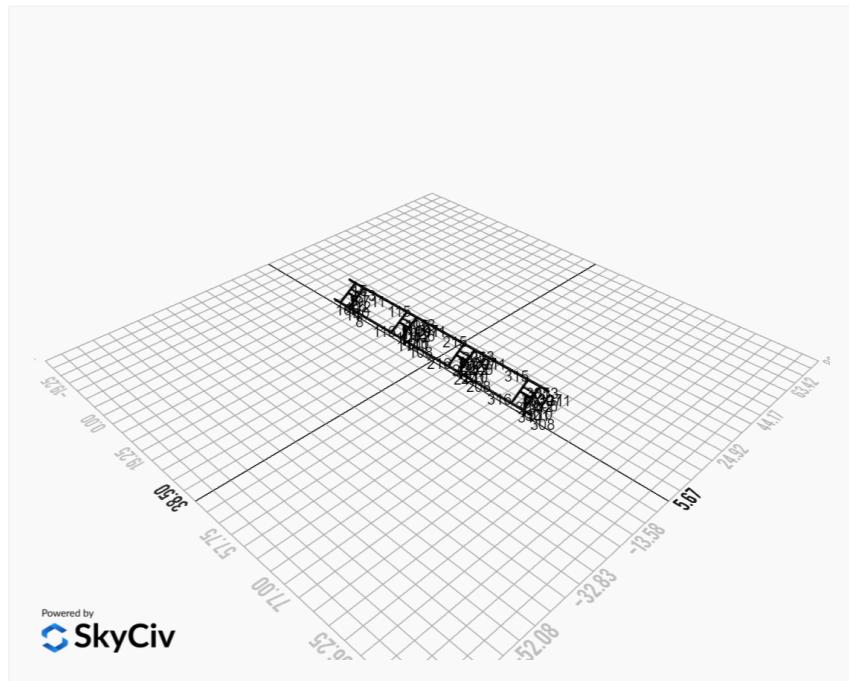
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Design Notes:

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







FEM Results (Envelope Worst Case for each member)







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

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	0.0426	1.6206	0.1741	0.3099	-0.1143	-0.2491
ULS: 2. D + L	0.0426	1.6206	0.1741	0.3099	-0.1143	-0.2491
ULS: 3. D + (S or Lr or R)	0.0999	3.3379	0.4085	0.7276	-0.2684	-0.6144
ULS: 3. D + (S or Lr or R)	0.0426	1.6206	0.1741	0.3099	-0.1143	-0.2491
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0855	2.9086	0.3499	0.6232	-0.2299	-0.5231
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0426	1.6206	0.1741	0.3099	-0.1143	-0.2491
ULS: 5b. D + 0.7E	0.0426	1.6206	0.1741	0.3099	-0.1143	-0.2491
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0855	2.9086	0.3499	0.6232	-0.2299	-0.5231
ULS: 8. 0.6D + 0.7E	0.0255	0.9724	0.1044	0.1859	-0.0686	-0.1494
ULS: 5a. D + 0.6W_Wind downforce Case A only	-1.8817	4.4372	0.6933	1.1783	-0.9589	13.5521
ULS: 5a. D + 0.6W_Wind downforce Case B only	-1.8817	4.4372	0.6933	1.1783	-0.9589	13.5521
ULS: 5a. D + 0.6W_Wind uplift Case A only	1.6699	-0.7620	-0.2577	-0.4118	0.5892	-11.4852
ULS: 5a. D + 0.6W_Wind uplift Case B only	1.4208	-0.3757	-0.2238	-0.3538	0.5437	-15.6593
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.3577	5.0210	0.7393	1.2745	-0.8633	9.8278
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.3577	5.0210	0.7393	1.2745	-0.8633	9.8278
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.3061	1.1216	0.0260	0.0820	0.2978	-8.9502
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.1192	1.4113	0.0514	0.1254	0.2637	-12.0808
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.4006	3.7331	0.5635	0.9612	-0.7478	10.1018
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.4006	3.7331	0.5635	0.9612	-0.7478	10.1018
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.2631	-0.1664	-0.1498	-0.2314	0.4133	-8.6761
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.0762	0.1234	-0.1244	-0.1879	0.3792	-11.8068
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-1.8987	3.7890	0.6237	1.0543	-0.9132	13.6518
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-1.8987	3.7890	0.6237	1.0543	-0.9132	13.6518
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	1.6529	-1.4103	-0.3273	-0.5357	0.6349	-11.3855
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	1.4037	-1.0240	-0.2935	-0.4778	0.5894	-15.5597

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
Axial	7.4976
Shear X	-3.2071
Shear Z	1.1967
Moment X	2.0373
Moment Z	26.4219

Worst Case Reactions ASD

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

Result	Value
Axial	5.0210
Shear X	-1.8987
Shear Z	0.7393
Moment X	1.2745
Moment Z	15.6593

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	-0.0426	2.2997	-0.0251	-0.0453	0.0394	0.3012
ULS: 2. D + L	-0.0426	2.2997	-0.0251	-0.0453	0.0394	0.3012
ULS: 3. D + (S or Lr or R)	-0.0999	4.9296	-0.0590	-0.1064	0.0924	0.6798
ULS: 3. D + (S or Lr or R)	-0.0426	2.2997	-0.0251	-0.0453	0.0394	0.3012
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0855	4.2722	-0.0505	-0.0911	0.0791	0.5851
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0426	2.2997	-0.0251	-0.0453	0.0394	0.3012
ULS: 5b. D + 0.7E	-0.0426	2.2997	-0.0251	-0.0453	0.0394	0.3012
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0855	4.2722	-0.0505	-0.0911	0.0791	0.5851

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 8. 0.6D + 0.7E	-0.0255	1.3798	-0.0151	-0.0272	0.0236	0.1807
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.0311	6.7666	-0.0825	-0.1512	0.1059	21.2711
ULS: 5a. D + 0.6W_Wind downforce Case B only	-3.0311	6.7666	-0.0825	-0.1512	0.1059	21.2711
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.4882	-1.4824	0.0255	0.0474	-0.0215	-16.6024
ULS: 5a. D + 0.6W_Wind uplift Case B only	2.0444	-0.8412	-0.0044	-0.0031	0.0327	-22.1958
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or L or R)_Wind downforce Case A only	-2.3269	7.6223	-0.0935	-0.1705	0.1290	16.3125
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or L or R)_Wind downforce Case B only	-2.3269	7.6223	-0.0935	-0.1705	0.1290	16.3125
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or L or R)_Wind uplift Case A only	1.8126	1.4356	-0.0125	-0.0215	0.0334	-12.0925
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or L or R)_Wind uplift Case B only	1.4797	1.9164	-0.0349	-0.0594	0.0741	-16.2876
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or L or R)_Wind downforce Case A only	-2.2840	5.6499	-0.0681	-0.1248	0.0893	16.0286
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or L or R)_Wind downforce Case B only	-2.2840	5.6499	-0.0681	-0.1248	0.0893	16.0286
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or L or R)_Wind uplift Case A only	1.8555	-0.5369	0.0128	0.0242	-0.0063	-12.3765
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or L or R)_Wind uplift Case B only	1.5227	-0.0560	-0.0096	-0.0136	0.0344	-16.5716
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.0141	5.8467	-0.0724	-0.1331	0.0902	21.1506
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-3.0141	5.8467	-0.0724	-0.1331	0.0902	21.1506
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.5053	-2.4023	0.0356	0.0656	-0.0373	-16.7229
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	2.0614	-1.7611	0.0057	0.0151	0.0170	-22.3163

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
Axial	11.5196
Shear X	-5.0604
Shear Z	-0.1416
Moment X	-0.2605
Moment Z	37.4950

Worst Case Reactions ASD

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

Result	Value
Axial	7.6223
Shear X	-3.0311
Shear Z	-0.0935
Moment X	-0.1705
Moment Z	22.3163

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	-0.0426	2.2997	0.0251	0.0453	-0.0393	0.3012
ULS: 2. D + L	-0.0426	2.2997	0.0251	0.0453	-0.0393	0.3012
ULS: 3. D + (S or L or R)	-0.0998	4.9296	0.0590	0.1062	-0.0921	0.6798
ULS: 3. D + (S or L or R)	-0.0426	2.2997	0.0251	0.0453	-0.0393	0.3012
ULS: 4. D + 0.75L + 0.75(S or L or R)	-0.0855	4.2722	0.0505	0.0910	-0.0789	0.5851
ULS: 4. D + 0.75L + 0.75(S or L or R)	-0.0426	2.2997	0.0251	0.0453	-0.0393	0.3012
ULS: 5b. D + 0.7E	-0.0426	2.2997	0.0251	0.0453	-0.0393	0.3012
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0855	4.2722	0.0505	0.0910	-0.0789	0.5851
ULS: 8. 0.6D + 0.7E	-0.0255	1.3798	0.0151	0.0272	-0.0236	0.1807
ULS: 5a. D + 0.6W_Wind downforce Case A only	-3.0311	6.7666	0.0825	0.1512	-0.1059	21.2711
ULS: 5a. D + 0.6W_Wind downforce Case B only	-3.0311	6.7666	0.0825	0.1512	-0.1059	21.2711
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.4882	-1.4824	-0.0255	-0.0475	0.0216	-16.6024
ULS: 5a. D + 0.6W_Wind uplift Case B only	2.0444	-0.8412	0.0044	0.0030	-0.0327	-22.1958
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or L or R)_Wind downforce Case A only	-2.3269	7.6223	0.0935	0.1704	-0.1288	16.3125
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or L or R)_Wind downforce Case B only	-2.3269	7.6223	0.0935	0.1704	-0.1288	16.3125
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or L or R)_Wind uplift Case A only	1.8126	1.4356	0.0125	0.0214	-0.0332	-12.0926
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or L or R)_Wind uplift Case B only	1.4797	1.9164	0.0349	0.0593	-0.0739	-16.2876
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or L or R)_Wind downforce Case A only	-2.2840	5.6499	0.0681	0.1247	-0.0892	16.0286
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or L or R)_Wind downforce Case B only	-2.2840	5.6499	0.0681	0.1247	-0.0892	16.0286

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.8555	-0.5369	-0.0128	-0.0243	0.0064	-12.3765
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.5227	-0.0560	0.0096	0.0136	-0.0343	-16.5716
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-3.0141	5.8467	0.0724	0.1331	-0.0901	21.1506
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-3.0141	5.8467	0.0724	0.1331	-0.0901	21.1506
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.5053	-2.4023	-0.0355	-0.0656	0.0373	-16.7229
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	2.0614	-1.7611	-0.0057	-0.0151	-0.0169	-22.3163

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
Axial	11.5197
Shear X	-5.0604
Shear Z	0.1416
Moment X	0.2594
Moment Z	37.4950

Worst Case Reactions ASD

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

Result	Value
Axial	7.6223
Shear X	-3.0311
Shear Z	0.0935
Moment X	0.1704
Moment Z	22.3163

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	0.0426	1.6206	-0.1741	-0.3099	0.1144	-0.2490
ULS: 2. D + L	0.0426	1.6206	-0.1741	-0.3099	0.1144	-0.2490
ULS: 3. D + (S or Lr or R)	0.0998	3.3379	-0.4085	-0.7279	0.2686	-0.6143
ULS: 3. D + (S or Lr or R)	0.0426	1.6206	-0.1741	-0.3099	0.1144	-0.2490
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0855	2.9086	-0.3499	-0.6234	0.2301	-0.5230
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0426	1.6206	-0.1741	-0.3099	0.1144	-0.2490
ULS: 5b. D + 0.7E	0.0426	1.6206	-0.1741	-0.3099	0.1144	-0.2490
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0855	2.9086	-0.3499	-0.6234	0.2301	-0.5230
ULS: 8. 0.6D + 0.7E	0.0255	0.9724	-0.1044	-0.1860	0.0686	-0.1494
ULS: 5a. D + 0.6W_Wind downforce Case A only	-1.8817	4.4372	-0.6933	-1.1784	0.9590	13.5522
ULS: 5a. D + 0.6W_Wind downforce Case B only	-1.8817	4.4372	-0.6933	-1.1784	0.9590	13.5522
ULS: 5a. D + 0.6W_Wind uplift Case A only	1.6699	-0.7620	0.2577	0.4117	-0.5891	-11.4851
ULS: 5a. D + 0.6W_Wind uplift Case B only	1.4207	-0.3757	0.2238	0.3538	-0.5436	-15.6593
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.3577	5.0210	-0.7393	-1.2748	0.8635	9.8279
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.3577	5.0210	-0.7393	-1.2748	0.8635	9.8279
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.3060	1.1216	-0.0261	-0.0822	-0.2976	-8.9501
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.1192	1.4113	-0.0515	-0.1257	-0.2634	-12.0807
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.4006	3.7331	-0.5635	-0.9613	0.7478	10.1019
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.4006	3.7331	-0.5635	-0.9613	0.7478	10.1019
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.2631	-0.1664	0.1498	0.2313	-0.4132	-8.6761
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.0762	0.1234	0.1244	0.1878	-0.3791	-11.8067
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-1.8987	3.7890	-0.6237	-1.0544	0.9132	13.6518
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-1.8987	3.7890	-0.6237	-1.0544	0.9132	13.6518
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	1.6529	-1.4103	0.3273	0.5357	-0.6349	-11.3855
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	1.4037	-1.0240	0.2935	0.4777	-0.5894	-15.5597

Worst Case Reactions LRFD

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

Worst Case Reactions ASD

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

Result	Value
Axial	7.4976
Shear X	-3.2071
Shear Z	-1.1967
Moment X	-2.0385
Moment Z	26.4224

Result	Value
Axial	5.0210
Shear X	-1.8987
Shear Z	-0.7393
Moment X	-1.2748
Moment Z	15.6593

Project Details

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

User Name: sales@mtsolard.com
 Project Name: J BAR L Big House
 Unit System: imperial



Design Input Information

Design Factors			
Φ_t	Φ_c	Φ_b	Φ_v
0.9	0.9	0.9	0.9

Design Materials			
ID	E (ksi)	F _y (ksi)	F _u (ksi)
1	29000	50	65

Section Dimensions								
ID	Name	d (in)	t _w (in)					
2	2in Pipe Sch 80	2.38	0.22					
5	4in Pipe Sch 80	4.50	0.34					
7	6in Pipe Sch 40	6.63	0.28					
ID	Name	d (in)	b (in)	t _w (in)	t _b (in)	r (in)		
16	HSS5x3x3/16	5.00	3.00	0.17	0.17	0.17		
ID	Name	d (in)	t _w (in)	b _t (in)	b _b (in)	t _t (in)	t _b (in)	r (in)
19	W8x10	7.89	0.17	3.94	3.94	0.20	0.20	0.30

Section Properties								
ID	Name	A (in ²)	J (in ⁴)	I _{yp} (in ⁴)	I _{zp} (in ⁴)	I _w (in ⁶)	S _{yp} (in ³)	S _{zp} (in ³)
2	2in Pipe Sch 80	1.48	1.74	0.87	0.87	0.00	1.02	1.02
5	4in Pipe Sch 80	4.41	19.22	9.61	9.61	0.00	5.85	5.85

					/,1.0/,1.0/,1.20,1.0/,1.0/,1.0/,1.0/	0	0	
24	19	1.14	1.14	1.75	1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.29,2.17,1.30,1.30,1.30,1.10,1.30,1.30,1.32,1.33,1.3 0,1.30,1.29,1.55,1.30,1.30,1.30,1.17	300	200	1
25	19	2.60	2.60	4.00	1.07,1.07,1.07,1.07,1.07,1.07,1.08,1.08,1.09,1.12,1.08,1.08,1.09,1.11,1.07,1.07,1.05,1.04,1.0 8,1.08,1.10,1.13,1.08,1.08,1.08,1.10	300	200	1
26	19	1.14	1.14	1.75	1.32,1.32,1.32,1.32,1.32,1.35,1.35,1.38,1.42,1.35,1.35,1.36,1.40,1.33,1.33,1.26,1.09,1.3 4,1.34,1.40,1.44,1.35,1.35,1.36,1.39	300	200	1
27	19	2.60	2.60	4.00	1.06,1.06,1.06,1.06,1.06,1.06,1.07,1.07,1.07,1.01,1.07,1.07,1.07,1.02,1.06,1.06,1.06,1.07,1.0 7,1.07,1.07,1.21,1.07,1.07,1.07,1.03	300	200	1
28	19	1.14	1.14	1.75	1.36,1.36,1.36,1.36,1.36,1.36,1.36,1.35,1.22,1.35,1.35,1.35,1.15,1.36,1.36,1.39,1.41,1.3 6,1.36,1.34,2.21,1.35,1.35,1.35,1.20	300	200	1
29	19	2.60	2.60	4.00	1.45,1.46,1.46,1.46,1.46,1.46,1.39,1.39,1.35,1.39,1.39,1.39,1.37,1.40,1.42,1.42,1.75,1.08,1.4 0,1.40,1.33,1.38,1.39,1.39,1.38,1.40	300	200	1
30	19	1.14	1.14	1.75	2.13,2.13,2.13,2.13,2.13,2.18,2.18,2.30,2.13,2.22,2.22,2.33,2.20,2.16,2.16,1.76,1.00,2.1 7,2.17,2.27,1.99,2.24,2.24,2.34,2.21	300	200	1
31	19	2.60	2.60	4.00	1.49,1.49,1.49,1.50,1.49,1.49,1.58,1.58,1.72,1.58,1.59,1.59,1.66,1.64,1.55,1.55,1.34,1.51,1.5 7,1.57,1.82,1.55,1.60,1.60,1.64,1.71	300	200	1
32	19	1.14	1.14	1.75	1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.7 1,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71,1.71	300	200	1
33	5	0.73	0.73	1.13	-	300	200	1
34	5	0.57	0.57	0.88	-	300	200	1
101	7	14.42	14.42	6.87	-	300	200	1
102	5	1.30	1.30	2.00	-	300	200	1
103	16	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.18,1.18,1.19,1.21,1.1 8,1.18,1.17,1.17,1.18,1.18,1.18,1.18	300	200	1
104	16	2.44	2.44	3.75	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.74,1.67,1.67,1.66,1.62,1.67,1.67,1.69,1.67,1.6 7,1.67,1.65,1.71,1.67,1.67,1.66,1.65	300	200	1
105	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.66,1.67,1.67,1.68,1.70,1.6 7,1.67,1.66,1.66,1.67,1.67,1.66,1.67	300	200	1
106	16	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.21,1.1 8,1.18,1.17,1.17,1.18,1.18,1.18,1.18	300	200	1
107	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.68,1.75,1.6 7,1.67,1.66,1.66,1.67,1.67,1.66,1.67	300	200	1
108	19	1.33	1.33	2.05	1.95,1.95,1.96,1.95,1.95,1.96,1.90,1.90,1.86,1.31,1.89,1.89,1.88,1.12,1.92,1.92,2.11,2.22,1.9 0,1.90,1.84,1.86,1.89,1.89,1.88,1.25	300	200	1
109	2	2.60	2.60	4.00	-	300	200	1
110	16	2.44	2.44	3.75	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.71,1.67,1.67,1.66,1.58,1.67,1.67,1.69,1.67,1.6 4,1.67,1.65,1.71,1.67,1.67,1.66,1.64	300	200	1
111	19	1.33	1.33	2.05	2.10,2.10,2.10,2.10,2.10,2.25,2.25,2.34,2.13,2.26,2.26,2.30,2.21,2.23,2.23,1.59,1.10,2.2 5,2.25,2.20,2.11,2.26,2.26,2.29,2.31	300	200	1
112	5	0.57	0.57	0.88	-	300	200	1
113	19	1.14	1.14	1.75	1.32,1.32,1.32,1.32,1.32,1.35,1.35,1.38,1.42,1.35,1.35,1.36,1.40,1.33,1.33,1.26,1.09,1.3 4,1.34,1.40,1.44,1.35,1.35,1.36,1.39	300	200	1
114	19	1.14	1.14	1.75	1.36,1.36,1.36,1.36,1.36,1.36,1.36,1.35,1.22,1.35,1.35,1.35,1.35,1.16,1.36,1.36,1.39,1.41,1.3 6,1.36,1.34,2.21,1.35,1.35,1.35,1.20	300	200	1
115	19	8.42	8.42	12.95	1.17,1.17,1.17,1.17,1.17,1.17,1.16,1.16,1.14,1.13,1.15,1.15,1.15,1.13,1.16,1.16,1.24,2.27,1.1 6,1.16,1.13,1.12,1.15,1.15,1.15,1.13	300	200	1

116	19	8.42	8.42	12. 95	1.18,1.18,1.18,1.18,1.18,1.18,1.19,1.19,1.18,1.19,1.19,1.18,1.19,1.19,1.18,1.19,1.19,1.18,1.19,1.18,1.17,1.16,1.1 9,1.19,1.19,1.11,1.19,1.19,1.19,1.61	3 0 0	2 0 0	1
201	7	14.4 2	14.4 2	6.8 7	-	3 0 0	2 0 0	1
202	5	0.73	0.73	1.1 3	-	3 0 0	2 0 0	1
203	16	0.92	0.92	1.4 2	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.17,1.18,1.18,1.18,1.19,1.18,1.18,1.18,1.18,1.18,1.21,1.1 8,1.18,1.17,1.17,1.18,1.18,1.18	3 0 0	2 0 0	1
204	16	2.44	2.44	3.7 5	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.71,1.67,1.67,1.66,1.58,1.67,1.67,1.69,1.67,1.6 7,1.67,1.65,1.71,1.67,1.67,1.66,1.64	3 0 0	2 0 0	1
205	16	1.52	1.52	2.3 3	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.68,1.75,1.6 7,1.67,1.66,1.66,1.67,1.67,1.66,1.67	3 0 0	2 0 0	1
206	16	0.92	0.92	1.4 2	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.17,1.17,1.18,1.18,1.17,1.18,1.18,1.18,1.19,1.21,1.1 8,1.18,1.17,1.17,1.18,1.18,1.18,1.18	3 0 0	2 0 0	1
207	16	1.52	1.52	2.3 3	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.68,1.70,1.6 7,1.67,1.66,1.66,1.67,1.67,1.66,1.67	3 0 0	2 0 0	1
208	19	1.33	1.33	2.0 5	2.30,2.30,2.30,2.30,2.30,2.28,2.28,2.26,1.10,2.28,2.28,2.27,1.27,2.29,2.29,2.31,2.15,2.2 8,2.28,2.26,1.39,2.28,2.28,2.27,1.41	3 0 0	2 0 0	1
209	2	2.60	2.60	4.0 0	-	3 0 0	2 0 0	1
210	16	2.44	2.44	3.7 5	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.74,1.67,1.67,1.66,1.62,1.67,1.67,1.69,1.67,1.6 7,1.67,1.65,1.71,1.67,1.67,1.66,1.65	3 0 0	2 0 0	1
211	19	1.33	1.33	2.0 5	2.34,2.35,2.35,2.34,2.35,2.35,2.12,2.12,1.99,1.77,2.11,2.11,2.09,1.88,2.14,2.14,1.92,1.20,2.1 2,2.12,1.82,1.68,2.11,2.11,2.10,1.92	3 0 0	2 0 0	1
212	5	1.30	1.30	2.0 0	-	3 0 0	2 0 0	1
213	19	1.14	1.14	1.7 5	1.38,1.38,1.38,1.38,1.38,1.44,1.44,1.51,1.59,1.44,1.44,1.48,1.55,1.41,1.41,1.29,1.13,1.4 3,1.43,1.56,1.64,1.45,1.45,1.47,1.53	3 0 0	2 0 0	1
214	19	1.14	1.14	1.7 5	1.30,1.30,1.30,1.30,1.30,1.30,1.30,1.29,2.17,1.30,1.30,1.30,1.30,1.10,1.30,1.30,1.32,1.33,1.3 0,1.30,1.29,1.55,1.30,1.30,1.30,1.17	3 0 0	2 0 0	1
215	19	8.42	8.42	12. 95	1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.16,1.15,1.17,1.17,1.17,1.15,1.18,1.18,1.47,1.46,1.1 8,1.18,1.15,1.14,1.17,1.17,1.17,1.15	3 0 0	2 0 0	1
216	19	8.42	8.42	12. 95	1.21,1.21,1.21,1.21,1.21,1.21,1.21,1.22,1.08,1.21,1.21,1.21,1.62,1.21,1.21,1.19,1.18,1.2 1,1.21,1.22,1.12,1.21,1.21,1.21,3.23	3 0 0	2 0 0	1
301	7	14.4 2	14.4 2	6.8 7	-	3 0 0	2 0 0	1
302	5	1.30	1.30	2.0 0	-	3 0 0	2 0 0	1
303	16	0.92	0.92	1.4 2	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.19,1.19,1.18,1.19,1.19,1.19,1.19,1.23,1.1 9,1.19,1.18,1.18,1.19,1.19,1.18,1.19	3 0 0	2 0 0	1
304	16	2.44	2.44	3.7 5	1.69,1.68,1.69,1.68,1.68,1.69,1.67,1.67,1.66,1.73,1.67,1.67,1.66,1.57,1.67,1.67,1.69,1.68,1.6 7,1.67,1.64,1.72,1.67,1.67,1.66,1.63	3 0 0	2 0 0	1
305	16	1.52	1.52	2.3 3	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.68,1.88,1.6 7,1.67,1.65,1.66,1.67,1.67,1.66,1.67	3 0 0	2 0 0	1
306	16	0.92	0.92	1.4 2	1.18,1.18,1.18,1.17,1.18,1.18,1.17,1.15,1.16,1.17,1.17,1.16,1.16,1.17,1.17,1.19,1.48,1.1 7,1.17,1.14,1.15,1.17,1.17,1.16,1.16	3 0 0	2 0 0	1
307	16	1.52	1.52	2.3 3	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.65,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.69,1.88,1.6 7,1.67,1.64,1.65,1.67,1.67,1.66,1.66	3 0 0	2 0 0	1
308	19	2.10	2.10	1.0 0	2.33,2.33,2.32,2.32,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.3 3,2.3 3	3 0 0	2 0 0	1
309	2	2.60	2.60	4.0 0	-	3 0 0	2 0 0	1

310	16	2.44	2.44	3.7 5	1.70,1.69,1.70,1.68,1.69,1.70,1.67,1.67,1.65,1.71,1.67,1.67,1.65,1.81,1.67,1.67,1.70,1.68,1.6 8,1.68,1.63,1.72,1.67,1.67,1.66,1.18	3 0 0	2 0 0	1
311	19	2.10	2.10	1.0 0	2.33,2.33,2.32,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.3 3,2.33,2.33,2.33,2.33,2.33,2.33,2.33	3 0 0	2 0 0	1
312	5	1.30	1.30	2.0 0	-	3 0 0	2 0 0	1
313	19	1.14	1.14	1.7 5	1.71,1.71 1,1.71	3 0 0	2 0 0	1
314	19	1.14	1.14	1.7 5	2.10,2.10,2.10,2.10,2.10,2.10,1.94,1.94,1.77,1.20,1.92,1.92,1.84,1.01,2.03,2.03,2.34,2.29,1.9 6,1.96,1.71,1.36,1.91,1.91,1.86,1.05	3 0 0	2 0 0	1
315	19	8.42	8.42	12. 95	1.10,1.10 0,1.10,1.09,1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.10,1.10	3 0 0	2 0 0	1
316	19	8.42	8.42	12. 95	1.10,1.10 0,1.10,1.09,1.18,1.10,1.10,1.10,1.10,1.24	3 0 0	2 0 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	251.16	162.67	42.30	42.30	75.35	75.35
2	198.33	196.72	21.95	21.95	59.50	59.50
3	116.10	115.41	15.79	11.10	42.08	23.28
4	116.10	111.33	15.79	11.10	42.08	23.28
5	116.10	114.23	15.79	11.10	42.08	23.28
6	116.10	115.41	15.79	11.10	42.08	23.28
7	116.10	114.23	15.79	11.10	42.08	23.28
8	133.20	126.01	32.87	6.12	40.24	43.62
9	66.48	58.89	3.82	3.82	19.94	19.94
10	116.10	111.33	15.79	11.10	42.08	23.28
11	133.20	126.01	32.87	6.12	40.24	43.62
12	198.33	196.72	21.95	21.95	59.50	59.50
13	133.20	126.79	32.87	6.12	40.24	43.62
14	133.20	126.79	32.87	6.12	40.24	43.62
15	133.20	121.82	32.87	6.12	40.24	43.62
16	133.20	121.82	32.87	6.12	40.24	43.62
17	133.20	118.19	32.87	6.12	40.24	43.62
18	133.20	126.79	32.87	6.12	40.24	43.62
19	133.20	118.19	32.87	6.12	40.24	43.62
20	133.20	126.79	32.87	6.12	40.24	43.62
21	133.20	118.19	32.14	6.12	40.24	43.62
22	133.20	126.79	32.87	6.12	40.24	43.62
23	133.20	118.19	31.22	6.12	40.24	43.62
24	133.20	126.79	32.87	6.12	40.24	43.62
25	133.20	118.19	32.14	6.12	40.24	43.62
26	133.20	126.79	32.87	6.12	40.24	43.62
27	133.20	118.19	31.22	6.12	40.24	43.62
28	133.20	126.79	32.87	6.12	40.24	43.62
29	133.20	118.19	32.87	6.12	40.24	43.62
30	133.20	126.79	32.87	6.12	40.24	43.62
31	133.20	118.19	32.87	6.12	40.24	43.62
32	133.20	126.79	32.87	6.12	40.24	43.62
33	198.33	197.82	21.95	21.95	59.50	59.50
34	198.33	198.03	21.95	21.95	59.50	59.50
101	251.16	162.67	42.30	42.30	75.35	75.35

L01	L01.10	L02.07	L02.08	L02.09	L03.00	L03.01
102	198.33	196.72	21.95	21.95	59.50	59.50
103	116.10	115.41	15.79	11.10	42.08	23.28
104	116.10	111.33	15.79	11.10	42.08	23.28
105	116.10	114.23	15.79	11.10	42.08	23.28
106	116.10	115.41	15.79	11.10	42.08	23.28
107	116.10	114.23	15.79	11.10	42.08	23.28
108	133.20	126.01	32.87	6.12	40.24	43.62
109	66.48	58.89	3.82	3.82	19.94	19.94
110	116.10	111.33	15.79	11.10	42.08	23.28
111	133.20	126.01	32.87	6.12	40.24	43.62
112	198.33	198.03	21.95	21.95	59.50	59.50
113	133.20	126.79	32.87	6.12	40.24	43.62
114	133.20	126.79	32.87	6.12	40.24	43.62
115	133.20	46.28	12.13	6.12	40.24	43.62
116	133.20	46.28	12.02	6.12	40.24	43.62
201	251.16	162.67	42.30	42.30	75.35	75.35
202	198.33	197.82	21.95	21.95	59.50	59.50
203	116.10	115.41	15.79	11.10	42.08	23.28
204	116.10	111.33	15.79	11.10	42.08	23.28
205	116.10	114.23	15.79	11.10	42.08	23.28
206	116.10	115.41	15.79	11.10	42.08	23.28
207	116.10	114.23	15.79	11.10	42.08	23.28
208	133.20	126.01	32.87	6.12	40.24	43.62
209	66.48	58.89	3.82	3.82	19.94	19.94
210	116.10	111.33	15.79	11.10	42.08	23.28
211	133.20	126.01	32.87	6.12	40.24	43.62
212	198.33	196.72	21.95	21.95	59.50	59.50
213	133.20	126.79	32.87	6.12	40.24	43.62
214	133.20	126.79	32.87	6.12	40.24	43.62
215	133.20	46.28	12.35	6.12	40.24	43.62
216	133.20	46.28	11.70	6.12	40.24	43.62
301	251.16	162.67	42.30	42.30	75.35	75.35
302	198.33	196.72	21.95	21.95	59.50	59.50
303	116.10	115.41	15.79	11.10	42.08	23.28
304	116.10	111.33	15.79	11.10	42.08	23.28
305	116.10	114.23	15.79	11.10	42.08	23.28
306	116.10	115.41	15.79	11.10	42.08	23.28
307	116.10	114.23	15.79	11.10	42.08	23.28
308	133.20	121.82	32.87	6.12	40.24	43.62
309	66.48	58.89	3.82	3.82	19.94	19.94
310	116.10	111.33	15.79	11.10	42.08	23.28
311	133.20	121.82	32.87	6.12	40.24	43.62
312	198.33	196.72	21.95	21.95	59.50	59.50
313	133.20	126.79	32.87	6.12	40.24	43.62
314	133.20	126.79	32.87	6.12	40.24	43.62
315	133.20	46.28	11.81	6.12	40.24	43.62
316	133.20	46.28	11.81	6.12	40.24	43.62

Design Ratio

Member ID	P	M _z	M _y	V _y	V _z	(P,M _z ,M _y)	Worst LC	KL/r	δ	Status
1	0.046	0.625	0.146	0.042	0.016	0.639	#32	0.385	Not Required	Pass
2	0.001	0.130	0.101	0.010	0.022	0.241	#13	0.053	Not Required	Pass

#	0.004	0.159	0.101	0.040	0.022	0.241	#13	0.055	Not Required	Pass
3	0.004	0.329	0.034	0.031	0.014	0.364	#13	0.045	Not Required	Pass
4	0.002	0.326	0.088	0.033	0.019	0.415	#13	0.120	Not Required	Pass
5	0.003	0.203	0.017	0.033	0.006	0.220	#13	0.074	Not Required	Pass
6	0.008	0.613	0.107	0.064	0.028	0.694	#13	0.045	Not Required	Pass
7	0.009	0.379	0.162	0.061	0.042	0.415	#13	0.074	Not Required	Pass
8	0.005	0.156	0.173	0.039	0.014	0.206	#21	0.095	Not Required	Pass
9	0.007	0.058	0.092	0.004	0.007	0.143	#13	0.204	Not Required	Pass
10	0.011	0.566	0.146	0.057	0.030	0.600	#13	0.080	Not Required	Pass
11	0.008	0.143	0.179	0.043	0.014	0.210	#21	0.095	Not Required	Pass
12	0.003	0.419	0.175	0.083	0.032	0.595	#13	0.053	Not Required	Pass
13	0.008	0.057	0.371	0.054	0.017	0.391	#21	0.081	Not Required	Pass
14	0.000	0.029	0.049	0.017	0.005	0.073	#21	Not Required	Not Required	Pass
15	0.000	0.004	0.006	0.006	0.002	0.010	#21	Not Required	Not Required	Pass
16	0.000	0.004	0.006	0.006	0.002	0.010	#21	Not Required	Not Required	Pass
17	0.001	0.061	0.078	0.016	0.006	0.098	#13	0.186	Not Required	Pass
18	0.000	0.030	0.049	0.018	0.005	0.073	#21	Not Required	Not Required	Pass
19	0.004	0.049	0.158	0.016	0.011	0.187	#21	0.186	Not Required	Pass
20	0.005	0.075	0.363	0.050	0.017	0.387	#24	0.081	Not Required	Pass
21	0.001	0.198	0.074	0.015	0.004	0.242	#21	0.186	Not Required	Pass
22	0.008	0.173	0.377	0.065	0.017	0.531	#21	0.081	Not Required	Pass
23	0.008	0.227	0.098	0.014	0.005	0.287	#13	0.186	Not Required	Pass
24	0.006	0.205	0.353	0.058	0.017	0.523	#21	0.081	Not Required	Pass
25	0.001	0.198	0.073	0.015	0.004	0.242	#21	0.186	Not Required	Pass
26	0.007	0.187	0.359	0.059	0.017	0.521	#21	0.081	Not Required	Pass
27	0.008	0.227	0.098	0.014	0.005	0.288	#13	0.186	Not Required	Pass
28	0.005	0.207	0.374	0.066	0.017	0.544	#21	0.081	Not Required	Pass
29	0.001	0.061	0.078	0.016	0.006	0.098	#13	0.186	Not Required	Pass
30	0.008	0.057	0.371	0.054	0.017	0.390	#21	0.081	Not Required	Pass
31	0.004	0.049	0.158	0.016	0.011	0.187	#21	0.186	Not Required	Pass
32	0.000	0.029	0.049	0.017	0.005	0.073	#21	Not Required	Not Required	Pass
33	0.004	0.210	0.127	0.093	0.042	0.338	#13	0.020	Not Required	Pass
34	0.004	0.430	0.227	0.093	0.042	0.659	#13	0.015	Not Required	Pass
101	0.071	0.886	0.017	0.067	0.002	0.893	#32	0.385	Not Required	Pass
102	0.003	0.462	0.236	0.098	0.043	0.699	#13	0.035	Not Required	Pass
103	0.008	0.732	0.045	0.073	0.002	0.764	#13	0.045	Not Required	Pass
104	0.008	0.744	0.152	0.075	0.031	0.796	#13	0.080	Not Required	Pass
105	0.008	0.453	0.168	0.073	0.043	0.482	#13	0.074	Not Required	Pass
106	0.008	0.714	0.039	0.072	0.003	0.731	#13	0.045	Not Required	Pass
107	0.008	0.444	0.158	0.071	0.040	0.467	#13	0.074	Not Required	Pass
108	0.006	0.092	0.165	0.047	0.014	0.241	#21	0.095	Not Required	Pass
109	0.016	0.065	0.055	0.001	0.001	0.125	#13	0.204	Not Required	Pass
110	0.008	0.698	0.157	0.070	0.033	0.763	#13	0.080	Not Required	Pass
111	0.007	0.072	0.169	0.048	0.014	0.237	#21	0.095	Not Required	Pass
112	0.004	0.430	0.227	0.093	0.042	0.659	#13	0.015	Not Required	Pass
113	0.007	0.187	0.359	0.059	0.017	0.522	#21	0.081	Not Required	Pass
114	0.005	0.207	0.374	0.066	0.017	0.544	#21	0.081	Not Required	Pass
115	0.021	0.587	0.197	0.053	0.014	0.708	#13	0.601	Not Required	Pass
116	0.013	0.568	0.198	0.055	0.014	0.683	#13	0.601	Not Required	Pass
201	0.071	0.886	0.017	0.067	0.002	0.893	#32	0.385	Not Required	Pass
202	0.004	0.210	0.127	0.093	0.042	0.338	#13	0.020	Not Required	Pass
203	0.008	0.714	0.039	0.072	0.003	0.731	#13	0.045	Not Required	Pass
204	0.008	0.698	0.157	0.070	0.033	0.763	#13	0.080	Not Required	Pass
205	0.008	0.444	0.158	0.071	0.040	0.467	#13	0.074	Not Required	Pass

206	0.008	0.732	0.045	0.073	0.002	0.764	#13	0.045	Not Required	Pass
207	0.008	0.453	0.168	0.073	0.043	0.482	#13	0.074	Not Required	Pass
208	0.005	0.076	0.181	0.055	0.014	0.243	#21	0.095	Not Required	Pass
209	0.016	0.065	0.055	0.001	0.001	0.125	#13	0.204	Not Required	Pass
210	0.008	0.744	0.152	0.075	0.031	0.796	#13	0.080	Not Required	Pass
211	0.008	0.071	0.185	0.053	0.014	0.233	#21	0.095	Not Required	Pass
212	0.003	0.462	0.236	0.098	0.043	0.699	#13	0.035	Not Required	Pass
213	0.008	0.173	0.377	0.065	0.017	0.531	#21	0.081	Not Required	Pass
214	0.006	0.205	0.353	0.058	0.017	0.523	#21	0.081	Not Required	Pass
215	0.020	0.376	0.199	0.048	0.014	0.511	#21	0.601	Not Required	Pass
216	0.012	0.308	0.195	0.047	0.014	0.453	#21	0.601	Not Required	Pass
301	0.046	0.625	0.146	0.042	0.016	0.639	#32	0.385	Not Required	Pass
302	0.003	0.419	0.175	0.083	0.032	0.595	#13	0.053	Not Required	Pass
303	0.008	0.613	0.107	0.064	0.028	0.694	#13	0.045	Not Required	Pass
304	0.011	0.566	0.146	0.057	0.030	0.600	#13	0.080	Not Required	Pass
305	0.009	0.379	0.162	0.061	0.042	0.415	#13	0.074	Not Required	Pass
306	0.004	0.329	0.034	0.031	0.014	0.364	#13	0.045	Not Required	Pass
307	0.003	0.203	0.017	0.033	0.006	0.220	#13	0.074	Not Required	Pass
308	0.000	0.004	0.006	0.006	0.002	0.010	#21	Not Required	Not Required	Pass
309	0.007	0.058	0.092	0.004	0.007	0.143	#13	0.204	Not Required	Pass
310	0.002	0.326	0.088	0.033	0.019	0.415	#13	0.120	Not Required	Pass
311	0.000	0.004	0.006	0.006	0.002	0.010	#21	Not Required	Not Required	Pass
312	0.004	0.139	0.101	0.040	0.022	0.241	#13	0.053	Not Required	Pass
313	0.000	0.030	0.049	0.018	0.005	0.073	#21	Not Required	Not Required	Pass
314	0.005	0.075	0.363	0.050	0.017	0.387	#24	0.081	Not Required	Pass
315	0.021	0.625	0.198	0.043	0.014	0.739	#13	0.601	Not Required	Pass
316	0.013	0.613	0.195	0.042	0.014	0.732	#13	0.601	Not Required	Pass

Definitions

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

REFERENCES	CALCULATIONS	RESULTS																										
	<p>SkyCiv Foundation Design Pile Foundation</p> <p>Design Information : Design code : IBC 2021 (International Building Code) Unit System : Imperial</p>																											
	<p>Pile Input</p> <p>Geometry</p> <p>Pile shape: rectangular $b = 48 \text{ in}$ - Pile width $D = 48 \text{ in}$ - Pile depth $L = 5.25 \text{ ft}$ - Total pile length $h_1 = 0 \text{ ft}$ - Lateral load height from the top of the pile, $h_2 = 0 \text{ ft}$ - Depth to resisting surface $h_e = 0 \text{ ft}$ - Length of pile above the ground</p> <p>Tabulation of Soil Parameters</p> <table border="1"> <thead> <tr> <th>Layer</th> <th>Label</th> <th>Allowable Bearing Pressure (q_a) (psf)</th> <th>Allowable Lateral Pressure (R) (psf/ft)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Sand, silty sand, clayey sand, silty gravel & clayey gravel</td> <td>2000.000</td> <td>150.000</td> </tr> </tbody> </table> <p>Tabulation of Loads</p> <table border="1"> <thead> <tr> <th>Load Component</th> <th>ASD</th> <th>LRFD</th> </tr> </thead> <tbody> <tr> <td>P (kip)</td> <td>5.021</td> <td>7.498</td> </tr> <tr> <td>V_x (kip)</td> <td>-1.899</td> <td>-3.207</td> </tr> <tr> <td>V_z (kip)</td> <td>0.739</td> <td>1.197</td> </tr> <tr> <td>M_x (kipft)</td> <td>1.275</td> <td>2.037</td> </tr> <tr> <td>M_z (kipft)</td> <td>15.659</td> <td>26.422</td> </tr> </tbody> </table> <p>Material Properties $f_{ck}' = 3 \text{ ksi}$ - Concrete strength,</p> <p>Required depth to resist lateral loads (ASD)</p> <p>H - Point of application of the lateral load</p> $H = h_1 + h_2 + h_e$ $H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})$ $H = 0 \text{ ft}$ <p>Considering x-direction: H_o - Lateral force per length of pile,</p> $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-1.899 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.30239 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$	Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) (psf/ft)	1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000	Load Component	ASD	LRFD	P (kip)	5.021	7.498	V_x (kip)	-1.899	-3.207	V_z (kip)	0.739	1.197	M_x (kipft)	1.275	2.037	M_z (kipft)	15.659	26.422	
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$$M_o = \frac{(15.659 \text{ kipft}) + ((-1.899 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 2.4935 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$L_{e,x} = 4.8205 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.739 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.11768 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(1.275 \text{ kipft}) + ((0.739 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.20303 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$L_{e,z} = 3.4338 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(4.8205 \text{ ft}), (3.4338 \text{ ft})]$$

$$L_{e,req} = 4.821 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (5.25 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$$

$$L_e = 5.25 \text{ ft}$$

Ratio - Embedded depth

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

$$Ratio = \frac{(4.821 \text{ ft})}{(5.25 \text{ ft})}$$

$$Ratio = 0.91829$$

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

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = b D$$

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

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

q - End-bearing pressure

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

$$q = \frac{(5.021 \text{ kip})}{(16 \text{ ft}^2)}$$

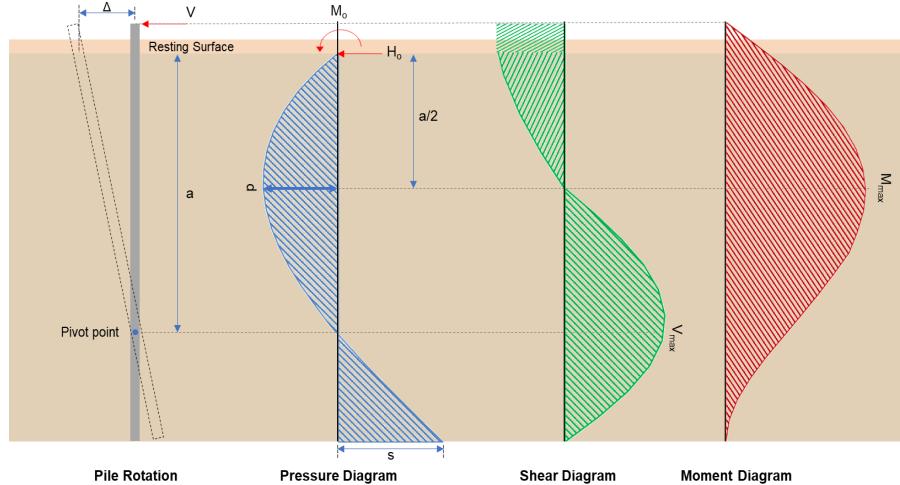
	$q = 0.31381 \text{ kip/ft}^2$	
	<p>Check bearing capacity ratio:</p> <p><i>Ratio - Capacity</i></p> $Ratio = \frac{q}{q_a}$ $Ratio = \frac{(0.31381 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $Ratio = 0.15691$	Status: PASS Ratio: 0.160
Czerniak	<p>Lateral Soil Pressure (ASD):</p> <p><i>L/D</i> - Length to least lateral dimension ratio,</p> $L/D = \frac{L}{D}$ $L/D = \frac{(5.25 \text{ ft})}{(48 \text{ in})}$ $L/D = 1.3125$ <p>Since $L/D \leq 10$,</p> <p style="text-align: center;">Pile is short.</p> <p>Considering x-direction:</p> <p>$H_o = -0.30239 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 2.4935 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (2.4935 \text{ kipft/ft}) \times (5.25 \text{ ft})) + (3 \times (-0.30239 \text{ kip/ft}) \times (5.25 \text{ ft})^2)}{(6 \times (2.4935 \text{ kipft/ft})) + (4 \times (-0.30239 \text{ kip/ft}) \times (5.25 \text{ ft}))}$ $a = 3.6304 \text{ ft}$ <p><i>p</i> - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (2.4935 \text{ kipft/ft})) + (3 \times (-0.30239 \text{ kip/ft}) \times (5.25 \text{ ft}))]^2}{(5.25 \text{ ft})^2 \times [(3 \times (2.4935 \text{ kipft/ft})) + (2 \times (-0.30239 \text{ kip/ft}) \times (5.25 \text{ ft}))]}$ $p = 0.17164 \text{ kip/ft}^2$ <p><i>s</i> - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (2.4935 \text{ kipft/ft})) + ((-0.30239 \text{ kip/ft}) \times (5.25 \text{ ft}))]}{(5.25 \text{ ft})^2}$ $s = 0.74001 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p><i>p_a</i> - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(3.6304 \text{ ft})}{2}$ $p_a = 0.27228 \text{ kip/ft}^2$ <p><i>Ratio</i> - Lateral soil capacity</p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.17164 \text{ kip/ft}^2)}{(0.27228 \text{ kip/ft}^2)}$ $Ratio = 0.63039$ <p><i>p_s</i> - Allowable lateral soil pressure at depth L_e,</p>	Status: PASS Ratio: 0.630

	$p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (5.25 \text{ ft})$ $p_s = 0.7875 \text{ kip/ft}^2$ <i>Ratio - Lateral soil capacity</i> $Ratio = \frac{s}{p_s}$ $Ratio = \frac{(0.74001 \text{ kip/ft}^2)}{(0.7875 \text{ kip/ft}^2)}$ $Ratio = 0.9397$ Status: PASS Ratio: 0.940
	<p>Considering z-direction:</p> <p>$H_o = 0.11768 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 0.20303 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.20303 \text{ kipft/ft}) \times (5.25 \text{ ft})) + (3 \times (0.11768 \text{ kip/ft}) \times (5.25 \text{ ft})^2)}{(6 \times (0.20303 \text{ kipft/ft})) + (4 \times (0.11768 \text{ kip/ft}) \times (5.25 \text{ ft}))}$ $a = 3.793 \text{ ft}$ <p>p - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.20303 \text{ kipft/ft})) + (3 \times (0.11768 \text{ kip/ft}) \times (5.25 \text{ ft}))]^2}{(5.25 \text{ ft})^2 \times [(3 \times (0.20303 \text{ kipft/ft})) + (2 \times (0.11768 \text{ kip/ft}) \times (5.25 \text{ ft}))]}$ $p = 0.1048 \text{ kip/ft}^2$ <p>s - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.20303 \text{ kipft/ft})) + ((0.11768 \text{ kip/ft}) \times (5.25 \text{ ft}))]}{(5.25 \text{ ft})^2}$ $s = 0.22288 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p>p_a - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(3.793 \text{ ft})}{2}$ $p_a = 0.28448 \text{ kip/ft}^2$ <p><i>Ratio - Lateral soil capacity</i></p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.1048 \text{ kip/ft}^2)}{(0.28448 \text{ kip/ft}^2)}$ $Ratio = 0.36841$ Status: PASS Ratio: 0.370 <p>p_s - Allowable lateral soil pressure at depth L_e,</p> $p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (5.25 \text{ ft})$ $p_s = 0.7875 \text{ kip/ft}^2$ <p><i>Ratio - Lateral soil capacity</i></p> $Ratio = \frac{s}{p_s}$

$$\text{Ratio} = \frac{(0.22288 \text{ kip}/\text{ft}^2)}{(0.7875 \text{ kip}/\text{ft}^2)}$$

$$\text{Ratio} = 0.28302$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-3.207 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.51067 \text{ kip}/\text{ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(26.422 \text{ kipft}) + ((-3.207 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 4.2073 \text{ kipft}/\text{ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(4.2073 \text{ kipft}/\text{ft})}{(-0.51067 \text{ kip}/\text{ft})}$$

$$E = 8.2389 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (4.2073 \text{ kipft}/\text{ft}) \times (5.25 \text{ ft})) + (3 \times (-0.51067 \text{ kip}/\text{ft}) \times (5.25 \text{ ft})^2)}{(6 \times (4.2073 \text{ kipft}/\text{ft})) + (4 \times (-0.51067 \text{ kip}/\text{ft}) \times (5.25 \text{ ft}))}$$

$$a = 3.6304 \text{ ft}$$

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

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

$$V_{max} = ((-0.51067 \text{ kip}/\text{ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (8.2389 \text{ ft})}{(5.25 \text{ ft})} + 3 \right) \times \left(\frac{(3.6304 \text{ ft})}{(5.25 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (8.2389 \text{ ft})}{(5.25 \text{ ft})} + 2 \right) \times \left(\frac{(3.6304 \text{ ft})}{(5.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 7.0192 \text{ kip}$$

<p>M_{max} - Max bending moment located at depth $a/2$,</p> $M_{max} = (H_o D L_e) \left[\left(\frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[\left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{2 L_e} \right)^3 \right] + \left[\left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{2 L_e} \right)^4 \right] \right]$ $M_{max} = ((-0.51067 \text{ kip/ft}) \times (48 \text{ in}) \times (5.25 \text{ ft})) \times \left[\left(\frac{(8.2389 \text{ ft})}{(5.25 \text{ ft})} + \frac{(3.6304 \text{ ft})}{2 \times (5.25 \text{ ft})} \right) - \left[\left(\frac{4 \times (8.2389 \text{ ft})}{(5.25 \text{ ft})} + 3 \right) \times \left(\frac{(3.6304 \text{ ft})}{2 \times (5.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (8.2389 \text{ ft})}{(5.25 \text{ ft})} + 2 \right) \times \left(\frac{(3.6304 \text{ ft})}{2 \times (5.25 \text{ ft})} \right)^4 \right] \right]$ $M_{max} = 17.453 \text{ kipft}$
<p>Shear force and Bending moment (z-direction, LRFD)</p> <p>H_o - Lateral force per length of pile,</p> $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(1.197 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = 0.19061 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(2.037 \text{ kipft}) + ((1.197 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.32436 \text{ kipft/ft}$ <p>E - Distance from lateral load to resisting surface,</p> $E = \frac{M_o}{H_o}$ $E = \frac{(0.32436 \text{ kipft/ft})}{(0.19061 \text{ kip/ft})}$ $E = 1.7018 \text{ ft}$ <p>a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.32436 \text{ kipft/ft}) \times (5.25 \text{ ft})) + (3 \times (0.19061 \text{ kip/ft}) \times (5.25 \text{ ft})^2)}{(6 \times (0.32436 \text{ kipft/ft})) + (4 \times (0.19061 \text{ kip/ft}) \times (5.25 \text{ ft}))}$ $a = 3.7944 \text{ ft}$ <p>V_{max} - Max shear force located at depth a,</p> $V_{max} = (H_o b) \left[1 - \left[3 \left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{L_e} \right)^2 \right] + \left[4 \left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{L_e} \right)^3 \right] \right]$ $V_{max} = ((0.19061 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (1.7018 \text{ ft})}{(5.25 \text{ ft})} + 3 \right) \times \left(\frac{(3.7944 \text{ ft})}{(5.25 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (1.7018 \text{ ft})}{(5.25 \text{ ft})} + 2 \right) \times \left(\frac{(3.7944 \text{ ft})}{(5.25 \text{ ft})} \right)^3 \right] \right]$ $V_{max} = 0.94869 \text{ kip}$ <p>M_{max} - Max bending moment located at depth $a/2$,</p> $M_{max} = (H_o b L_e) \left[\left(\frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[\left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{2 L_e} \right)^3 \right] + \left[\left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{2 L_e} \right)^4 \right] \right]$ $M_{max} = ((0.19061 \text{ kip/ft}) \times (48 \text{ in}) \times (5.25 \text{ ft})) \times \left[\left(\frac{(1.7018 \text{ ft})}{(5.25 \text{ ft})} + \frac{(3.7944 \text{ ft})}{2 \times (5.25 \text{ ft})} \right) - \left[\left(\frac{4 \times (1.7018 \text{ ft})}{(5.25 \text{ ft})} + 3 \right) \times \left(\frac{(3.7944 \text{ ft})}{2 \times (5.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (1.7018 \text{ ft})}{(5.25 \text{ ft})} + 2 \right) \times \left(\frac{(3.7944 \text{ ft})}{2 \times (5.25 \text{ ft})} \right)^4 \right] \right]$

	$M_{max} = 2.1352 \text{ kipft}$	
	<p>Minimum Reinforcement Check (LRFD)</p> <p>Parameters:</p> <p>$f'_{ck} = 3 \text{ ksi}$ - 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,</p> <p>Longitudinal reinforcement:</p> <p>Required reinforcement due to axial load, $A_{st,required}$</p> $A_{st,required} = Min \left[\frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = Min \left[\frac{\frac{(7.498 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (3 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -102.02 \text{ in}^2$ <p>A_{min} - Governing minimum reinforcement area,</p> $A_{min} = Max [A_{st,required}, (0.0018 A_g)]$ $A_{min} = Max [(-102.02 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ <p>n_{rebar} - Required number of reinforcement,</p> $n_{rebar} = \frac{A_{min}}{A_{rebar}}$ $n_{rebar} = \frac{(4.1472 \text{ in}^2)}{(0.3068 \text{ in}^2)}$ $n_{rebar} = 14$ <p>A_{st} - Actual total reinforcement area,</p> $A_{st} = n_{rebar} \frac{\pi d_{bar}^2}{4}$ $A_{st} = (14) \times \frac{\pi \times (0.625 \text{ in})^2}{4}$ $A_{st} = 4.2951 \text{ in}^2$ <p>Ratio - Capacity</p> $Ratio = \frac{A_{min}}{A_{st}}$ $Ratio = \frac{(4.1472 \text{ in}^2)}{(4.2951 \text{ in}^2)}$ $Ratio = 0.96556$	
25.2.3	<p>s_{rebar} - 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>Ties:</p> <p>Since longitudinal reinforcement is \leq No. 10ø: Use #3(0.375 in)</p> <p>s_{ties} - 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>Summary:</p> <p>Main reinforcement: 14 - #5 (0.625 in)</p>	Status: PASS Ratio: 0.970
25.7.2.2		
25.7.2.1		

	Ties: #3(0.375 in) - 10 in	
22.4.2.2	<p>Axial Compression Strength (ACI 318-19, LRFD)</p> <p>ϕP_N - Allowable axial compressive strength</p> $\phi P_N = \phi \cdot 0.80 \left[(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st}) \right]$ $\phi P_N = (0.65) \times 0.80 \times [(0.85 \times (3 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2))]$ $\phi P_N = 3183.4 \text{ kip}$ <p><i>Ratio</i> - Capacity</p> $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(7.498 \text{ kip})}{(3183.4 \text{ kip})}$ $Ratio = 0.0023553$	Status: PASS Ratio: 0.000
22.5.2.2	<p>Shear Strength (ACI 318-19, LRFD)</p> <p>Parameters:</p> <p>$b_w = 48 \text{ in}$ - Effective width, d - Effective depth</p> $d = 0.80 D$ $d = 0.80 \times (48 \text{ in})$ $d = 38.4 \text{ in}$ <p>λ_s - size effect modification factor</p> $\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.64282$ <p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$,</p> <p>$V_{c,max}$ - Max shear strength of concrete</p> $V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$ $V_{c,max} = 5 \times (0.64282) \times \sqrt{(3000 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,max} = 324.49 \text{ kip}$ <p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$, $P = 7.498 \text{ kip} \rightarrow 7498 \text{ lbf}$,</p> <p>$V_{c,a}$ - Shear strength of concrete (a)</p> $V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + \frac{(7498 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 130.79 \text{ kip}$ <p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$,</p> <p>$V_{c,b}$ - Shear strength of concrete (b)</p> $V_{c,b} = \left[2 \lambda_s \sqrt{f'_{ck}} + (0.05 f'_{ck}) \right] b_w d$ $V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + (0.05 \times (3000 \text{ psi})) \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,b} = 406.27 \text{ kip}$ <p>V_c - Governing shear strength of concrete</p> $V_c = Min [V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = Min [(324.49 \text{ kip}), (130.79 \text{ kip}), (406.27 \text{ kip})]$ $V_c = 130.79 \text{ kip}$	
22.5.5.1.1		
22.5.5.1.1(a)		
22.5.5.1.2		

22.5.1.2	<p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$,</p> <p>$V_{s,a}$ - Shear strength of steel (a)</p> $V_{s,a} = 8 \sqrt{f'_{ck} b_w d}$ $V_{s,a} = 8 \times \sqrt{(3000 \text{ psi}) \times (48 \text{ in}) \times (38.4 \text{ in})}$ $V_{s,a} = 807.65 \text{ kip}$ <p>A_v - Ties rebar area,</p> $A_v = \frac{\pi d_{ties}^2}{4}$ $A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$ $A_v = 0.11045 \text{ in}^2$	
22.5.8.5.3	<p>$V_{s,b}$ - Shear strength of steel (b)</p> $V_{s,b} = \frac{2 A_v f_{yw} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$ <p>V_s - Governing shear strength of steel</p> $V_s = MIN[V_{s,a}, V_{s,b}]$	
22.5.1.1	<p>ϕV_n - Allowable shear strength</p> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((130.79 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 118.1 \text{ kip}$ <p>Considering x-direction:</p> <p>$V_{max} = 7.0192 \text{ kip}$ - Maximum shear force in the x-direction, $Ratio$ - Capacity</p>	$Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(7.0192 \text{ kip})}{(118.1 \text{ kip})}$ $Ratio = 0.059436$
	<p>Considering z-direction:</p> <p>$V_{max} = 0.94869 \text{ kip}$ - Maximum shear force in the z-direction, $Ratio$ - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.94869 \text{ kip})}{(118.1 \text{ kip})}$ $Ratio = 0.0080331$	Status: PASS Ratio: 0.060
	<p>Flexural Strength (ACI 318-19, LRFD)</p> <p>S_m - Section modulus</p> $S_m = \frac{b D^2}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$	

	<p>$\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$</p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f'_c) \times S_m}$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(3ksi) \times 18432.001in^3}$ $\phi M_{n,1} = 273.423kipft$ <p>14.5.2.1b $\phi M_{n,2}$</p> $\phi M_{n,2} = \phi 0.85 f'_{ck} S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (3 \text{ ksi}) \times (18432 \text{ in}^3)$ $\phi M_{n,2} = 2545.9 \text{ kipft}$ <p>Therefore, ϕM_n - Allowable flexural strength,</p> $\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = MIN[(273.42 \text{ kipft}), (2545.9 \text{ kipft})]$ $\phi M_n = 273.42 \text{ kipft}$ <p>Considering x-direction:</p> <p>$M_{max} = 17.453 \text{ kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(17.453 \text{ kipft})}{(273.42 \text{ kipft})}$ $Ratio = 0.063831$	Status: PASS Ratio: 0.060
	<p>Considering z-direction:</p> <p>$M_{max} = 2.1352 \text{ kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(2.1352 \text{ kipft})}{(273.42 \text{ kipft})}$ $Ratio = 0.0078092$	Status: PASS Ratio: 0.010

REFERENCES	CALCULATIONS	RESULTS																										
	<p>SkyCiv Foundation Design</p> <p>Pile Foundation</p> <p>Design Information :</p> <p>Design code : IBC 2021 (International Building Code) Unit System : Imperial</p>																											
	<p>Pile Input</p> <p>Geometry</p> <p>Pile shape: rectangular $b = 48 \text{ in}$ - Pile width $D = 48 \text{ in}$ - Pile depth $L = 5.25 \text{ ft}$ - Total pile length $h_1 = 0 \text{ ft}$ - Lateral load height from the top of the pile, $h_2 = 0 \text{ ft}$ - Depth to resisting surface $h_e = 0 \text{ ft}$ - Length of pile above the ground</p> <p>Tabulation of Soil Parameters</p> <table border="1"> <thead> <tr> <th>Layer</th> <th>Label</th> <th>Allowable Bearing Pressure (q_a) (psf)</th> <th>Allowable Lateral Pressure (R) (psf/ft)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Sand, silty sand, clayey sand, silty gravel & clayey gravel</td> <td>2000.000</td> <td>150.000</td> </tr> </tbody> </table> <p>Tabulation of Loads</p> <table border="1"> <thead> <tr> <th>Load Component</th> <th>ASD</th> <th>LRFD</th> </tr> </thead> <tbody> <tr> <td>P (kip)</td> <td>5.021</td> <td>7.498</td> </tr> <tr> <td>V_x (kip)</td> <td>-1.899</td> <td>-3.207</td> </tr> <tr> <td>V_z (kip)</td> <td>-0.739</td> <td>-1.197</td> </tr> <tr> <td>M_x (kipft)</td> <td>-1.275</td> <td>-2.038</td> </tr> <tr> <td>M_z (kipft)</td> <td>15.659</td> <td>26.422</td> </tr> </tbody> </table> <p>Material Properties</p> <p>$f'_{ck} = 3 \text{ ksi}$ - Concrete strength,</p> <p>Required depth to resist lateral loads (ASD)</p> <p>H - Point of application of the lateral load</p> $H = h_1 + h_2 + h_e$ $H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})$ $H = 0 \text{ ft}$ <p>Considering x-direction:</p> <p>H_o - Lateral force per length of pile,</p> $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-1.899 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.30239 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$	Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) (psf/ft)	1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000	Load Component	ASD	LRFD	P (kip)	5.021	7.498	V_x (kip)	-1.899	-3.207	V_z (kip)	-0.739	-1.197	M_x (kipft)	-1.275	-2.038	M_z (kipft)	15.659	26.422	
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$$M_o = \frac{(15.659 \text{ kipft}) + ((-1.899 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 2.4935 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$L_{e,x} = 4.8205 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.739 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.11768 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(1.275 \text{ kipft}) + ((-0.739 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.20303 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$L_{e,z} = 1.6565 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(4.8205 \text{ ft}), (1.6565 \text{ ft})]$$

$$L_{e,req} = 4.821 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (5.25 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$$

$$L_e = 5.25 \text{ ft}$$

Ratio - Embedded depth

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

$$Ratio = \frac{(4.821 \text{ ft})}{(5.25 \text{ ft})}$$

$$Ratio = 0.91829$$

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

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = b D$$

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

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

q - End-bearing pressure

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

$$q = \frac{(5.021 \text{ kip})}{(16 \text{ ft}^2)}$$

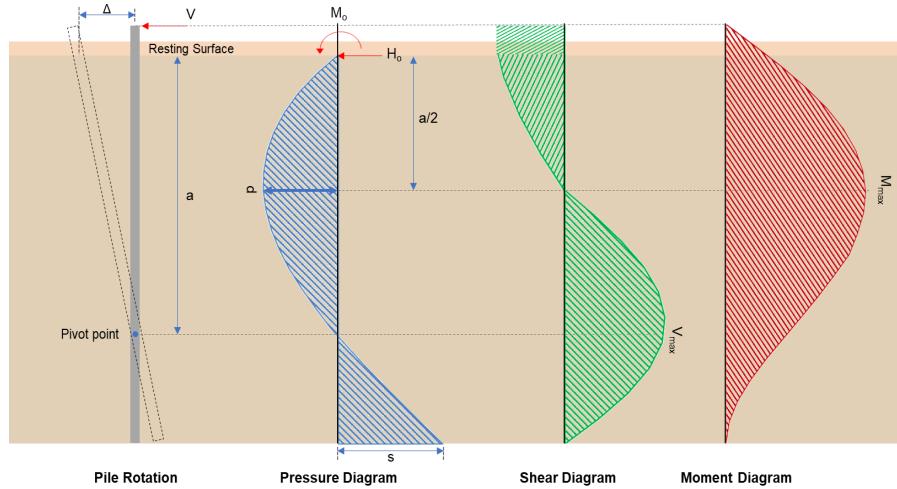
	$q = 0.31381 \text{ kip/ft}^2$	
	<p>Check bearing capacity ratio:</p> <p><i>Ratio - Capacity</i></p> $Ratio = \frac{q}{q_a}$ $Ratio = \frac{(0.31381 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $Ratio = 0.15691$	Status: PASS Ratio: 0.160
Czerniak	<p>Lateral Soil Pressure (ASD):</p> <p><i>L/D</i> - Length to least lateral dimension ratio,</p> $L/D = \frac{L}{D}$ $L/D = \frac{(5.25 \text{ ft})}{(48 \text{ in})}$ $L/D = 1.3125$ <p>Since $L/D \leq 10$,</p> <p style="text-align: center;">Pile is short.</p> <p>Considering x-direction:</p> <p>$H_o = -0.30239 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 2.4935 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (2.4935 \text{ kipft/ft}) \times (5.25 \text{ ft})) + (3 \times (-0.30239 \text{ kip/ft}) \times (5.25 \text{ ft})^2)}{(6 \times (2.4935 \text{ kipft/ft})) + (4 \times (-0.30239 \text{ kip/ft}) \times (5.25 \text{ ft}))}$ $a = 3.6304 \text{ ft}$ <p><i>p</i> - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (2.4935 \text{ kipft/ft})) + (3 \times (-0.30239 \text{ kip/ft}) \times (5.25 \text{ ft}))]^2}{(5.25 \text{ ft})^2 \times [(3 \times (2.4935 \text{ kipft/ft})) + (2 \times (-0.30239 \text{ kip/ft}) \times (5.25 \text{ ft}))]}$ $p = 0.17164 \text{ kip/ft}^2$ <p><i>s</i> - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (2.4935 \text{ kipft/ft})) + ((-0.30239 \text{ kip/ft}) \times (5.25 \text{ ft}))]}{(5.25 \text{ ft})^2}$ $s = 0.74001 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p><i>p_a</i> - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(3.6304 \text{ ft})}{2}$ $p_a = 0.27228 \text{ kip/ft}^2$ <p><i>Ratio</i> - Lateral soil capacity</p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.17164 \text{ kip/ft}^2)}{(0.27228 \text{ kip/ft}^2)}$ $Ratio = 0.63039$ <p><i>p_s</i> - Allowable lateral soil pressure at depth L_e,</p>	Status: PASS Ratio: 0.630

	$p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (5.25 \text{ ft})$ $p_s = 0.7875 \text{ kip/ft}^2$ <i>Ratio - Lateral soil capacity</i> $Ratio = \frac{s}{p_s}$ $Ratio = \frac{(0.74001 \text{ kip/ft}^2)}{(0.7875 \text{ kip/ft}^2)}$ $Ratio = 0.9397$ Status: PASS Ratio: 0.940	
	<p>Considering z-direction:</p> <p>$H_o = -0.11768 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 0.20303 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.20303 \text{ kipft/ft}) \times (5.25 \text{ ft})) + (3 \times (-0.11768 \text{ kip/ft}) \times (5.25 \text{ ft})^2)}{(6 \times (0.20303 \text{ kipft/ft})) + (4 \times (-0.11768 \text{ kip/ft}) \times (5.25 \text{ ft}))}$ $a = 3.793 \text{ ft}$ <p>p - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.20303 \text{ kipft/ft})) + (3 \times (-0.11768 \text{ kip/ft}) \times (5.25 \text{ ft}))]^2}{(5.25 \text{ ft})^2 \times [(3 \times (0.20303 \text{ kipft/ft})) + (2 \times (-0.11768 \text{ kip/ft}) \times (5.25 \text{ ft}))]}$ $p = -0.047092 \text{ kip/ft}^2$ <p>s - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.20303 \text{ kipft/ft})) + ((-0.11768 \text{ kip/ft}) \times (5.25 \text{ ft}))]}{(5.25 \text{ ft})^2}$ $s = -0.046094 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p>p_a - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(3.793 \text{ ft})}{2}$ $p_a = 0.28448 \text{ kip/ft}^2$ <p><i>Ratio - Lateral soil capacity</i></p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(-0.047092 \text{ kip/ft}^2)}{(0.28448 \text{ kip/ft}^2)}$ $Ratio = -0.16554$ Status: PASS Ratio: -0.170	

$$Ratio = \frac{(-0.046094 \text{ kip}/\text{ft}^2)}{(0.7875 \text{ kip}/\text{ft}^2)}$$

$$Ratio = -0.058532$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-3.207 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.51067 \text{ kip}/\text{ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(26.422 \text{ kipft}) + ((-3.207 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 4.2073 \text{ kipft}/\text{ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(4.2073 \text{ kipft}/\text{ft})}{(-0.51067 \text{ kip}/\text{ft})}$$

$$E = 8.2389 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (4.2073 \text{ kipft}/\text{ft}) \times (5.25 \text{ ft})) + (3 \times (-0.51067 \text{ kip}/\text{ft}) \times (5.25 \text{ ft})^2)}{(6 \times (4.2073 \text{ kipft}/\text{ft})) + (4 \times (-0.51067 \text{ kip}/\text{ft}) \times (5.25 \text{ ft}))}$$

$$a = 3.6304 \text{ ft}$$

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

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

$$V_{max} = ((-0.51067 \text{ kip}/\text{ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (8.2389 \text{ ft})}{(5.25 \text{ ft})} + 3 \right) \times \left(\frac{(3.6304 \text{ ft})}{(5.25 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (8.2389 \text{ ft})}{(5.25 \text{ ft})} + 2 \right) \times \left(\frac{(3.6304 \text{ ft})}{(5.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 7.0192 \text{ kip}$$

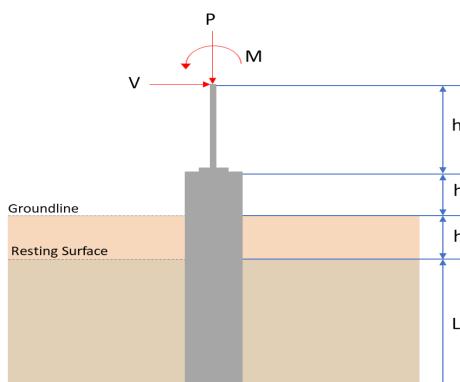
<p>M_{max} - Max bending moment located at depth $a/2$,</p> $M_{max} = (H_o D L_e) \left[\left(\frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[\left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{2 L_e} \right)^3 \right] + \left[\left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{2 L_e} \right)^4 \right] \right]$ $M_{max} = ((-0.51067 \text{ kip/ft}) \times (48 \text{ in}) \times (5.25 \text{ ft})) \times \left[\left(\frac{(8.2389 \text{ ft})}{(5.25 \text{ ft})} + \frac{(3.6304 \text{ ft})}{2 \times (5.25 \text{ ft})} \right) - \left[\left(\frac{4 \times (8.2389 \text{ ft})}{(5.25 \text{ ft})} + 3 \right) \times \left(\frac{(3.6304 \text{ ft})}{2 \times (5.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (8.2389 \text{ ft})}{(5.25 \text{ ft})} + 2 \right) \times \left(\frac{(3.6304 \text{ ft})}{2 \times (5.25 \text{ ft})} \right)^4 \right] \right]$ $M_{max} = 17.453 \text{ kipft}$
<p>Shear force and Bending moment (z-direction, LRFD)</p> <p>H_o - Lateral force per length of pile,</p> $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(-1.197 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.19061 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(2.038 \text{ kipft}) + ((-1.197 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.32452 \text{ kipft/ft}$ <p>E - Distance from lateral load to resisting surface,</p> $E = \frac{M_o}{H_o}$ $E = \frac{(0.32452 \text{ kipft/ft})}{(-0.19061 \text{ kip/ft})}$ $E = 1.7026 \text{ ft}$ <p>a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.32452 \text{ kipft/ft}) \times (5.25 \text{ ft})) + (3 \times (-0.19061 \text{ kip/ft}) \times (5.25 \text{ ft})^2)}{(6 \times (0.32452 \text{ kipft/ft})) + (4 \times (-0.19061 \text{ kip/ft}) \times (5.25 \text{ ft}))}$ $a = 3.7943 \text{ ft}$ <p>V_{max} - Max shear force located at depth a,</p> $V_{max} = (H_o b) \left[1 - \left[3 \left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{L_e} \right)^2 \right] + \left[4 \left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{L_e} \right)^3 \right] \right]$ $V_{max} = ((-0.19061 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (1.7026 \text{ ft})}{(5.25 \text{ ft})} + 3 \right) \times \left(\frac{(3.7943 \text{ ft})}{(5.25 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (1.7026 \text{ ft})}{(5.25 \text{ ft})} + 2 \right) \times \left(\frac{(3.7943 \text{ ft})}{(5.25 \text{ ft})} \right)^3 \right] \right]$ $V_{max} = 0.9489 \text{ kip}$ <p>M_{max} - Max bending moment located at depth $a/2$,</p> $M_{max} = (H_o b L_e) \left[\left(\frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[\left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{2 L_e} \right)^3 \right] + \left[\left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{2 L_e} \right)^4 \right] \right]$ $M_{max} = ((-0.19061 \text{ kip/ft}) \times (48 \text{ in}) \times (5.25 \text{ ft})) \times \left[\left(\frac{(1.7026 \text{ ft})}{(5.25 \text{ ft})} + \frac{(3.7943 \text{ ft})}{2 \times (5.25 \text{ ft})} \right) - \left[\left(\frac{4 \times (1.7026 \text{ ft})}{(5.25 \text{ ft})} + 3 \right) \times \left(\frac{(3.7943 \text{ ft})}{2 \times (5.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (1.7026 \text{ ft})}{(5.25 \text{ ft})} + 2 \right) \times \left(\frac{(3.7943 \text{ ft})}{2 \times (5.25 \text{ ft})} \right)^4 \right] \right]$
<p>SkyCiv AutoDesigner Report - J BAR L Big House</p> <p>Page 36 of 60</p>

	$M_{max} = 2.1358 \text{ kipft}$	
	<p>Minimum Reinforcement Check (LRFD)</p> <p>Parameters:</p> <p>$f'_{ck} = 3 \text{ ksi}$ - 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,</p> <p>Longitudinal reinforcement:</p> <p>Required reinforcement due to axial load, $A_{st,required}$</p>	
Table 22.4.2.1 22.4.2.2, 10.6.1.1	$A_{st,required} = Min \left[\frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = Min \left[\frac{\frac{(7.498 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (3 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -102.02 \text{ in}^2$ <p>A_{min} - Governing minimum reinforcement area,</p> $A_{min} = Max [A_{st,required}, (0.0018 A_g)]$ $A_{min} = Max [(-102.02 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ <p>n_{rebar} - Required number of reinforcement,</p> $n_{rebar} = \frac{A_{min}}{A_{rebar}}$ $n_{rebar} = \frac{(4.1472 \text{ in}^2)}{(0.3068 \text{ in}^2)}$ $n_{rebar} = 14$ <p>A_{st} - Actual total reinforcement area,</p> $A_{st} = n_{rebar} \frac{\pi d_{bar}^2}{4}$ $A_{st} = (14) \times \frac{\pi \times (0.625 \text{ in})^2}{4}$ $A_{st} = 4.2951 \text{ in}^2$ <p>Ratio - Capacity</p> $Ratio = \frac{A_{min}}{A_{st}}$ $Ratio = \frac{(4.1472 \text{ in}^2)}{(4.2951 \text{ in}^2)}$ $Ratio = 0.96556$	
25.2.3 25.7.2.2 25.7.2.1	<p>s_{rebar} - 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>Ties:</p> <p>Since longitudinal reinforcement is \leq No. 10ø: Use #3(0.375 in)</p> <p>s_{ties} - 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>Summary:</p> <p>Main reinforcement: 14 - #5 (0.625 in)</p>	Status: PASS Ratio: 0.970

	Ties: #3(0.375 in) - 10 in	
22.4.2.2	<p>Axial Compression Strength (ACI 318-19, LRFD)</p> <p>ϕP_N - Allowable axial compressive strength</p> $\phi P_N = \phi \cdot 0.80 \left[(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st}) \right]$ $\phi P_N = (0.65) \times 0.80 \times [(0.85 \times (3 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2))]$ $\phi P_N = 3183.4 \text{ kip}$ <p><i>Ratio</i> - Capacity</p> $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(7.498 \text{ kip})}{(3183.4 \text{ kip})}$ $Ratio = 0.0023553$	Status: PASS Ratio: 0.000
22.5.2.2	<p>Shear Strength (ACI 318-19, LRFD)</p> <p>Parameters:</p> <p>$b_w = 48 \text{ in}$ - Effective width, d - Effective depth</p> $d = 0.80 D$ $d = 0.80 \times (48 \text{ in})$ $d = 38.4 \text{ in}$ <p>λ_s - size effect modification factor</p> $\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.64282$ <p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$,</p> <p>$V_{c,max}$ - Max shear strength of concrete</p> $V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$ $V_{c,max} = 5 \times (0.64282) \times \sqrt{(3000 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,max} = 324.49 \text{ kip}$ <p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$, $P = 7.498 \text{ kip} \rightarrow 7498 \text{ lbf}$,</p> <p>$V_{c,a}$ - Shear strength of concrete (a)</p> $V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + \frac{(7498 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 130.79 \text{ kip}$ <p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$,</p> <p>$V_{c,b}$ - Shear strength of concrete (b)</p> $V_{c,b} = \left[2 \lambda_s \sqrt{f'_{ck}} + (0.05 f'_{ck}) \right] b_w d$ $V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + (0.05 \times (3000 \text{ psi})) \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,b} = 406.27 \text{ kip}$ <p>V_c - Governing shear strength of concrete</p> $V_c = Min [V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = Min [(324.49 \text{ kip}), (130.79 \text{ kip}), (406.27 \text{ kip})]$ $V_c = 130.79 \text{ kip}$	
22.5.5.1.1		
22.5.5.1.1(a)		
22.5.5.1.2		

22.5.1.2	<p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$,</p> <p>$V_{s,a}$ - Shear strength of steel (a)</p> $V_{s,a} = 8 \sqrt{f'_{ck} b_w d}$ $V_{s,a} = 8 \times \sqrt{(3000 \text{ psi}) \times (48 \text{ in}) \times (38.4 \text{ in})}$ $V_{s,a} = 807.65 \text{ kip}$ <p>A_v - Ties rebar area,</p> $A_v = \frac{\pi d_{ties}^2}{4}$ $A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$ $A_v = 0.11045 \text{ in}^2$	
22.5.8.5.3	<p>$V_{s,b}$ - Shear strength of steel (b)</p> $V_{s,b} = \frac{2 A_v f_{yw} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$ <p>V_s - Governing shear strength of steel</p> $V_s = MIN[V_{s,a}, V_{s,b}]$ $V_s = MIN[(807.65 \text{ kip}), (50.894 \text{ kip})]$ $V_s = 50.894 \text{ kip}$	
22.5.1.1	<p>ϕV_n - Allowable shear strength</p> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((130.79 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 118.1 \text{ kip}$	
	<p>Considering x-direction:</p> <p>$V_{max} = 7.0192 \text{ kip}$ - Maximum shear force in the x-direction, $Ratio$ - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(7.0192 \text{ kip})}{(118.1 \text{ kip})}$ $Ratio = 0.059436$	Status: PASS Ratio: 0.060
	<p>Considering z-direction:</p> <p>$V_{max} = 0.9489 \text{ kip}$ - Maximum shear force in the z-direction, $Ratio$ - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.9489 \text{ kip})}{(118.1 \text{ kip})}$ $Ratio = 0.0080349$	Status: PASS Ratio: 0.010
	<p>Flexural Strength (ACI 318-19, LRFD)</p> <p>S_m - Section modulus</p> $S_m = \frac{b D^2}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$	

	<p>$\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$</p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f'_c) \times S_m}$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(3ksi) \times 18432.001in^3}$ $\phi M_{n,1} = 273.423kipft$ <p>14.5.2.1b $\phi M_{n,2}$</p> $\phi M_{n,2} = \phi 0.85 f'_{ck} S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (3 \text{ ksi}) \times (18432 \text{ in}^3)$ $\phi M_{n,2} = 2545.9 \text{ kipft}$ <p>Therefore, ϕM_n - Allowable flexural strength,</p> $\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = MIN[(273.42 \text{ kipft}), (2545.9 \text{ kipft})]$ $\phi M_n = 273.42 \text{ kipft}$ <p>Considering x-direction:</p> <p>$M_{max} = 17.453 \text{ kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(17.453 \text{ kipft})}{(273.42 \text{ kipft})}$ $Ratio = 0.063831$	Status: PASS Ratio: 0.060
	<p>Considering z-direction:</p> <p>$M_{max} = 2.1358 \text{ kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(2.1358 \text{ kipft})}{(273.42 \text{ kipft})}$ $Ratio = 0.0078113$	Status: PASS Ratio: 0.010

REFERENCES	CALCULATIONS	RESULTS																										
	<p>SkyCiv Foundation Design</p> <p>Pile Foundation</p> <p>Design Information :</p> <p>Design code : IBC 2021 (International Building Code) Unit System : Imperial</p>																											
	<p>Pile Input</p>  <p>Geometry</p> <p>Pile shape: rectangular $b = 48 \text{ in}$ - Pile width $D = 48 \text{ in}$ - Pile depth $L = 5.75 \text{ ft}$ - Total pile length $h_1 = 0 \text{ ft}$ - Lateral load height from the top of the pile, $h_2 = 0 \text{ ft}$ - Depth to resisting surface $h_e = 0 \text{ ft}$ - Length of pile above the ground</p> <p>Tabulation of Soil Parameters</p> <table border="1"> <thead> <tr> <th>Layer</th> <th>Label</th> <th>Allowable Bearing Pressure (q_a) (psf)</th> <th>Allowable Lateral Pressure (R) (psf/ft)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Sand, silty sand, clayey sand, silty gravel & clayey gravel</td> <td>2000.000</td> <td>150.000</td> </tr> </tbody> </table> <p>Tabulation of Loads</p> <table border="1"> <thead> <tr> <th>Load Component</th> <th>ASD</th> <th>LRFD</th> </tr> </thead> <tbody> <tr> <td>P (kip)</td> <td>7.622</td> <td>11.520</td> </tr> <tr> <td>V_x (kip)</td> <td>-3.031</td> <td>-5.060</td> </tr> <tr> <td>V_z (kip)</td> <td>-0.093</td> <td>-0.142</td> </tr> <tr> <td>M_x (kipft)</td> <td>-0.171</td> <td>-0.261</td> </tr> <tr> <td>M_z (kipft)</td> <td>22.316</td> <td>37.495</td> </tr> </tbody> </table> <p>Material Properties</p> <p>$f'_{ck} = 3 \text{ ksi}$ - Concrete strength,</p> <p>Required depth to resist lateral loads (ASD)</p> <p>H - Point of application of the lateral load</p> $H = h_1 + h_2 + h_e$ $H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})$ $H = 0 \text{ ft}$ <p>Considering x-direction:</p> <p>H_o - Lateral force per length of pile,</p> $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-3.031 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.48264 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$	Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) (psf/ft)	1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000	Load Component	ASD	LRFD	P (kip)	7.622	11.520	V_x (kip)	-3.031	-5.060	V_z (kip)	-0.093	-0.142	M_x (kipft)	-0.171	-0.261	M_z (kipft)	22.316	37.495	
Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) (psf/ft)																									
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M_z (kipft)	22.316	37.495																										

$$M_o = \frac{(22.316 \text{ kipft}) + ((-3.031 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 3.5535 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$L_{e,x} = 5.1366 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.093 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.014809 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.171 \text{ kipft}) + ((-0.093 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.027229 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$L_{e,z} = 1.0706 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(5.1366 \text{ ft}), (1.0706 \text{ ft})]$$

$$L_{e,req} = 5.137 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (5.75 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$$

$$L_e = 5.75 \text{ ft}$$

Ratio - Embedded depth

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

$$Ratio = \frac{(5.137 \text{ ft})}{(5.75 \text{ ft})}$$

$$Ratio = 0.89339$$

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

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = b D$$

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

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

q - End-bearing pressure

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

$$q = \frac{(7.622 \text{ kip})}{(16 \text{ ft}^2)}$$

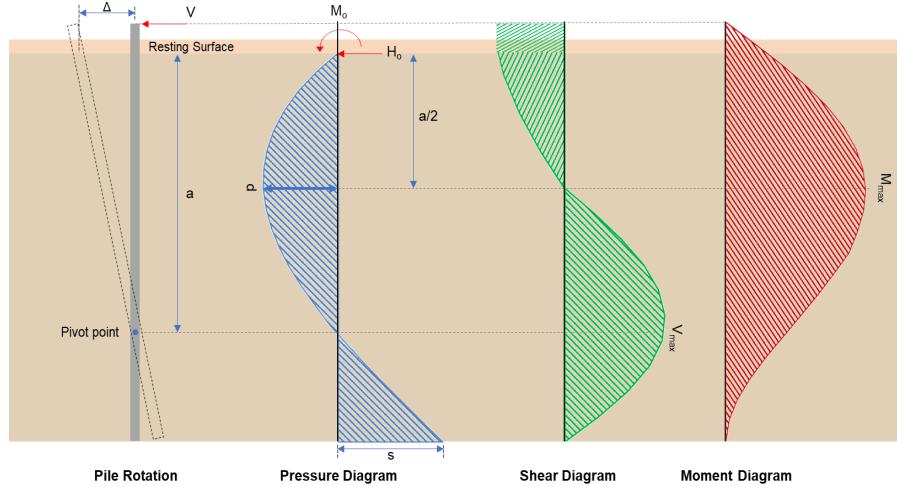
	$q = 0.47638 \text{ kip/ft}^2$	
	<p>Check bearing capacity ratio:</p> <p>Ratio - Capacity</p> $\text{Ratio} = \frac{q}{q_a}$ $\text{Ratio} = \frac{(0.47638 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $\text{Ratio} = 0.23819$	Status: PASS Ratio: 0.240
Czerniak	<p>Lateral Soil Pressure (ASD):</p> <p>L/D - Length to least lateral dimension ratio,</p> $L/D = \frac{L}{D}$ $L/D = \frac{(5.75 \text{ ft})}{(48 \text{ in})}$ $L/D = 1.4375$ <p>Since $L/D \leq 10$,</p> <p>Pile is short.</p> <p>Considering x-direction:</p> <p>$H_o = -0.48264 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 3.5535 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (3.5535 \text{ kipft/ft}) \times (5.75 \text{ ft})) + (3 \times (-0.48264 \text{ kip/ft}) \times (5.75 \text{ ft})^2)}{(6 \times (3.5535 \text{ kipft/ft})) + (4 \times (-0.48264 \text{ kip/ft}) \times (5.75 \text{ ft}))}$ $a = 3.9974 \text{ ft}$ <p>p - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (3.5535 \text{ kipft/ft})) + (3 \times (-0.48264 \text{ kip/ft}) \times (5.75 \text{ ft}))]^2}{(5.75 \text{ ft})^2 \times [(3 \times (3.5535 \text{ kipft/ft})) + (2 \times (-0.48264 \text{ kip/ft}) \times (5.75 \text{ ft}))]}$ $p = 0.15392 \text{ kip/ft}^2$ <p>s - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (3.5535 \text{ kipft/ft})) + ((-0.48264 \text{ kip/ft}) \times (5.75 \text{ ft}))]}{(5.75 \text{ ft})^2}$ $s = 0.78611 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p>p_a - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(3.9974 \text{ ft})}{2}$ $p_a = 0.2998 \text{ kip/ft}^2$ <p>$Ratio$ - Lateral soil capacity</p> $\text{Ratio} = \frac{p}{p_a}$ $\text{Ratio} = \frac{(0.15392 \text{ kip/ft}^2)}{(0.2998 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.5134$ <p>p_s - Allowable lateral soil pressure at depth L_e,</p>	Status: PASS Ratio: 0.510

	$p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (5.75 \text{ ft})$ $p_s = 0.8625 \text{ kip/ft}^2$ <i>Ratio - Lateral soil capacity</i> $Ratio = \frac{s}{p_s}$ $Ratio = \frac{(0.78611 \text{ kip/ft}^2)}{(0.8625 \text{ kip/ft}^2)}$ $Ratio = 0.91143$	Status: PASS Ratio: 0.910
	<p>Considering z-direction:</p> <p>$H_o = -0.014809 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 0.027229 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.027229 \text{ kipft/ft}) \times (5.75 \text{ ft})) + (3 \times (-0.014809 \text{ kip/ft}) \times (5.75 \text{ ft})^2)}{(6 \times (0.027229 \text{ kipft/ft})) + (4 \times (-0.014809 \text{ kip/ft}) \times (5.75 \text{ ft}))}$ $a = 4.1572 \text{ ft}$ <p>p - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.027229 \text{ kipft/ft})) + (3 \times (-0.014809 \text{ kip/ft}) \times (5.75 \text{ ft}))]^2}{(5.75 \text{ ft})^2 \times [(3 \times (0.027229 \text{ kipft/ft})) + (2 \times (-0.014809 \text{ kip/ft}) \times (5.75 \text{ ft}))]}$ $p = -0.0054968 \text{ kip/ft}^2$ <p>s - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.027229 \text{ kipft/ft})) + ((-0.014809 \text{ kip/ft}) \times (5.75 \text{ ft}))]}{(5.75 \text{ ft})^2}$ $s = -0.0055699 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p>p_a - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.1572 \text{ ft})}{2}$ $p_a = 0.31179 \text{ kip/ft}^2$ <p><i>Ratio - Lateral soil capacity</i></p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(-0.0054968 \text{ kip/ft}^2)}{(0.31179 \text{ kip/ft}^2)}$ $Ratio = -0.01763$	Status: PASS Ratio: -0.020

$$Ratio = \frac{(-0.0055699 \text{ kip}/\text{ft}^2)}{(0.8625 \text{ kip}/\text{ft}^2)}$$

$$Ratio = -0.0064579$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-5.06 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.80573 \text{ kip}/\text{ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(37.495 \text{ kipft}) + ((-5.06 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 5.9705 \text{ kipft}/\text{ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(5.9705 \text{ kipft}/\text{ft})}{(-0.80573 \text{ kip}/\text{ft})}$$

$$E = 7.4101 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.9705 \text{ kipft}/\text{ft}) \times (5.75 \text{ ft})) + (3 \times (-0.80573 \text{ kip}/\text{ft}) \times (5.75 \text{ ft})^2)}{(6 \times (5.9705 \text{ kipft}/\text{ft})) + (4 \times (-0.80573 \text{ kip}/\text{ft}) \times (5.75 \text{ ft}))}$$

$$a = 3.9967 \text{ ft}$$

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

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

$$V_{max} = ((-0.80573 \text{ kip}/\text{ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (7.4101 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(3.9967 \text{ ft})}{(5.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (7.4101 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(3.9967 \text{ ft})}{(5.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 9.475 \text{ kip}$$

<p>M_{max} - Max bending moment located at depth $a/2$,</p> $M_{max} = (H_o D L_e) \left[\left(\frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[\left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{2 L_e} \right)^3 \right] + \left[\left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{2 L_e} \right)^4 \right] \right]$ $M_{max} = ((-0.80573 \text{ kip/ft}) \times (48 \text{ in}) \times (5.75 \text{ ft})) \times \left[\left(\frac{(7.4101 \text{ ft})}{(5.75 \text{ ft})} + \frac{(3.9967 \text{ ft})}{2 \times (5.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (7.4101 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(3.9967 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (7.4101 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(3.9967 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^4 \right] \right]$ $M_{max} = 25.565 \text{ kipft}$
<p>Shear force and Bending moment (z-direction, LRFD)</p> <p>H_o - Lateral force per length of pile,</p> $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(-0.142 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.022611 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(0.261 \text{ kipft}) + ((-0.142 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.041561 \text{ kipft/ft}$ <p>E - Distance from lateral load to resisting surface,</p> $E = \frac{M_o}{H_o}$ $E = \frac{(0.041561 \text{ kipft/ft})}{(-0.022611 \text{ kip/ft})}$ $E = 1.838 \text{ ft}$ <p>a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.041561 \text{ kipft/ft}) \times (5.75 \text{ ft})) + (3 \times (-0.022611 \text{ kip/ft}) \times (5.75 \text{ ft})^2)}{(6 \times (0.041561 \text{ kipft/ft})) + (4 \times (-0.022611 \text{ kip/ft}) \times (5.75 \text{ ft}))}$ $a = 4.1572 \text{ ft}$ <p>V_{max} - Max shear force located at depth a,</p> $V_{max} = (H_o b) \left[1 - \left[3 \left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{L_e} \right)^2 \right] + \left[4 \left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{L_e} \right)^3 \right] \right]$ $V_{max} = ((-0.022611 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (1.838 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.1572 \text{ ft})}{(5.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (1.838 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.1572 \text{ ft})}{(5.75 \text{ ft})} \right)^3 \right] \right]$ $V_{max} = 0.11184 \text{ kip}$ <p>M_{max} - Max bending moment located at depth $a/2$,</p> $M_{max} = (H_o b L_e) \left[\left(\frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[\left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{2 L_e} \right)^3 \right] + \left[\left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{2 L_e} \right)^4 \right] \right]$ $M_{max} = ((-0.022611 \text{ kip/ft}) \times (48 \text{ in}) \times (5.75 \text{ ft})) \times \left[\left(\frac{(1.838 \text{ ft})}{(5.75 \text{ ft})} + \frac{(4.1572 \text{ ft})}{2 \times (5.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (1.838 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.1572 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (1.838 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.1572 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^4 \right] \right]$

	$M_{max} = 0.27541 \text{ kipft}$	
	<p>Minimum Reinforcement Check (LRFD)</p> <p>Parameters:</p> <p>$f'_{ck} = 3 \text{ ksi}$ - 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,</p> <p>Longitudinal reinforcement:</p> <p>Required reinforcement due to axial load, $A_{st,required}$</p>	
Table 22.4.2.1 22.4.2.2, 10.6.1.1	$A_{st,required} = Min \left[\frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = Min \left[\frac{\frac{(11.52 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (3 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -101.88 \text{ in}^2$ <p>A_{min} - Governing minimum reinforcement area,</p> $A_{min} = Max [A_{st,required}, (0.0018 A_g)]$ $A_{min} = Max [(-101.88 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ <p>n_{rebar} - Required number of reinforcement,</p> $n_{rebar} = \frac{A_{min}}{A_{rebar}}$ $n_{rebar} = \frac{(4.1472 \text{ in}^2)}{(0.3068 \text{ in}^2)}$ $n_{rebar} = 14$ <p>A_{st} - Actual total reinforcement area,</p> $A_{st} = n_{rebar} \frac{\pi d_{bar}^2}{4}$ $A_{st} = (14) \times \frac{\pi \times (0.625 \text{ in})^2}{4}$ $A_{st} = 4.2951 \text{ in}^2$ <p>Ratio - Capacity</p> $Ratio = \frac{A_{min}}{A_{st}}$ $Ratio = \frac{(4.1472 \text{ in}^2)}{(4.2951 \text{ in}^2)}$ $Ratio = 0.96556$	
25.2.3 25.7.2.2 25.7.2.1	<p>s_{rebar} - 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>Ties:</p> <p>Since longitudinal reinforcement is \leq No. 10ø: Use #3(0.375 in)</p> <p>s_{ties} - 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>Summary:</p> <p>Main reinforcement: 14 - #5 (0.625 in)</p>	Status: PASS Ratio: 0.970

	Ties: #3(0.375 in) - 10 in	
22.4.2.2	<p>Axial Compression Strength (ACI 318-19, LRFD)</p> <p>ϕP_N - Allowable axial compressive strength</p> $\phi P_N = \phi \cdot 0.80 \left[(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st}) \right]$ $\phi P_N = (0.65) \times 0.80 \times [(0.85 \times (3 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2))]$ $\phi P_N = 3183.4 \text{ kip}$ <p><i>Ratio</i> - Capacity</p> $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(11.52 \text{ kip})}{(3183.4 \text{ kip})}$ $Ratio = 0.0036188$	Status: PASS Ratio: 0.000
22.5.2.2	<p>Shear Strength (ACI 318-19, LRFD)</p> <p>Parameters:</p> <p>$b_w = 48 \text{ in}$ - Effective width, d - Effective depth</p> $d = 0.80 D$ $d = 0.80 \times (48 \text{ in})$ $d = 38.4 \text{ in}$ <p>λ_s - size effect modification factor</p> $\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.64282$ <p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$,</p> <p>$V_{c,max}$ - Max shear strength of concrete</p> $V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$ $V_{c,max} = 5 \times (0.64282) \times \sqrt{(3000 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,max} = 324.49 \text{ kip}$ <p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$, $P = 11.52 \text{ kip} \rightarrow 11520 \text{ lbf}$,</p> <p>$V_{c,a}$ - Shear strength of concrete (a)</p> $V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + \frac{(11520 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 131.33 \text{ kip}$ <p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$,</p> <p>$V_{c,b}$ - Shear strength of concrete (b)</p> $V_{c,b} = \left[2 \lambda_s \sqrt{f'_{ck}} + (0.05 f'_{ck}) \right] b_w d$ $V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + (0.05 \times (3000 \text{ psi})) \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,b} = 406.27 \text{ kip}$ <p>V_c - Governing shear strength of concrete</p> $V_c = Min [V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = Min [(324.49 \text{ kip}), (131.33 \text{ kip}), (406.27 \text{ kip})]$ $V_c = 131.33 \text{ kip}$	
22.5.5.1.1		
22.5.5.1.1(a)		
22.5.5.1.2		

22.5.1.2	<p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$,</p> <p>$V_{s,a}$ - Shear strength of steel (a)</p> $V_{s,a} = 8 \sqrt{f'_{ck} b_w d}$ $V_{s,a} = 8 \times \sqrt{(3000 \text{ psi}) \times (48 \text{ in}) \times (38.4 \text{ in})}$ $V_{s,a} = 807.65 \text{ kip}$ <p>A_v - Ties rebar area,</p> $A_v = \frac{\pi d_{ties}^2}{4}$ $A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$ $A_v = 0.11045 \text{ in}^2$	
22.5.8.5.3	<p>$V_{s,b}$ - Shear strength of steel (b)</p> $V_{s,b} = \frac{2 A_v f_{yw} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$ <p>V_s - Governing shear strength of steel</p> $V_s = MIN[V_{s,a}, V_{s,b}]$ $V_s = MIN[(807.65 \text{ kip}), (50.894 \text{ kip})]$ $V_s = 50.894 \text{ kip}$	
22.5.1.1	<p>ϕV_n - Allowable shear strength</p> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((131.33 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 118.45 \text{ kip}$	
	<p>Considering x-direction:</p> <p>$V_{max} = 9.475 \text{ kip}$ - Maximum shear force in the x-direction, $Ratio$ - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(9.475 \text{ kip})}{(118.45 \text{ kip})}$ $Ratio = 0.079995$	Status: PASS Ratio: 0.080
	<p>Considering z-direction:</p> <p>$V_{max} = 0.11184 \text{ kip}$ - Maximum shear force in the z-direction, $Ratio$ - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.11184 \text{ kip})}{(118.45 \text{ kip})}$ $Ratio = 0.00094421$	Status: PASS Ratio: 0.000
	<p>Flexural Strength (ACI 318-19, LRFD)</p> <p>S_m - Section modulus</p> $S_m = \frac{b D^2}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$	

	<p>$\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$</p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f'_c) \times S_m}$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(3ksi) \times 18432.001in^3}$ $\phi M_{n,1} = 273.423kipft$ <p>14.5.2.1b $\phi M_{n,2}$</p> $\phi M_{n,2} = \phi \cdot 0.85 f'_{ck} S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (3 \text{ ksi}) \times (18432 \text{ in}^3)$ $\phi M_{n,2} = 2545.9 \text{ kipft}$ <p>Therefore, ϕM_n - Allowable flexural strength,</p> $\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = MIN[(273.42 \text{ kipft}), (2545.9 \text{ kipft})]$ $\phi M_n = 273.42 \text{ kipft}$ <p>Considering x-direction:</p> <p>$M_{max} = 25.565 \text{ kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(25.565 \text{ kipft})}{(273.42 \text{ kipft})}$ $Ratio = 0.0935$	Status: PASS Ratio: 0.090
	<p>Considering z-direction:</p> <p>$M_{max} = 0.27541 \text{ kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(0.27541 \text{ kipft})}{(273.42 \text{ kipft})}$ $Ratio = 0.0010072$	Status: PASS Ratio: 0.000

REFERENCES	CALCULATIONS	RESULTS																										
	<p>SkyCiv Foundation Design Pile Foundation</p> <p>Design Information : Design code : IBC 2021 (International Building Code) Unit System : Imperial</p>																											
	<p>Pile Input</p> <p>Geometry</p> <p>Pile shape: rectangular $b = 48 \text{ in}$ - Pile width $D = 48 \text{ in}$ - Pile depth $L = 5.75 \text{ ft}$ - Total pile length $h_1 = 0 \text{ ft}$ - Lateral load height from the top of the pile, $h_2 = 0 \text{ ft}$ - Depth to resisting surface $h_e = 0 \text{ ft}$ - Length of pile above the ground</p> <p>Tabulation of Soil Parameters</p> <table border="1"> <thead> <tr> <th>Layer</th> <th>Label</th> <th>Allowable Bearing Pressure (q_a) (psf)</th> <th>Allowable Lateral Pressure (R) (psf/ft)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Sand, silty sand, clayey sand, silty gravel & clayey gravel</td> <td>2000.000</td> <td>150.000</td> </tr> </tbody> </table> <p>Tabulation of Loads</p> <table border="1"> <thead> <tr> <th>Load Component</th> <th>ASD</th> <th>LRFD</th> </tr> </thead> <tbody> <tr> <td>P (kip)</td> <td>7.622</td> <td>11.520</td> </tr> <tr> <td>V_x (kip)</td> <td>-3.031</td> <td>-5.060</td> </tr> <tr> <td>V_z (kip)</td> <td>0.094</td> <td>0.142</td> </tr> <tr> <td>M_x (kipft)</td> <td>0.170</td> <td>0.259</td> </tr> <tr> <td>M_z (kipft)</td> <td>22.316</td> <td>37.495</td> </tr> </tbody> </table> <p>Material Properties $f'_{ck} = 3 \text{ ksi}$ - Concrete strength,</p> <p>Required depth to resist lateral loads (ASD)</p> <p>H - Point of application of the lateral load</p> $H = h_1 + h_2 + h_e$ $H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})$ $H = 0 \text{ ft}$ <p>Considering x-direction: H_o - Lateral force per length of pile,</p> $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-3.031 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.48264 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$	Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) (psf/ft)	1	Sand, silty sand, clayey sand, silty gravel & clayey gravel	2000.000	150.000	Load Component	ASD	LRFD	P (kip)	7.622	11.520	V_x (kip)	-3.031	-5.060	V_z (kip)	0.094	0.142	M_x (kipft)	0.170	0.259	M_z (kipft)	22.316	37.495	
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$$M_o = \frac{(22.316 \text{ kipft}) + ((-3.031 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 3.5535 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$L_{e,x} = 5.1366 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.094 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.014968 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.17 \text{ kipft}) + ((0.094 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.02707 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$L_{e,z} = 1.5232 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(5.1366 \text{ ft}), (1.5232 \text{ ft})]$$

$$L_{e,req} = 5.137 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (5.75 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$$

$$L_e = 5.75 \text{ ft}$$

Ratio - Embedded depth

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

$$Ratio = \frac{(5.137 \text{ ft})}{(5.75 \text{ ft})}$$

$$Ratio = 0.89339$$

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

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = b D$$

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

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

q - End-bearing pressure

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

$$q = \frac{(7.622 \text{ kip})}{(16 \text{ ft}^2)}$$

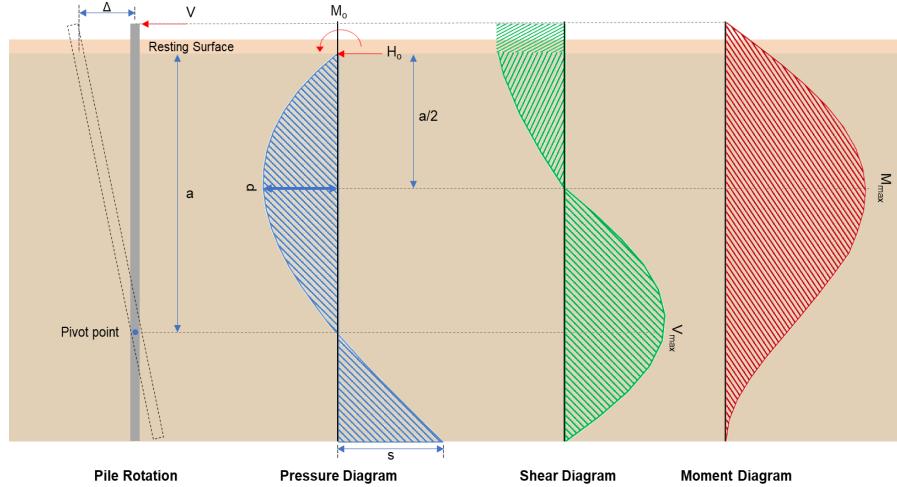
	$q = 0.47638 \text{ kip/ft}^2$	
	<p>Check bearing capacity ratio:</p> <p><i>Ratio - Capacity</i></p> $Ratio = \frac{q}{q_a}$ $Ratio = \frac{(0.47638 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $Ratio = 0.23819$	Status: PASS Ratio: 0.240
Czerniak	<p>Lateral Soil Pressure (ASD):</p> <p><i>L/D - Length to least lateral dimension ratio,</i></p> $L/D = \frac{L}{D}$ $L/D = \frac{(5.75 \text{ ft})}{(48 \text{ in})}$ $L/D = 1.4375$ <p>Since L/D ≤ 10,</p> <p>Pile is short.</p> <p>Considering x-direction:</p> <p>$H_o = -0.48264 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 3.5535 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (3.5535 \text{ kipft/ft}) \times (5.75 \text{ ft})) + (3 \times (-0.48264 \text{ kip/ft}) \times (5.75 \text{ ft})^2)}{(6 \times (3.5535 \text{ kipft/ft})) + (4 \times (-0.48264 \text{ kip/ft}) \times (5.75 \text{ ft}))}$ $a = 3.9974 \text{ ft}$ <p><i>p</i> - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (3.5535 \text{ kipft/ft})) + (3 \times (-0.48264 \text{ kip/ft}) \times (5.75 \text{ ft}))]^2}{(5.75 \text{ ft})^2 \times [(3 \times (3.5535 \text{ kipft/ft})) + (2 \times (-0.48264 \text{ kip/ft}) \times (5.75 \text{ ft}))]}$ $p = 0.15392 \text{ kip/ft}^2$ <p><i>s</i> - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (3.5535 \text{ kipft/ft})) + ((-0.48264 \text{ kip/ft}) \times (5.75 \text{ ft}))]}{(5.75 \text{ ft})^2}$ $s = 0.78611 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p><i>p_a</i> - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(3.9974 \text{ ft})}{2}$ $p_a = 0.2998 \text{ kip/ft}^2$ <p><i>Ratio - Lateral soil capacity</i></p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.15392 \text{ kip/ft}^2)}{(0.2998 \text{ kip/ft}^2)}$ $Ratio = 0.5134$ <p><i>p_s</i> - Allowable lateral soil pressure at depth L_e,</p>	Status: PASS Ratio: 0.510

	$p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (5.75 \text{ ft})$ $p_s = 0.8625 \text{ kip/ft}^2$ <i>Ratio - Lateral soil capacity</i> $Ratio = \frac{s}{p_s}$ $Ratio = \frac{(0.78611 \text{ kip/ft}^2)}{(0.8625 \text{ kip/ft}^2)}$ $Ratio = 0.91143$	Status: PASS Ratio: 0.910
	Considering z-direction: $H_o = 0.014968 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 0.02707 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point, $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.02707 \text{ kipft/ft}) \times (5.75 \text{ ft})) + (3 \times (0.014968 \text{ kip/ft}) \times (5.75 \text{ ft})^2)}{(6 \times (0.02707 \text{ kipft/ft})) + (4 \times (0.014968 \text{ kip/ft}) \times (5.75 \text{ ft}))}$ $a = 4.1589 \text{ ft}$ <p>p - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.02707 \text{ kipft/ft})) + (3 \times (0.014968 \text{ kip/ft}) \times (5.75 \text{ ft}))]^2}{(5.75 \text{ ft})^2 \times [(3 \times (0.02707 \text{ kipft/ft})) + (2 \times (0.014968 \text{ kip/ft}) \times (5.75 \text{ ft}))]}$ $p = 0.012026 \text{ kip/ft}^2$ <p>s - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.02707 \text{ kipft/ft})) + ((0.014968 \text{ kip/ft}) \times (5.75 \text{ ft}))]}{(5.75 \text{ ft})^2}$ $s = 0.025444 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p>p_a - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.1589 \text{ ft})}{2}$ $p_a = 0.31192 \text{ kip/ft}^2$ <p><i>Ratio - Lateral soil capacity</i></p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.012026 \text{ kip/ft}^2)}{(0.31192 \text{ kip/ft}^2)}$ $Ratio = 0.038555$	Status: PASS Ratio: 0.040

$$Ratio = \frac{(0.025444 \text{ kip}/\text{ft}^2)}{(0.8625 \text{ kip}/\text{ft}^2)}$$

$$Ratio = 0.0295$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-5.06 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.80573 \text{ kip}/\text{ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(37.495 \text{ kipft}) + ((-5.06 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 5.9705 \text{ kipft}/\text{ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(5.9705 \text{ kipft}/\text{ft})}{(-0.80573 \text{ kip}/\text{ft})}$$

$$E = 7.4101 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.9705 \text{ kipft}/\text{ft}) \times (5.75 \text{ ft})) + (3 \times (-0.80573 \text{ kip}/\text{ft}) \times (5.75 \text{ ft})^2)}{(6 \times (5.9705 \text{ kipft}/\text{ft})) + (4 \times (-0.80573 \text{ kip}/\text{ft}) \times (5.75 \text{ ft}))}$$

$$a = 3.9967 \text{ ft}$$

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

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

$$V_{max} = ((-0.80573 \text{ kip}/\text{ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (7.4101 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(3.9967 \text{ ft})}{(5.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (7.4101 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(3.9967 \text{ ft})}{(5.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 9.475 \text{ kip}$$

<p>M_{max} - Max bending moment located at depth $a/2$,</p> $M_{max} = (H_o D L_e) \left[\left(\frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[\left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{2 L_e} \right)^3 \right] + \left[\left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{2 L_e} \right)^4 \right] \right]$ $M_{max} = ((-0.80573 \text{ kip/ft}) \times (48 \text{ in}) \times (5.75 \text{ ft})) \times \left[\left(\frac{(7.4101 \text{ ft})}{(5.75 \text{ ft})} + \frac{(3.9967 \text{ ft})}{2 \times (5.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (7.4101 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(3.9967 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (7.4101 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(3.9967 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^4 \right] \right]$ $M_{max} = 25.565 \text{ kipft}$
<p>Shear force and Bending moment (z-direction, LRFD)</p> <p>H_o - Lateral force per length of pile,</p> $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(0.142 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = 0.022611 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(0.259 \text{ kipft}) + ((0.142 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.041242 \text{ kipft/ft}$ <p>E - Distance from lateral load to resisting surface,</p> $E = \frac{M_o}{H_o}$ $E = \frac{(0.041242 \text{ kipft/ft})}{(0.022611 \text{ kip/ft})}$ $E = 1.8239 \text{ ft}$ <p>a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.041242 \text{ kipft/ft}) \times (5.75 \text{ ft})) + (3 \times (0.022611 \text{ kip/ft}) \times (5.75 \text{ ft})^2)}{(6 \times (0.041242 \text{ kipft/ft})) + (4 \times (0.022611 \text{ kip/ft}) \times (5.75 \text{ ft}))}$ $a = 4.158 \text{ ft}$ <p>V_{max} - Max shear force located at depth a,</p> $V_{max} = (H_o b) \left[1 - \left[3 \left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{L_e} \right)^2 \right] + \left[4 \left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{L_e} \right)^3 \right] \right]$ $V_{max} = ((0.022611 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (1.8239 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.158 \text{ ft})}{(5.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (1.8239 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.158 \text{ ft})}{(5.75 \text{ ft})} \right)^3 \right] \right]$ $V_{max} = 0.11145 \text{ kip}$ <p>M_{max} - Max bending moment located at depth $a/2$,</p> $M_{max} = (H_o b L_e) \left[\left(\frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[\left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{2 L_e} \right)^3 \right] + \left[\left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{2 L_e} \right)^4 \right] \right]$ $M_{max} = ((0.022611 \text{ kip/ft}) \times (48 \text{ in}) \times (5.75 \text{ ft})) \times \left[\left(\frac{(1.8239 \text{ ft})}{(5.75 \text{ ft})} + \frac{(4.158 \text{ ft})}{2 \times (5.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (1.8239 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.158 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (1.8239 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.158 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^4 \right] \right]$

	$M_{max} = 0.2743 \text{ kipft}$	
	<p>Minimum Reinforcement Check (LRFD)</p> <p>Parameters:</p> <p>$f'_{ck} = 3 \text{ ksi}$ - 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,</p> <p>Longitudinal reinforcement:</p> <p>Required reinforcement due to axial load, $A_{st,required}$</p> $A_{st,required} = Min \left[\frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = Min \left[\frac{\frac{(11.52 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (3 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -101.88 \text{ in}^2$ <p>A_{min} - Governing minimum reinforcement area,</p> $A_{min} = Max [A_{st,required}, (0.0018 A_g)]$ $A_{min} = Max [(-101.88 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ <p>n_{rebar} - Required number of reinforcement,</p> $n_{rebar} = \frac{A_{min}}{A_{rebar}}$ $n_{rebar} = \frac{(4.1472 \text{ in}^2)}{(0.3068 \text{ in}^2)}$ $n_{rebar} = 14$ <p>A_{st} - Actual total reinforcement area,</p> $A_{st} = n_{rebar} \frac{\pi d_{bar}^2}{4}$ $A_{st} = (14) \times \frac{\pi \times (0.625 \text{ in})^2}{4}$ $A_{st} = 4.2951 \text{ in}^2$ <p>Ratio - Capacity</p> $Ratio = \frac{A_{min}}{A_{st}}$ $Ratio = \frac{(4.1472 \text{ in}^2)}{(4.2951 \text{ in}^2)}$ $Ratio = 0.96556$	
25.2.3	<p>s_{rebar} - 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>Ties:</p> <p>Since longitudinal reinforcement is \leq No. 10ø: Use #3(0.375 in)</p> <p>s_{ties} - Maximum spacing of ties,</p> $s_{ties} = Min [(16 d_{bar}), (48 d_{ties}), Min (D, b)]$ $s_{ties} = Min [(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), Min ((48 \text{ in}), (48 \text{ in}))]$ $s_{ties} = 10 \text{ in}$	Status: PASS Ratio: 0.970
25.7.2.2	<p>Summary:</p> <p>Main reinforcement: 14 - #5 (0.625 in)</p>	

	Ties: #3(0.375 in) - 10 in	
22.4.2.2	<p>Axial Compression Strength (ACI 318-19, LRFD)</p> <p>ϕP_N - Allowable axial compressive strength</p> $\phi P_N = \phi \cdot 0.80 \left[(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st}) \right]$ $\phi P_N = (0.65) \times 0.80 \times [(0.85 \times (3 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2))]$ $\phi P_N = 3183.4 \text{ kip}$ <p><i>Ratio</i> - Capacity</p> $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(11.52 \text{ kip})}{(3183.4 \text{ kip})}$ $Ratio = 0.0036188$	Status: PASS Ratio: 0.000
22.5.2.2	<p>Shear Strength (ACI 318-19, LRFD)</p> <p>Parameters:</p> <p>$b_w = 48 \text{ in}$ - Effective width, d - Effective depth</p> $d = 0.80 D$ $d = 0.80 \times (48 \text{ in})$ $d = 38.4 \text{ in}$ <p>λ_s - size effect modification factor</p> $\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.64282$ <p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$,</p> <p>$V_{c,max}$ - Max shear strength of concrete</p> $V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$ $V_{c,max} = 5 \times (0.64282) \times \sqrt{(3000 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,max} = 324.49 \text{ kip}$ <p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$, $P = 11.52 \text{ kip} \rightarrow 11520 \text{ lbf}$,</p> <p>$V_{c,a}$ - Shear strength of concrete (a)</p> $V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + \frac{(11520 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 131.33 \text{ kip}$ <p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$,</p> <p>$V_{c,b}$ - Shear strength of concrete (b)</p> $V_{c,b} = \left[2 \lambda_s \sqrt{f'_{ck}} + (0.05 f'_{ck}) \right] b_w d$ $V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + (0.05 \times (3000 \text{ psi})) \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,b} = 406.27 \text{ kip}$ <p>V_c - Governing shear strength of concrete</p> $V_c = Min [V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = Min [(324.49 \text{ kip}), (131.33 \text{ kip}), (406.27 \text{ kip})]$ $V_c = 131.33 \text{ kip}$	
22.5.5.1.1		
22.5.5.1.1(a)		
22.5.5.1.2		

22.5.1.2	<p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$,</p> <p>$V_{s,a}$ - Shear strength of steel (a)</p> $V_{s,a} = 8 \sqrt{f'_{ck} b_w d}$ $V_{s,a} = 8 \times \sqrt{(3000 \text{ psi}) \times (48 \text{ in}) \times (38.4 \text{ in})}$ $V_{s,a} = 807.65 \text{ kip}$ <p>A_v - Ties rebar area,</p> $A_v = \frac{\pi d_{ties}^2}{4}$ $A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$ $A_v = 0.11045 \text{ in}^2$	
22.5.8.5.3	<p>$V_{s,b}$ - Shear strength of steel (b)</p> $V_{s,b} = \frac{2 A_v f_{yw} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$ <p>V_s - Governing shear strength of steel</p> $V_s = MIN[V_{s,a}, V_{s,b}]$ $V_s = MIN[(807.65 \text{ kip}), (50.894 \text{ kip})]$ $V_s = 50.894 \text{ kip}$	
22.5.1.1	<p>ϕV_n - Allowable shear strength</p> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((131.33 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 118.45 \text{ kip}$	
	<p>Considering x-direction:</p> <p>$V_{max} = 9.475 \text{ kip}$ - Maximum shear force in the x-direction, $Ratio$ - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(9.475 \text{ kip})}{(118.45 \text{ kip})}$ $Ratio = 0.079995$	Status: PASS Ratio: 0.080
	<p>Considering z-direction:</p> <p>$V_{max} = 0.11145 \text{ kip}$ - Maximum shear force in the z-direction, $Ratio$ - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.11145 \text{ kip})}{(118.45 \text{ kip})}$ $Ratio = 0.00094096$	Status: PASS Ratio: 0.000
	<p>Flexural Strength (ACI 318-19, LRFD)</p> <p>S_m - Section modulus</p> $S_m = \frac{b D^2}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$	

	<p>$\lambda = 1$ - Concrete modification factor (Normal concrete), Allowable flexural strength: M_n shall be the lesser of: $\phi M_{n,1}$</p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{(f'_c) \times S_m}$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(3ksi) \times 18432.001in^3}$ $\phi M_{n,1} = 273.423kipft$ <p>14.5.2.1b $\phi M_{n,2}$</p> $\phi M_{n,2} = \phi 0.85 f'_{ck} S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (3 \text{ ksi}) \times (18432 \text{ in}^3)$ $\phi M_{n,2} = 2545.9 \text{ kipft}$ <p>Therefore, ϕM_n - Allowable flexural strength,</p> $\phi M_n = MIN[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = MIN[(273.42 \text{ kipft}), (2545.9 \text{ kipft})]$ $\phi M_n = 273.42 \text{ kipft}$ <p>Considering x-direction:</p> <p>$M_{max} = 25.565 \text{ kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(25.565 \text{ kipft})}{(273.42 \text{ kipft})}$ $Ratio = 0.0935$	Status: PASS Ratio: 0.090
	<p>Considering z-direction:</p> <p>$M_{max} = 0.2743 \text{ kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(0.2743 \text{ kipft})}{(273.42 \text{ kipft})}$ $Ratio = 0.0010032$	Status: PASS Ratio: 0.000