

Your Project Calculations

Project Name: MTSOLAR_DKJ0H3GCD6I9

S3D Model Link:

https://platform.skyciv.com/structural?preload_name=MTSOLAR_DKJ0H3GCD6I9&preload_path=Shared%20Enterprise%20Folder/MT_Solar_Projects/5_2023

Public Model Link:

https://platform.skyciv.com/structural-viewer?project_id=Kl6dxBVG0x1KBAjeu0T5BOobpUH2l2hkNEKXKI7kYcYZM8XWNRjMLhj0PuAqbeWV



Array Specification

Product:	Beam
Unique ID:	4P-19.75-10TOP-XD-12-L-5Hx12W-1LLK
Duty Classification:	XD
Module Width:	44.60 in
Module Length:	67.90in
Number of Rows:	5
Number of Columns:	12
Total Number of Modules:	60
Desired Tilt Angle:	7
Front Edge Clearance:	10
Total Array Height at Tilt:	12.28 ft
Total Frame Length:	68.75 ft
Frame Weight:	4545 lbs
Array Dimensions N/S:	18.79 ft
Array Dimensions E/W:	68.90 ft
Rail Length:	225.50 in
Rail Spacing:	2.83 ft
Rail Check:	Not Checked

Support Specifications

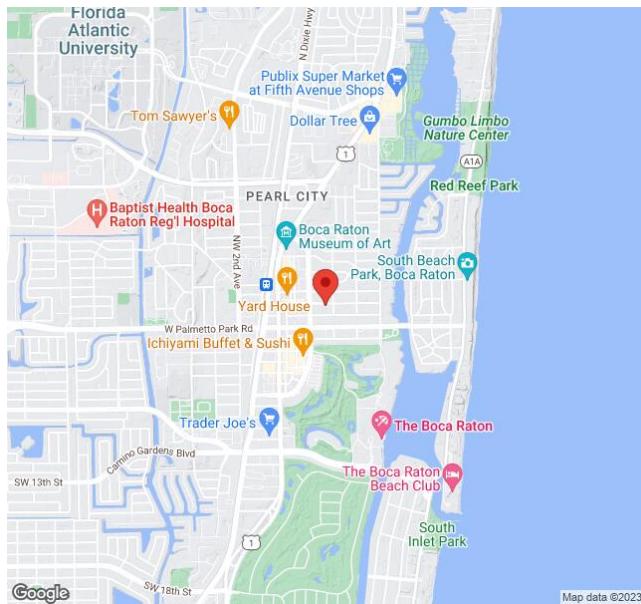
Pole Size:	10in Pipe Sch 40
Pole Length above Grade:	11.15 ft
Number of Poles:	4
Pole Spacing:	19.75 ft

Foundation Specifications

Foundation Type:	Square
Foundation Dimensions:	48 x 48 in
Foundation Depth (below grade):	Pile 1: 5.75 ft Pile 2: 6.25 ft Pile 3: 6.25 ft Pile 4: 5.75 ft
Foundation Volume:	14.222 y ³
Foundation Result:	PASSED
Mount Twist:	0.462770 kip

Site Info

Risk Category:	I
Exposure:	B
Soil Classification:	sand
Site Location:	266 NE 2nd St, Boca Raton, FL 33432, USA
Wind Speed:	160 mph
Snow Load:	0 psf
Design Uplift Pressure:	Multiple pressures
Design Downforce Pressure:	Multiple pressures
Design Snow Pressure:	0.000000 ksf



Design Disclaimer

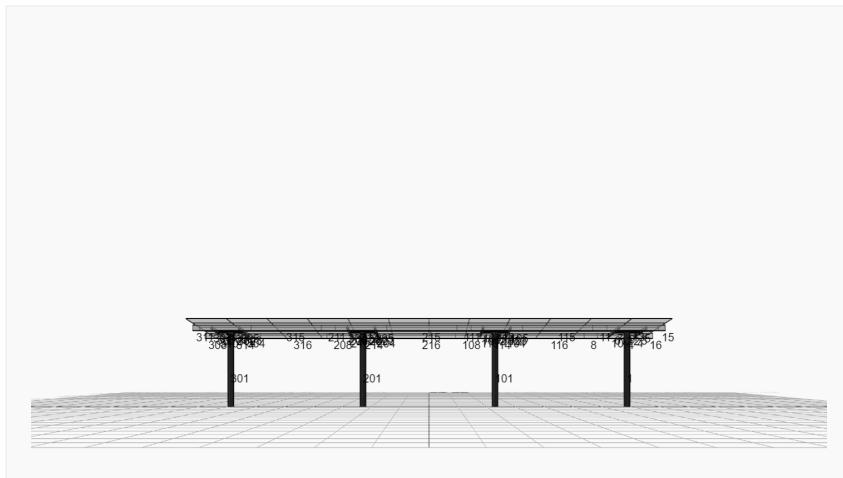
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

AutoDesigner Input

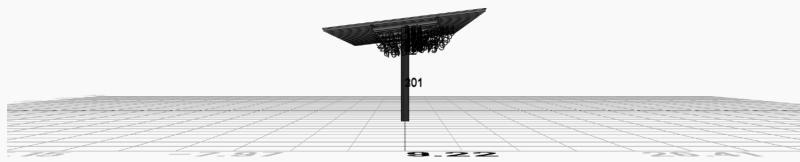
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Design Notes:

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



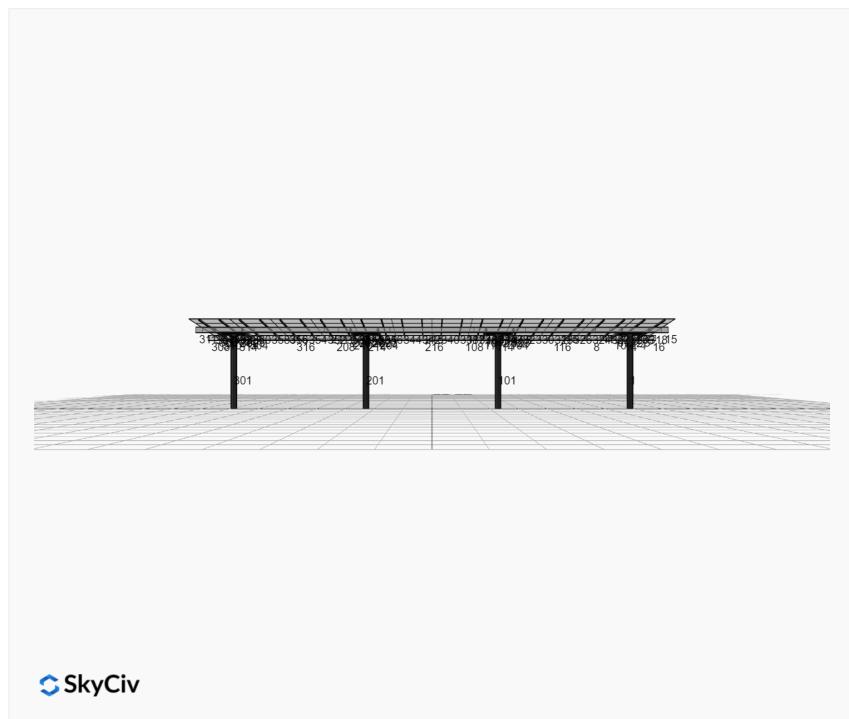
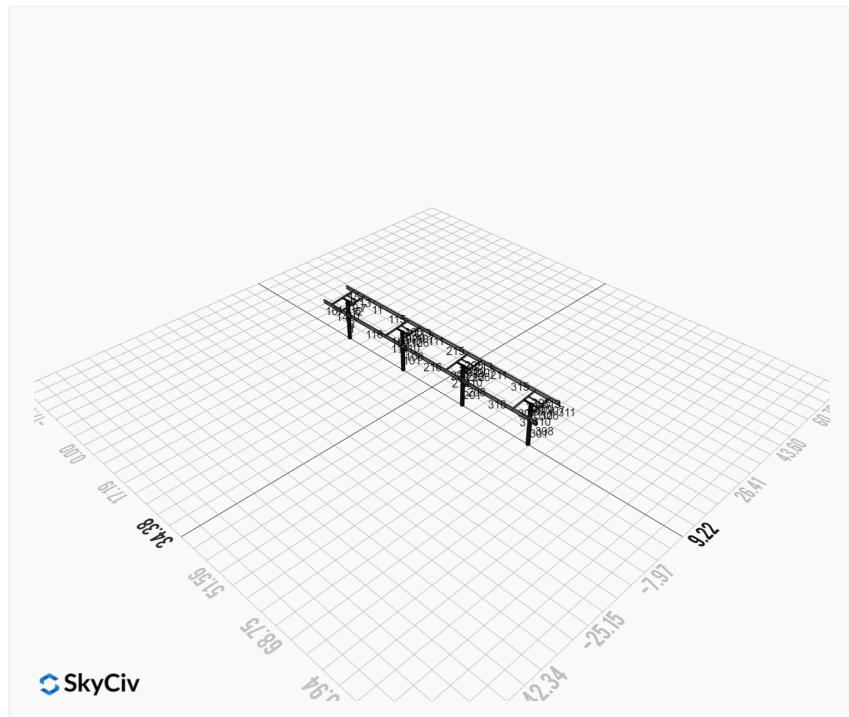
 SkyCiv



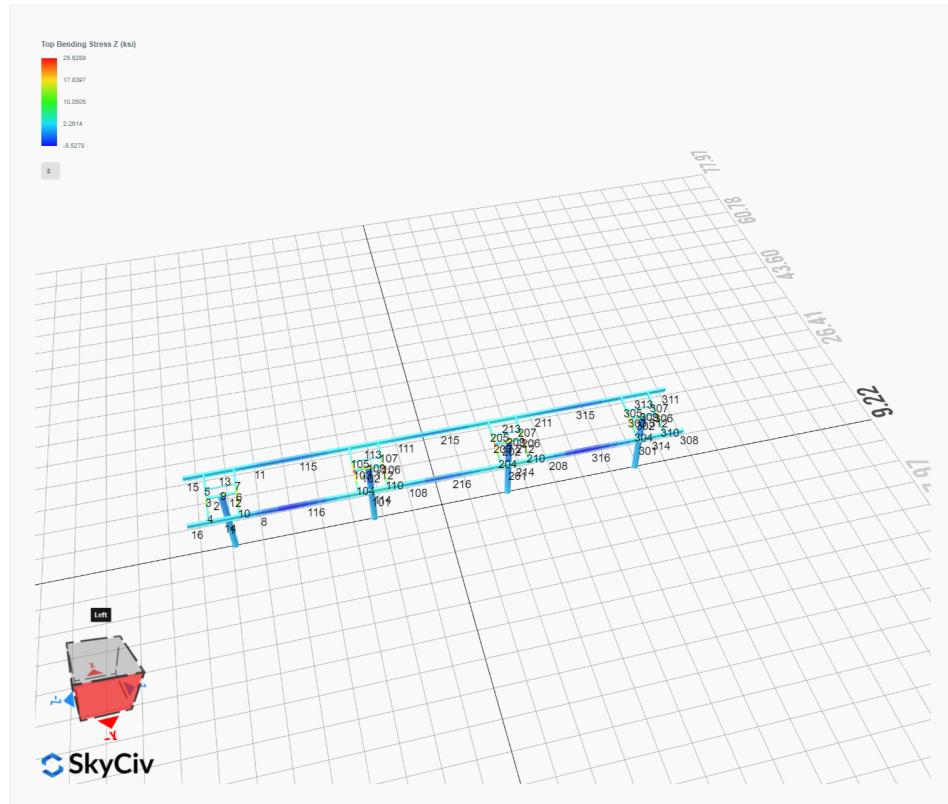
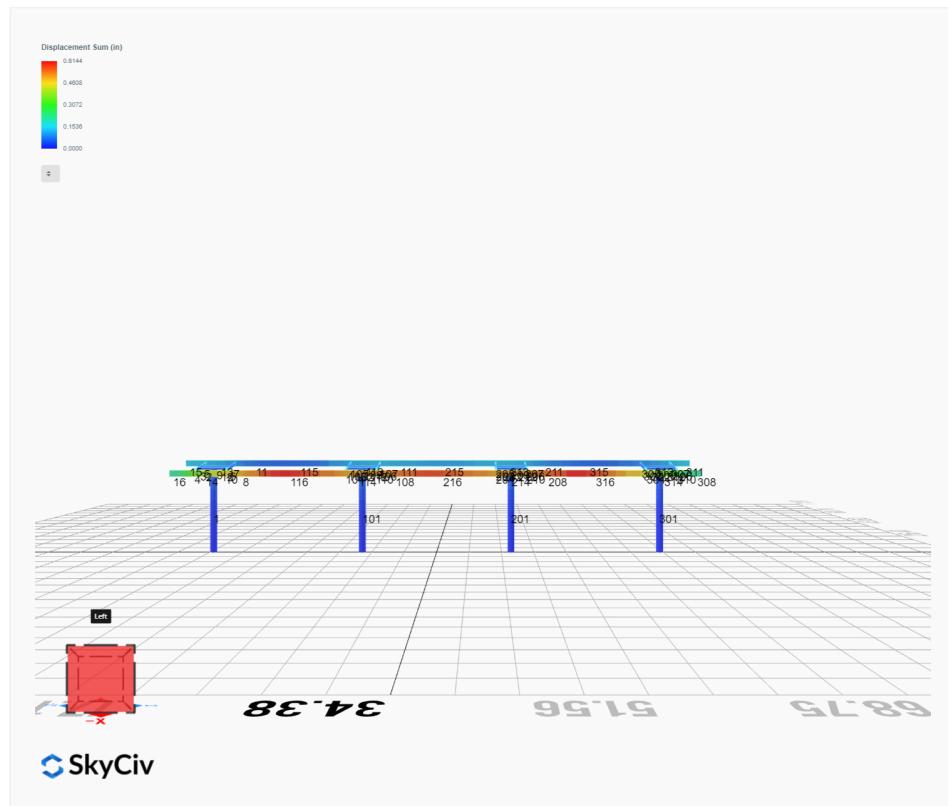
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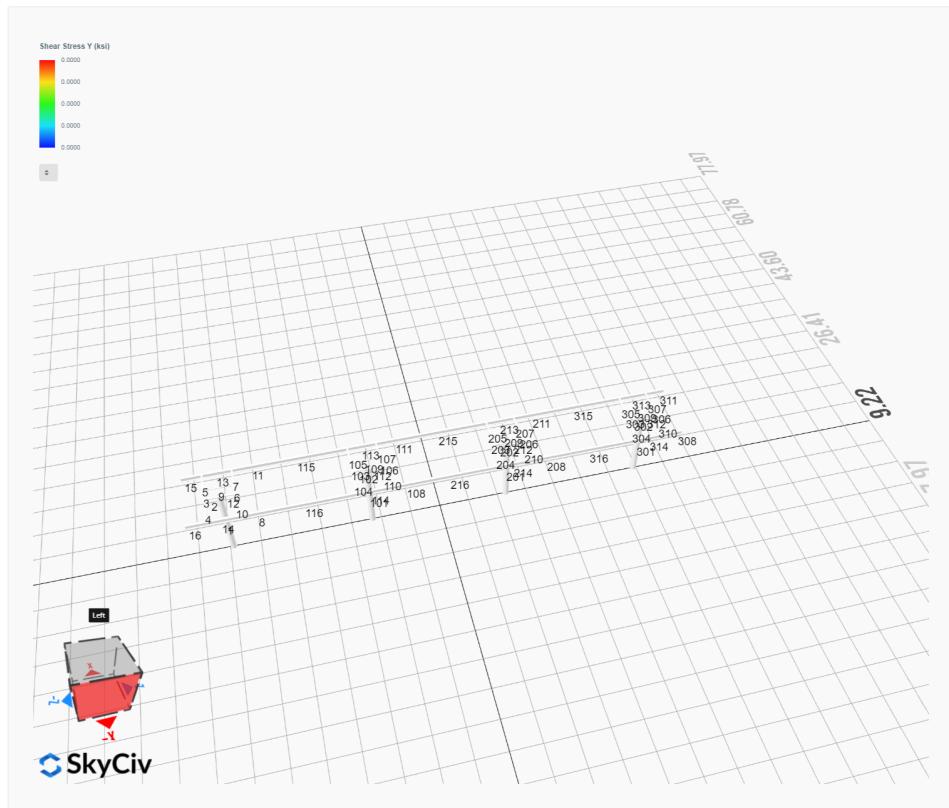
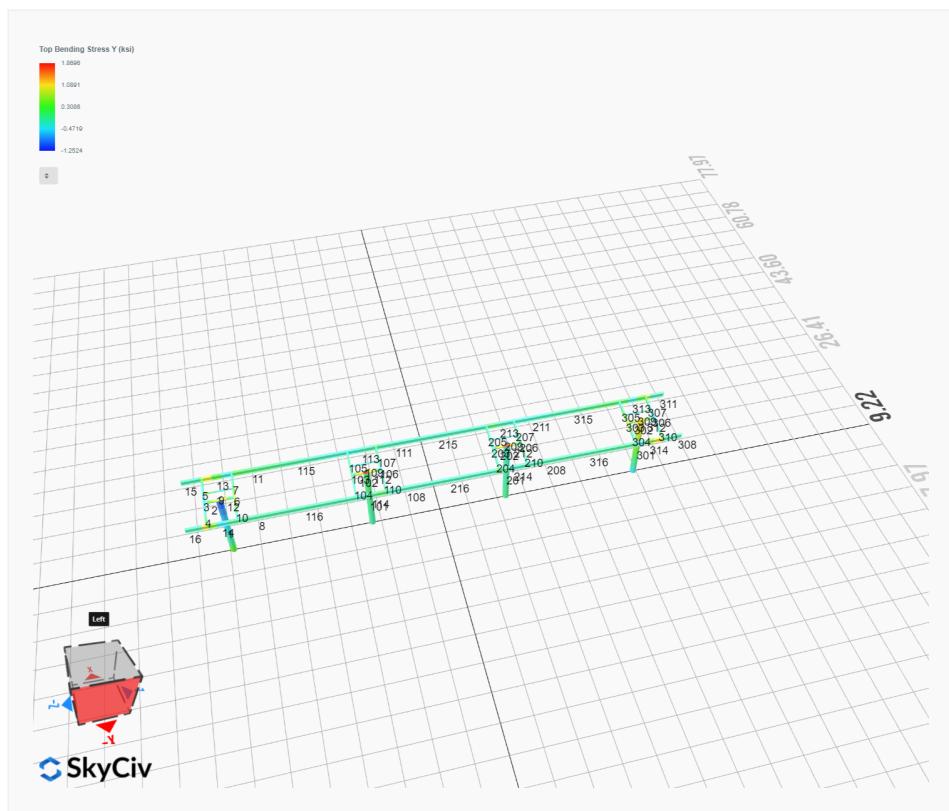


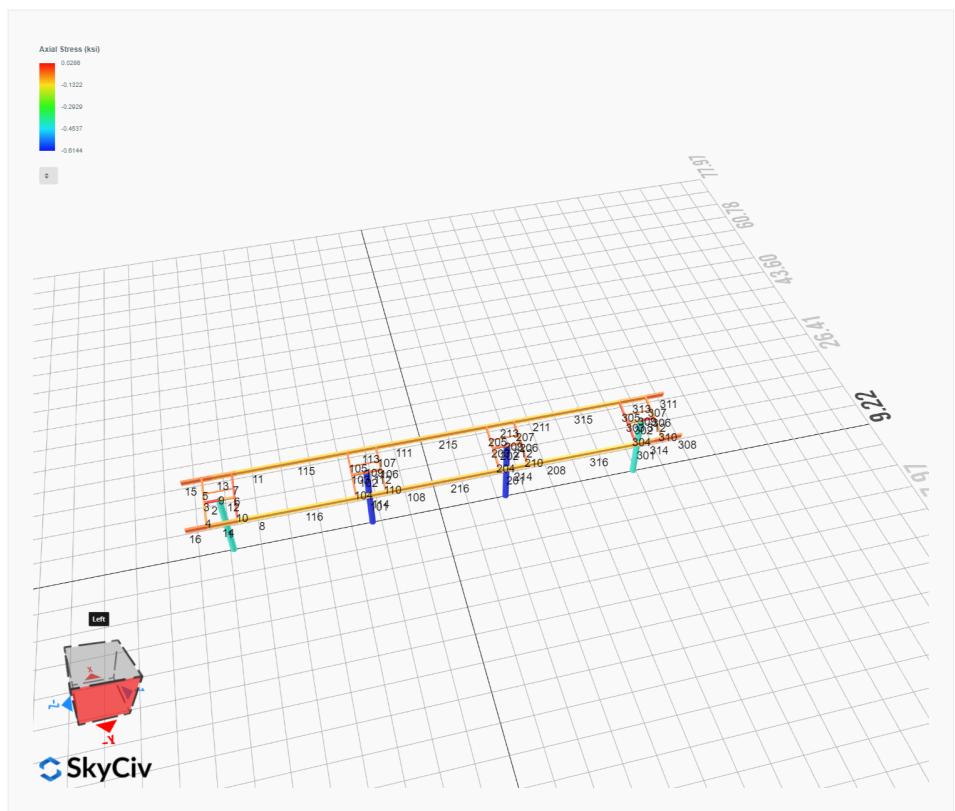
SkyCiv



FEM Results (Envelope Worst Case for each member)







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

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	0.0112	2.2325	0.1000	0.2698	-0.0205	-0.0871
ULS: 2. D + L	0.0112	2.2325	0.1000	0.2698	-0.0205	-0.0871
ULS: 3. D + (S or Lr or R)	0.0112	2.2325	0.1000	0.2698	-0.0205	-0.0871
ULS: 3. D + (S or Lr or R)	0.0112	2.2325	0.1000	0.2698	-0.0205	-0.0871
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0112	2.2325	0.1000	0.2698	-0.0205	-0.0871
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0112	2.2325	0.1000	0.2698	-0.0205	-0.0871
ULS: 5b. D + 0.7E	0.0112	2.2325	0.1000	0.2698	-0.0205	-0.0871
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0112	2.2325	0.1000	0.2698	-0.0205	-0.0871
ULS: 8. 0.6D + 0.7E	0.0067	1.3395	0.0600	0.1619	-0.0123	-0.0523
ULS: 5a. D + 0.6W_Wind downforce Case A only	-0.6073	7.1369	0.4325	1.1479	-0.2831	11.1132
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.6073	7.1369	0.4325	1.1479	-0.2831	11.1132
ULS: 5a. D + 0.6W_Wind uplift Case A only	0.3682	-0.6833	-0.0908	-0.2353	0.1180	-0.5499
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.3938	-0.6803	-0.1046	-0.2684	0.1589	-15.5313
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.4526	5.9108	0.3494	0.9284	-0.2174	8.3131
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.4526	5.9108	0.3494	0.9284	-0.2174	8.3131
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.2789	0.0456	-0.0431	-0.1090	0.0834	-0.4342
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.2981	0.0479	-0.0535	-0.1339	0.1141	-11.6702
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.4526	5.9108	0.3494	0.9284	-0.2174	8.3131
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.4526	5.9108	0.3494	0.9284	-0.2174	8.3131
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.2789	0.0456	-0.0431	-0.1090	0.0834	-0.4342
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.2981	0.0479	-0.0535	-0.1339	0.1141	-11.6702
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-0.6117	6.2439	0.3925	1.0400	-0.2749	11.1480
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.6117	6.2439	0.3925	1.0400	-0.2749	11.1480
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	0.3637	-1.5763	-0.1308	-0.3432	0.1262	-0.5151
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.3893	-1.5733	-0.1446	-0.3763	0.1671	-15.4964

Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	10.8529
Shear X	-1.0308
Shear Z	0.6750
Moment X	1.7898
Moment Y (Twist)	0.4627
Moment Z	25.9704

Worst Case Reactions ASD

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

Result	Value (kip, kip-ft)
Axial	7.1369
Shear X	-0.6117
Shear Z	0.4325
Moment X	1.1479
Moment Y (Twist)	0.2831
Moment Z	15.5313

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	-0.0112	2.9897	-0.0141	-0.0397	0.0101	0.1525
ULS: 2. D + L	-0.0112	2.9897	-0.0141	-0.0397	0.0101	0.1525
ULS: 3. D + (S or Lr or R)	-0.0112	2.9897	-0.0141	-0.0397	0.0101	0.1525
ULS: 3. D + (S or Lr or R)	-0.0112	2.9897	-0.0141	-0.0397	0.0101	0.1525
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0112	2.9897	-0.0141	-0.0397	0.0101	0.1525
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0112	2.9897	-0.0141	-0.0397	0.0101	0.1525
ULS: 5b. D + 0.7E	-0.0112	2.9897	-0.0141	-0.0397	0.0101	0.1525

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0112	2.9897	-0.0141	-0.0397	0.0101	0.1525
ULS: 8. 0.6D + 0.7E	-0.0067	1.7938	-0.0084	-0.0238	0.0060	0.0915
ULS: 5a. D + 0.6W_Wind downforce Case A only	-0.8993	10.3550	-0.0571	-0.1630	0.0219	16.0830
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.8993	10.3550	-0.0571	-0.1630	0.0219	16.0830
ULS: 5a. D + 0.6W_Wind uplift Case A only	0.5289	-1.4004	0.0144	0.0398	-0.0113	-0.8201
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.4990	-1.3685	0.0073	0.0241	0.0228	-21.1587
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.6773	8.5137	-0.0463	-0.1322	0.0190	12.1003
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.6773	8.5137	-0.0463	-0.1322	0.0190	12.1003
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.3939	-0.3029	0.0073	0.0199	-0.0059	-0.5770
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.3714	-0.2789	0.0020	0.0082	0.0196	-15.8309
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.6773	8.5137	-0.0463	-0.1322	0.0190	12.1003
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.6773	8.5137	-0.0463	-0.1322	0.0190	12.1003
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.3939	-0.3029	0.0073	0.0199	-0.0059	-0.5770
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.3714	-0.2789	0.0020	0.0082	0.0196	-15.8309
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-0.8948	9.1591	-0.0515	-0.1471	0.0179	16.0220
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.8948	9.1591	-0.0515	-0.1471	0.0179	16.0220
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	0.5334	-2.5963	0.0200	0.0557	-0.0153	-0.8811
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.5035	-2.5644	0.0129	0.0400	0.0188	-21.2197

Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	15.8633
Shear X	-1.4934
Shear Z	-0.0887
Moment X	-0.2535
Moment Y (Twist)	0.0355
Moment Z	35.5587

Worst Case Reactions ASD

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

Result	Value (kip, kip-ft)
Axial	10.3550
Shear X	-0.8993
Shear Z	-0.0571
Moment X	-0.1630
Moment Y (Twist)	0.0228
Moment Z	21.2197

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	-0.0112	2.9897	0.0141	0.0397	-0.0100	0.1525
ULS: 2. D + L	-0.0112	2.9897	0.0141	0.0397	-0.0100	0.1525
ULS: 3. D + (S or Lr or R)	-0.0112	2.9897	0.0141	0.0397	-0.0100	0.1525
ULS: 3. D + (S or Lr or R)	-0.0112	2.9897	0.0141	0.0397	-0.0100	0.1525
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0112	2.9897	0.0141	0.0397	-0.0100	0.1525
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0112	2.9897	0.0141	0.0397	-0.0100	0.1525
ULS: 5b. D + 0.7E	-0.0112	2.9897	0.0141	0.0397	-0.0100	0.1525
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0112	2.9897	0.0141	0.0397	-0.0100	0.1525
ULS: 8. 0.6D + 0.7E	-0.0067	1.7938	0.0084	0.0238	-0.0060	0.0915
ULS: 5a. D + 0.6W_Wind downforce Case A only	-0.8993	10.3550	0.0571	0.1630	-0.0219	16.0830
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.8993	10.3550	0.0571	0.1630	-0.0219	16.0830
ULS: 5a. D + 0.6W_Wind uplift Case A only	0.5289	-1.4004	-0.0144	-0.0398	0.0113	-0.8201
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.4990	-1.3685	-0.0073	-0.0241	-0.0228	-21.1587
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.6773	8.5137	0.0463	0.1322	-0.0189	12.1003
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.6773	8.5137	0.0463	0.1322	-0.0189	12.1003
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.3939	-0.3029	-0.0073	-0.0199	0.0059	-0.5770
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.3714	-0.2789	-0.0020	-0.0082	-0.0196	-15.8309

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.6773	8.5137	0.0463	0.1322	-0.0189	12.1003
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.6773	8.5137	0.0463	0.1322	-0.0189	12.1003
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.3939	-0.3029	-0.0073	-0.0199	0.0059	-0.5770
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.3714	-0.2789	-0.0020	-0.0082	-0.0196	-15.8309
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-0.8948	9.1591	0.0515	0.1471	-0.0179	16.0220
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.8948	9.1591	0.0515	0.1471	-0.0179	16.0220
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	0.5334	-2.5963	-0.0200	-0.0557	0.0153	-0.8811
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.5035	-2.5643	-0.0129	-0.0400	-0.0188	-21.2197

Worst Case Reactions LRFD

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

Result	Value (kip, kip-ft)
Axial	15.8633
Shear X	-1.4934
Shear Z	0.0887
Moment X	0.2535
Moment Y (Twist)	0.0355
Moment Z	35.5587

Worst Case Reactions ASD

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

Result	Value (kip, kip-ft)
Axial	10.3550
Shear X	-0.8993
Shear Z	0.0571
Moment X	0.1630
Moment Y (Twist)	0.0228
Moment Z	21.2197

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	0.0112	2.2325	-0.1000	-0.2698	0.0205	-0.0871
ULS: 2. D + L	0.0112	2.2325	-0.1000	-0.2698	0.0205	-0.0871
ULS: 3. D + (S or Lr or R)	0.0112	2.2325	-0.1000	-0.2698	0.0205	-0.0871
ULS: 3. D + (S or Lr or R)	0.0112	2.2325	-0.1000	-0.2698	0.0205	-0.0871
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0112	2.2325	-0.1000	-0.2698	0.0205	-0.0871
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0112	2.2325	-0.1000	-0.2698	0.0205	-0.0871
ULS: 5b. D + 0.7E	0.0112	2.2325	-0.1000	-0.2698	0.0205	-0.0871
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0112	2.2325	-0.1000	-0.2698	0.0205	-0.0871
ULS: 8. 0.6D + 0.7E	0.0067	1.3395	-0.0600	-0.1619	0.0123	-0.0523
ULS: 5a. D + 0.6W_Wind downforce Case A only	-0.6073	7.1369	-0.4325	-1.1479	0.2831	11.1132
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.6073	7.1369	-0.4325	-1.1479	0.2831	11.1132
ULS: 5a. D + 0.6W_Wind uplift Case A only	0.3682	-0.6833	0.0908	0.2353	-0.1180	-0.5499
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.3938	-0.6803	0.1046	0.2684	-0.1589	-15.5312
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.4526	5.9108	-0.3494	-0.9284	0.2174	8.3131
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.4526	5.9108	-0.3494	-0.9284	0.2174	8.3131
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.2789	0.0456	0.0431	0.1090	-0.0834	-0.4342
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.2981	0.0479	0.0535	0.1339	-0.1141	-11.6702
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-0.4526	5.9108	-0.3494	-0.9284	0.2174	8.3131
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.4526	5.9108	-0.3494	-0.9284	0.2174	8.3131
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	0.2789	0.0456	0.0431	0.1090	-0.0834	-0.4342
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.2981	0.0479	0.0535	0.1339	-0.1141	-11.6702
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-0.6117	6.2439	-0.3925	-1.0400	0.2749	11.1480
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.6117	6.2439	-0.3925	-1.0400	0.2749	11.1480
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	0.3637	-1.5763	0.1308	0.3432	-0.1262	-0.5151
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.3893	-1.5733	0.1446	0.3763	-0.1671	-15.4964

Worst Case Reactions LRFD

Worst Case Reactions ASD

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

Result	Value (kip, kip-ft)
Axial	10.8529
Shear X	-1.0308
Shear Z	-0.6750
Moment X	-1.7898
Moment Y (Twist)	0.4628
Moment Z	25.9705

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

Result	Value (kip, kip-ft)
Axial	7.1369
Shear X	-0.6117
Shear Z	-0.4325
Moment X	-1.1479
Moment Y (Twist)	0.2831
Moment Z	15.5312

Project Details

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

User Name: sales@mtsolard.com
 Unit System: imperial



Design Input Information

Design Factors			
Φ_t	Φ_c	Φ_b	Φ_v
0.9	0.9	0.9	0.9

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

Section Dimensions								
ID	Name	d (in)	t _w (in)					
3	2in Pipe Sch 120	2.38	0.25					
6	4in Pipe Sch 120	4.50	0.44					
11	10in Pipe Sch 40	10.75	0.36					
ID	Name	d (in)	b (in)	t _w (in)	t _b (in)	r (in)		
17	HSS5x3x1/4	5.00	3.00	0.23	0.23	0.23		
ID	Name	d (in)	t _w (in)	b _t (in)	b _b (in)	t _t (in)	t _b (in)	r (in)
20	W10x12	9.87	0.19	3.96	3.96	0.21	0.21	0.30

Section Properties								
ID	Name	A (in ²)	J (in ⁴)	I _{yp} (in ⁴)	I _{zp} (in ⁴)	I _w (in ⁶)	S _{yp} (in ³)	S _{zp} (in ³)
3	2in Pipe Sch 120	1.67	1.91	0.96	0.96	0.00	1.13	1.13
6	4in Pipe Sch 120	5.58	23.29	11.64	11.64	0.00	7.24	7.24
11	10in Pipe Sch 40	11.91	321.47	160.73	160.73	0.00	39.38	39.38

17	HS55x3x1/4				3.37	11.00	4.81	10.70	62.42	3.77	5.38
20	W10x12				3.54	0.05	2.18	53.80	50.90	1.74	12.60

Member Properties													
Member ID	Section ID	K _{ZL} (ft)	K _{YL} (ft)	L _{b(f)} (ft)	C _b						L _S T	L _S C	L _D
1	11	23.40	23.40	11.15	-						300	200	1
2	6	1.30	1.30	2.00	-						300	200	1
3	17	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.19,1.17,1.17,1.14,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.26,1.16,1.1	7,1.17,1.26,1.16,1.17,1.17,1.16,1.17					300	200	1
4	17	2.44	2.44	3.75	1.70,1.70,1.70,1.70,1.70,1.67,1.67,1.65,1.69,1.67,1.67,1.65,1.69,1.68,1.68,1.62,1.69,1.6	8,1.68,1.62,1.69,1.67,1.67,1.66,1.69					300	200	1
5	17	1.52	1.52	2.33	1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.67,1.64,1.66,1.67,1.67,1.64,1.66,1.67,1.67,1.81,1.65,1.6	7,1.67,1.81,1.65,1.67,1.67,1.65,1.66					300	200	1
6	17	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.17,1.18,1.19,1.19,1.31,1.18,1.1	9,1.19,1.31,1.18,1.18,1.18,1.18,1.18					300	200	1
7	17	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.65,1.66,1.67,1.67,1.65,1.66,1.67,1.67,1.86,1.66,1.6	7,1.67,1.86,1.66,1.67,1.67,1.66,1.66					300	200	1
8	20	1.33	1.33	2.05	1.23,1.23,1.23,1.23,1.23,1.22,1.22,1.25,1.44,1.22,1.22,1.25,1.44,1.22,1.22,1.26,1.32,1.2	2,1.22,1.26,1.32,1.22,1.22,1.25,1.55					300	200	1
9	3	2.60	2.60	4.00	-						300	200	1
10	17	2.44	2.44	3.75	1.69,1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.67,1.66,1.66,1.69,1.67,1.67,1.67,1.64,1.69,1.6	7,1.67,1.64,1.69,1.67,1.67,1.66,1.69					300	200	1
11	20	1.33	1.33	2.05	1.24,1.24,1.24,1.24,1.24,1.25,1.25,1.19,1.28,1.25,1.25,1.19,1.28,1.25,1.25,1.25,2.09,1.30,1.2	5,1.25,2.09,1.30,1.25,1.25,1.20,1.28					300	200	1
12	6	1.30	1.30	2.00	-						300	200	1
13	20	4.88	4.00	7.50	1.48,1.48,1.48,1.48,1.48,1.48,1.44,1.44,1.48,1.48,1.48,1.48,1.45,1.45,1.45,2.09,1.54,1.4	5,1.45,2.09,1.54,1.44,1.44,1.64,1.49					300	200	1
14	20	4.88	4.00	7.50	1.49,1.49,1.49,1.49,1.49,1.49,1.49,1.49,1.49,1.49,1.49,1.49,1.49,1.58,1.58,1.58,1.63,1.74,1.5	8,1.58,1.63,1.74,1.60,1.60,1.56,2.05					300	200	1
15	20	2.10	2.10	1.00	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.3	3,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33					300	200	1
16	20	2.10	2.10	1.00	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.3	3,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33					300	200	1
101	11	23.40	23.40	11.15	-						300	200	1
102	6	1.30	1.30	2.00	-						300	200	1
103	17	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.28,1.17,1.1	8,1.18,1.28,1.17,1.18,1.18,1.17,1.18					300	200	1
104	17	2.44	2.44	3.75	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.66,1.69,1.67,1.67,1.66,1.69,1.67,1.67,1.64,1.69,1.6	7,1.67,1.64,1.69,1.67,1.67,1.66,1.69					300	200	1
105	17	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.65,1.66,1.67,1.67,1.65,1.66,1.67,1.67,1.86,1.66,1.6	7,1.67,1.86,1.66,1.67,1.67,1.66,1.67					300	200	1
106	17	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.27,1.17,1.1	8,1.18,1.27,1.17,1.18,1.18,1.17,1.18					300	200	1
107	17	1.52	1.52	2.33	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.65,1.66,1.67,1.67,1.65,1.66,1.67,1.67,1.81,1.66,1.6	7,1.67,1.81,1.66,1.67,1.67,1.66,1.66					300	200	1

108	20	1.33	1.33	2.0 5	2.34,2.34,2.34,2.34,2.34,2.34,2.32,2.32,2.10,1.37,2.32,2.32,2.10,1.37,2.33,2.33,2.09,1.68,2.3 3,2.33,2.09,1.68,2.32,2.32,2.11,1.28	3 0 0	2 0 0	1
109	3	2.60	2.60	4.0 0	-	3 0 0	2 0 0	1
110	17	2.44	2.44	3.7 5	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.66,1.69,1.67,1.67,1.66,1.69,1.67,1.67,1.64,1.68,1.6 7,1.67,1.64,1.68,1.67,1.67,1.66,1.69	3 0 0	2 0 0	1
111	20	1.33	1.33	2.0 5	2.28,2.28,2.28,2.28,2.28,2.10,2.10,2.18,2.06,2.10,2.10,2.18,2.06,2.11,2.11,1.18,1.91,2.1 1,2.11,1.18,1.91,2.10,2.10,2.25,2.06	3 0 0	2 0 0	1
112	6	1.30	1.30	2.0 0	-	3 0 0	2 0 0	1
113	20	4.88	4.00	7.5 0	1.05,1.05,1.05,1.05,1.05,1.05,1.06,1.06,1.04,1.08,1.06,1.06,1.04,1.08,1.06,1.06,1.06,1.13,1.0 6,1.06,1.06,1.13,1.06,1.06,1.04,1.08	3 0 0	2 0 0	1
114	20	4.88	4.00	7.5 0	1.05,1.05,1.05,1.05,1.05,1.05,1.05,1.06,3.58,1.05,1.05,1.06,3.58,1.05,1.05,1.05,1.07,1.27,1.0 5,1.05,1.07,1.27,1.05,1.05,1.06,1.57	3 0 0	2 0 0	1
115	20	6.63	6.63	10. 20	1.16,1.16,1.16,1.16,1.16,1.16,1.15,1.15,1.22,1.13,1.15,1.15,1.22,1.13,1.15,1.15,1.08,1.12,1.1 5,1.15,1.08,1.12,1.15,1.15,1.20,1.13	3 0 0	2 0 0	1
116	20	6.63	6.63	10. 20	1.16,1.16,1.16,1.16,1.16,1.16,1.18,1.18,1.15,1.07,1.18,1.18,1.15,1.07,1.17,1.17,1.14,1.11,1.1 7,1.17,1.14,1.11,1.18,1.18,1.15,1.06	3 0 0	2 0 0	1
201	11	23.4 0	23.4 0	11. 15	-	3 0 0	2 0 0	1
202	6	1.30	1.30	2.0 0	-	3 0 0	2 0 0	1
203	17	0.92	0.92	1.4 2	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.27,1.17,1.1 8,1.18,1.27,1.17,1.18,1.18,1.17,1.18	3 0 0	2 0 0	1
204	17	2.44	2.44	3.7 5	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.66,1.69,1.67,1.67,1.66,1.69,1.67,1.67,1.64,1.68,1.6 7,1.67,1.64,1.68,1.67,1.67,1.66,1.69	3 0 0	2 0 0	1
205	17	1.52	1.52	2.3 3	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.65,1.66,1.67,1.67,1.65,1.66,1.67,1.67,1.81,1.66,1.6 6,7,1.67,1.81,1.66,1.67,1.67,1.66,1.66	3 0 0	2 0 0	1
206	17	0.92	0.92	1.4 2	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.28,1.17,1.1 8,1.18,1.28,1.17,1.18,1.18,1.17,1.18	3 0 0	2 0 0	1
207	17	1.52	1.52	2.3 3	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.65,1.66,1.67,1.67,1.65,1.66,1.66,1.67,1.67,1.86,1.66,1.6 6,7,1.67,1.86,1.66,1.67,1.67,1.66,1.67	3 0 0	2 0 0	1
208	20	1.33	1.33	2.0 5	2.04,2.04,2.04,2.04,2.04,2.04,2.09,2.09,1.84,1.24,2.09,2.09,1.84,1.24,2.08,2.08,1.75,1.43,2.0 8,2.08,1.75,1.43,2.09,2.09,1.86,1.17	3 0 0	2 0 0	1
209	3	2.60	2.60	4.0 0	-	3 0 0	2 0 0	1
210	17	2.44	2.44	3.7 5	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.66,1.69,1.67,1.67,1.66,1.69,1.67,1.67,1.64,1.69,1.6 6,7,1.67,1.64,1.69,1.67,1.67,1.66,1.69	3 0 0	2 0 0	1
211	20	1.33	1.33	2.0 5	2.02,2.02,2.02,2.02,2.02,2.02,1.86,1.86,2.26,1.61,1.86,1.86,2.26,1.61,1.88,1.88,1.08,1.54,1.8 8,1.88,1.08,1.54,1.85,1.85,2.13,1.63	3 0 0	2 0 0	1
212	6	1.30	1.30	2.0 0	-	3 0 0	2 0 0	1
213	20	4.88	4.00	7.5 0	1.05,1.05,1.05,1.05,1.05,1.05,1.06,1.06,1.04,1.08,1.06,1.06,1.04,1.08,1.06,1.06,1.06,1.13,1.0 6,1.06,1.06,1.13,1.06,1.06,1.04,1.08	3 0 0	2 0 0	1
214	20	4.88	4.00	7.5 0	1.05,1.05,1.05,1.05,1.05,1.05,1.05,1.06,3.58,1.05,1.05,1.06,3.58,1.05,1.05,1.05,1.07,1.27,1.0 5,1.05,1.07,1.27,1.05,1.05,1.06,1.57	3 0 0	2 0 0	1
215	20	6.63	6.63	10. 20	1.17,1.17,1.17,1.17,1.17,1.17,1.16,1.16,1.23,1.14,1.16,1.16,1.23,1.14,1.16,1.16,1.06,1.14,1.1 1,6,1.16,1.06,1.14,1.16,1.16,1.22,1.15	3 0 0	2 0 0	1
216	20	6.63	6.63	10. 20	1.18,1.18,1.18,1.18,1.18,1.19,1.19,1.16,1.10,1.19,1.19,1.16,1.10,1.19,1.19,1.16,1.12,1.1 1,9,1.19,1.16,1.12,1.19,1.19,1.16,1.08	3 0 0	2 0 0	1
301	11	23.4 0	23.4 0	11. 15	-	3 0 0	2 0 0	1

302	6	1.30	1.30	2.0 0	-	3 0 0	2 0 0	1
303	17	0.92	0.92	1.4 2	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.19,1.19,1.31,1.18,1.1 9,1.19,1.31,1.18,1.18,1.18,1.18,1.18	3 0 0	2 0 0	1
304	17	2.44	2.44	3.7 5	1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.67,1.66,1.69,1.67,1.67,1.66,1.69,1.67,1.67,1.64,1.69,1.6 7,1.67,1.64,1.69,1.67,1.67,1.66,1.69	3 0 0	2 0 0	1
305	17	1.52	1.52	2.3 3	1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.65,1.66,1.67,1.67,1.65,1.66,1.67,1.67,1.86,1.66,1.6 7,1.67,1.86,1.66,1.67,1.67,1.66,1.66	3 0 0	2 0 0	1
306	17	0.92	0.92	1.4 2	1.19,1.19,1.19,1.19,1.19,1.19,1.17,1.17,1.14,1.17,1.17,1.17,1.14,1.17,1.17,1.17,1.26,1.16,1.1 7,1.17,1.26,1.16,1.17,1.17,1.16,1.17	3 0 0	2 0 0	1
307	17	1.52	1.52	2.3 3	1.69,1.69,1.69,1.69,1.69,1.69,1.67,1.67,1.64,1.66,1.67,1.67,1.64,1.66,1.67,1.67,1.81,1.65,1.6 7,1.67,1.81,1.65,1.67,1.67,1.65,1.66	3 0 0	2 0 0	1
308	20	2.10	2.10	1.0 0	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 3,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	3 0 0	2 0 0	1
309	3	2.60	2.60	4.0 0	-	3 0 0	2 0 0	1
310	17	2.44	2.44	3.7 5	1.70,1.70,1.70,1.70,1.70,1.70,1.67,1.67,1.65,1.69,1.69,1.67,1.67,1.65,1.69,1.68,1.68,1.62,1.69,1.6 8,1.68,1.62,1.69,1.67,1.67,1.66,1.69	3 0 0	2 0 0	1
311	20	2.10	2.10	1.0 0	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.3 3,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	3 0 0	2 0 0	1
312	6	1.30	1.30	2.0 0	-	3 0 0	2 0 0	1
313	20	4.88	4.00	7.5 0	1.48,1.48,1.48,1.48,1.48,1.48,1.44,1.44,1.68,1.50,1.44,1.44,1.68,1.50,1.45,1.45,2.09,1.54,1.4 5,1.45,2.09,1.54,1.44,1.44,1.64,1.49	3 0 0	2 0 0	1
314	20	4.88	4.00	7.5 0	1.49,1.49,1.49,1.49,1.49,1.49,1.60,1.60,1.57,1.96,1.60,1.60,1.57,1.96,1.58,1.58,1.58,1.63,1.74,1.5 8,1.58,1.63,1.74,1.60,1.60,1.56,2.05	3 0 0	2 0 0	1
315	20	6.63	6.63	10. 20	1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08 8,1.08,1.23,1.08,1.08,1.08,1.08,1.08	3 0 0	2 0 0	1
316	20	6.63	6.63	10. 20	1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08 8,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08	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	535.87	349.53	147.68	147.68	160.76	160.76
2	251.01	248.88	27.16	27.16	75.30	75.30
3	151.65	150.70	20.17	14.14	54.12	28.95
4	151.65	145.15	20.17	14.14	54.12	28.95
5	151.65	149.10	20.17	14.14	54.12	28.95
6	151.65	150.70	20.17	14.14	54.12	28.95
7	151.65	149.10	20.17	14.14	54.12	28.95
8	159.30	142.47	46.90	6.46	56.26	44.91
9	75.10	66.32	4.25	4.25	22.53	22.53
10	151.65	145.15	20.17	14.14	54.12	28.95
11	159.30	142.47	46.90	6.46	56.26	44.91
12	251.01	248.88	27.16	27.16	75.30	75.30
13	159.30	116.35	44.01	6.46	56.26	44.91
14	159.30	116.35	45.54	6.46	56.26	44.91
15	159.30	137.23	46.90	6.46	56.26	44.91
16	159.30	137.23	46.90	6.46	56.26	44.91
101	535.87	349.53	147.68	147.68	160.76	160.76
102	251.01	248.88	27.16	27.16	75.30	75.30
103	151.65	150.70	20.17	14.14	54.12	28.95

103	104.05	105.00	106.11	107.14	108.12	109.95
104	151.65	145.15	20.17	14.14	54.12	28.95
105	151.65	149.10	20.17	14.14	54.12	28.95
106	151.65	150.70	20.17	14.14	54.12	28.95
107	151.65	149.10	20.17	14.14	54.12	28.95
108	159.30	142.47	46.90	6.46	56.26	44.91
109	75.10	66.32	4.25	4.25	22.53	22.53
110	151.65	145.15	20.17	14.14	54.12	28.95
111	159.30	142.47	46.90	6.46	56.26	44.91
112	251.01	248.88	27.16	27.16	75.30	75.30
113	159.30	116.35	31.78	6.46	56.26	44.91
114	159.30	116.35	32.09	6.46	56.26	44.91
115	159.30	75.13	20.80	6.46	56.26	44.91
116	159.30	75.13	20.41	6.46	56.26	44.91
201	535.87	349.53	147.68	147.68	160.76	160.76
202	251.01	248.88	27.16	27.16	75.30	75.30
203	151.65	150.70	20.17	14.14	54.12	28.95
204	151.65	145.15	20.17	14.14	54.12	28.95
205	151.65	149.10	20.17	14.14	54.12	28.95
206	151.65	150.70	20.17	14.14	54.12	28.95
207	151.65	149.10	20.17	14.14	54.12	28.95
208	159.30	142.47	46.90	6.46	56.26	44.91
209	75.10	66.32	4.25	4.25	22.53	22.53
210	151.65	145.15	20.17	14.14	54.12	28.95
211	159.30	142.47	46.90	6.46	56.26	44.91
212	251.01	248.88	27.16	27.16	75.30	75.30
213	159.30	116.35	31.78	6.46	56.26	44.91
214	159.30	116.35	32.09	6.46	56.26	44.91
215	159.30	75.13	20.41	6.46	56.26	44.91
216	159.30	75.13	20.80	6.46	56.26	44.91
301	535.87	349.53	147.68	147.68	160.76	160.76
302	251.01	248.88	27.16	27.16	75.30	75.30
303	151.65	150.70	20.17	14.14	54.12	28.95
304	151.65	145.15	20.17	14.14	54.12	28.95
305	151.65	149.10	20.17	14.14	54.12	28.95
306	151.65	150.70	20.17	14.14	54.12	28.95
307	151.65	149.10	20.17	14.14	54.12	28.95
308	159.30	137.23	46.90	6.46	56.26	44.91
309	75.10	66.32	4.25	4.25	22.53	22.53
310	151.65	145.15	20.17	14.14	54.12	28.95
311	159.30	137.23	46.90	6.46	56.26	44.91
312	251.01	248.88	27.16	27.16	75.30	75.30
313	159.30	116.35	44.01	6.46	56.26	44.91
314	159.30	116.35	45.54	6.46	56.26	44.91
315	159.30	75.13	20.80	6.46	56.26	44.91
316	159.30	75.13	20.80	6.46	56.26	44.91

Design Ratio

Member ID	P	M _z	M _y	V _y	V _z	(P,M _z ,M _y)	Worst LC	KL/r	δ	Status
1	0.031	0.176	0.039	0.006	0.004	0.183	#32	0.382	Not Required	Pass
2	0.001	0.219	0.026	0.053	0.005	0.245	#13	0.054	Not Required	Pass
3	0.001	0.449	0.020	0.044	0.004	0.469	#13	0.046	Not Required	Pass
4	0.001	0.200	0.021	0.020	0.006	0.221	#12	0.122	Not Required	Pass

4	0.001	0.300	0.031	0.030	0.006	0.551	#13	0.122	Not Required	Pass
5	0.001	0.278	0.013	0.045	0.005	0.291	#13	0.076	Not Required	Pass
6	0.001	0.668	0.028	0.069	0.007	0.696	#13	0.046	Not Required	Pass
7	0.001	0.414	0.017	0.066	0.006	0.427	#13	0.076	Not Required	Pass
8	0.002	0.107	0.030	0.027	0.002	0.123	#13	0.102	Not Required	Pass
9	0.001	0.083	0.029	0.004	0.002	0.112	#13	0.206	Not Required	Pass
10	0.001	0.470	0.027	0.047	0.006	0.498	#13	0.082	Not Required	Pass
11	0.002	0.146	0.027	0.041	0.002	0.156	#13	0.102	Not Required	Pass
12	0.001	0.430	0.043	0.083	0.008	0.473	#13	0.054	Not Required	Pass
13	0.003	0.067	0.048	0.054	0.002	0.096	#13	0.306	Not Required	Pass
14	0.003	0.055	0.051	0.037	0.003	0.076	#13	0.204	Not Required	Pass
15	0.000	0.005	0.001	0.008	0.000	0.005	#13	Not Required	Not Required	Pass
16	0.000	0.003	0.001	0.005	0.000	0.004	#13	Not Required	Not Required	Pass
101	0.045	0.241	0.005	0.009	0.001	0.245	#32	0.382	Not Required	Pass
102	0.000	0.505	0.053	0.104	0.010	0.558	#13	0.054	Not Required	Pass
103	0.001	0.835	0.008	0.084	0.001	0.843	#13	0.046	Not Required	Pass
104	0.001	0.602	0.013	0.060	0.002	0.607	#13	0.082	Not Required	Pass
105	0.001	0.517	0.017	0.083	0.005	0.523	#13	0.076	Not Required	Pass
106	0.001	0.814	0.007	0.081	0.002	0.816	#13	0.046	Not Required	Pass
107	0.001	0.505	0.010	0.081	0.003	0.507	#13	0.076	Not Required	Pass
108	0.002	0.042	0.011	0.033	0.001	0.053	#13	0.102	Not Required	Pass
109	0.001	0.078	0.014	0.001	0.000	0.093	#13	0.206	Not Required	Pass
110	0.001	0.571	0.012	0.057	0.003	0.582	#13	0.082	Not Required	Pass
111	0.002	0.052	0.011	0.047	0.001	0.056	#13	0.102	Not Required	Pass
112	0.000	0.478	0.051	0.100	0.010	0.530	#13	0.054	Not Required	Pass
113	0.003	0.250	0.041	0.066	0.002	0.256	#13	0.306	Not Required	Pass
114	0.004	0.207	0.044	0.048	0.002	0.219	#13	0.306	Not Required	Pass
115	0.004	0.409	0.023	0.053	0.001	0.427	#13	0.507	Not Required	Pass
116	0.005	0.284	0.024	0.038	0.001	0.300	#13	0.507	Not Required	Pass
201	0.045	0.241	0.005	0.009	0.001	0.245	#32	0.382	Not Required	Pass
202	0.000	0.478	0.051	0.100	0.010	0.530	#13	0.054	Not Required	Pass
203	0.001	0.814	0.007	0.081	0.002	0.816	#13	0.046	Not Required	Pass
204	0.001	0.571	0.012	0.057	0.003	0.582	#13	0.082	Not Required	Pass
205	0.001	0.505	0.010	0.081	0.003	0.507	#13	0.076	Not Required	Pass
206	0.001	0.835	0.008	0.084	0.001	0.843	#13	0.046	Not Required	Pass
207	0.001	0.517	0.017	0.083	0.005	0.523	#13	0.076	Not Required	Pass
208	0.002	0.052	0.024	0.038	0.001	0.059	#13	0.102	Not Required	Pass
209	0.001	0.078	0.014	0.001	0.000	0.093	#13	0.206	Not Required	Pass
210	0.001	0.602	0.013	0.060	0.002	0.607	#13	0.082	Not Required	Pass
211	0.002	0.089	0.023	0.053	0.001	0.095	#13	0.102	Not Required	Pass
212	0.000	0.505	0.053	0.104	0.010	0.558	#13	0.054	Not Required	Pass
213	0.003	0.250	0.041	0.066	0.002	0.256	#13	0.306	Not Required	Pass
214	0.004	0.207	0.044	0.048	0.002	0.219	#13	0.306	Not Required	Pass
215	0.003	0.265	0.016	0.047	0.001	0.283	#13	0.507	Not Required	Pass
216	0.004	0.161	0.016	0.033	0.001	0.176	#13	0.507	Not Required	Pass
301	0.031	0.176	0.039	0.006	0.004	0.183	#32	0.382	Not Required	Pass
302	0.001	0.430	0.043	0.083	0.008	0.473	#13	0.054	Not Required	Pass
303	0.001	0.668	0.028	0.069	0.007	0.696	#13	0.046	Not Required	Pass
304	0.001	0.470	0.027	0.047	0.006	0.498	#13	0.082	Not Required	Pass
305	0.001	0.414	0.017	0.066	0.006	0.427	#13	0.076	Not Required	Pass
306	0.001	0.449	0.020	0.044	0.004	0.469	#13	0.046	Not Required	Pass
307	0.001	0.278	0.013	0.045	0.005	0.291	#13	0.076	Not Required	Pass
308	0.000	0.003	0.001	0.005	0.000	0.004	#13	Not Required	Not Required	Pass
309	0.001	0.083	0.029	0.004	0.002	0.112	#13	0.206	Not Required	Pass

310	0.001	0.300	0.031	0.030	0.006	0.331	#13	0.122	Not Required	Pass
311	0.000	0.005	0.001	0.008	0.000	0.005	#13	Not Required	Not Required	Pass
312	0.001	0.219	0.026	0.053	0.005	0.245	#13	0.054	Not Required	Pass
313	0.003	0.067	0.048	0.054	0.002	0.096	#13	0.204	Not Required	Pass
314	0.003	0.055	0.051	0.037	0.003	0.076	#13	0.306	Not Required	Pass
315	0.004	0.441	0.027	0.041	0.002	0.457	#13	0.507	Not Required	Pass
316	0.005	0.307	0.030	0.027	0.002	0.327	#13	0.507	Not Required	Pass

Definitions

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

REFERENCES	CALCULATIONS	RESULTS																										
	<p>SkyCiv Foundation Design Pile Foundation</p> <p>Design Information : Design code : IBC 2021 (International Building Code) Unit System : Imperial</p>																											
	<p>Pile Input</p> <p>Geometry</p> <p>Pile shape: 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>7.137</td> <td>10.853</td> </tr> <tr> <td>V_x (kip)</td> <td>-0.612</td> <td>-1.031</td> </tr> <tr> <td>V_z (kip)</td> <td>0.433</td> <td>0.675</td> </tr> <tr> <td>M_x (kipft)</td> <td>1.148</td> <td>1.790</td> </tr> <tr> <td>M_z (kipft)</td> <td>15.531</td> <td>25.970</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> $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-0.612 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.097452 \text{ kip/ft}$ <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)	7.137	10.853	V_x (kip)	-0.612	-1.031	V_z (kip)	0.433	0.675	M_x (kipft)	1.148	1.790	M_z (kipft)	15.531	25.970	
Layer	Label	Allowable Bearing Pressure (q_a) (psf)	Allowable Lateral Pressure (R) (psf/ft)																									
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M_x (kipft)	1.148	1.790																										
M_z (kipft)	15.531	25.970																										

$$M_o = \frac{(15.531 \text{ kipft}) + ((-0.612 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 2.4731 \text{ kipft/ft}$$

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:

$L_{e,x} = 5.4929 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.433 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.068949 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(1.148 \text{ kipft}) + ((0.433 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.1828 \text{ kipft/ft}$$

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:

$L_{e,z} = 3.0015 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(5.4929 \text{ ft}), (3.0015 \text{ ft})]$$

$$L_{e,req} = 5.493 \text{ ft}$$

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

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

$$Ratio = \frac{(5.493 \text{ ft})}{(5.75 \text{ ft})}$$

$$Ratio = 0.9553$$

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

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = b D$$

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

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

q - End-bearing pressure

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

$$q = \frac{(7.137 \text{ kip})}{(16 \text{ ft}^2)}$$

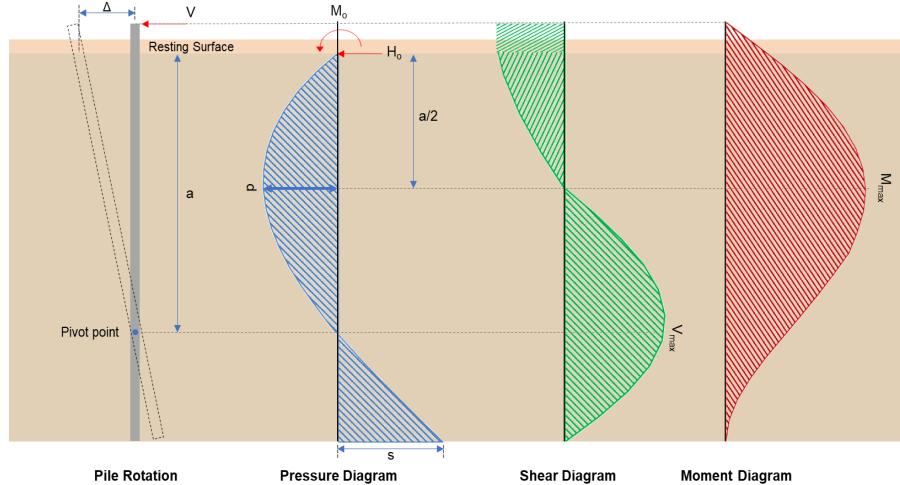
	$q = 0.44606 \text{ kip/ft}^2$	
	<p>Check bearing capacity ratio:</p> <p><i>Ratio - Capacity</i></p> $Ratio = \frac{q}{q_a}$ $Ratio = \frac{(0.44606 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $Ratio = 0.22303$	
		Status: PASS Ratio: 0.220
Czerniak	<p>Lateral Soil Pressure (ASD):</p> <p><i>L/D - Length to 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, Pile is short.</p> <p>Considering x-direction:</p> <p>$H_o = -0.097452 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 2.4731 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (2.4731 \text{ kipft/ft}) \times (5.75 \text{ ft})) + (3 \times (-0.097452 \text{ kip/ft}) \times (5.75 \text{ ft})^2)}{(6 \times (2.4731 \text{ kipft/ft})) + (4 \times (-0.097452 \text{ kip/ft}) \times (5.75 \text{ ft}))}$ $a = 3.8962 \text{ ft}$ <p><i>p</i> - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (2.4731 \text{ kipft/ft})) + (3 \times (-0.097452 \text{ kip/ft}) \times (5.75 \text{ ft}))]^2}{(5.75 \text{ ft})^2 \times [(3 \times (2.4731 \text{ kipft/ft})) + (2 \times (-0.097452 \text{ kip/ft}) \times (5.75 \text{ ft}))]}$ $p = 0.24283 \text{ kip/ft}^2$ <p><i>s</i> - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (2.4731 \text{ kipft/ft})) + ((-0.097452 \text{ kip/ft}) \times (5.75 \text{ ft}))]}{(5.75 \text{ ft})^2}$ $s = 0.79592 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p><i>p_a</i> - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(3.8962 \text{ ft})}{2}$ $p_a = 0.29222 \text{ kip/ft}^2$ <p><i>Ratio - Lateral soil capacity</i></p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.24283 \text{ kip/ft}^2)}{(0.29222 \text{ kip/ft}^2)}$ $Ratio = 0.83101$ <p><i>p_s</i> - Allowable lateral soil pressure at depth L_e,</p>	Status: PASS Ratio: 0.830

	$p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (5.75 \text{ ft})$ $p_s = 0.8625 \text{ kip/ft}^2$ <i>Ratio</i> - Lateral soil capacity $Ratio = \frac{s}{p_s}$ $Ratio = \frac{(0.79592 \text{ kip/ft}^2)}{(0.8625 \text{ kip/ft}^2)}$ $Ratio = 0.9228$ Status: PASS Ratio: 0.920
	<p>Considering z-direction:</p> <p>$H_o = 0.068949 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 0.1828 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.1828 \text{ kipft/ft}) \times (5.75 \text{ ft})) + (3 \times (0.068949 \text{ kip/ft}) \times (5.75 \text{ ft})^2)}{(6 \times (0.1828 \text{ kipft/ft})) + (4 \times (0.068949 \text{ kip/ft}) \times (5.75 \text{ ft}))}$ $a = 4.1166 \text{ ft}$ <p>p - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.1828 \text{ kipft/ft})) + (3 \times (0.068949 \text{ kip/ft}) \times (5.75 \text{ ft}))]^2}{(5.75 \text{ ft})^2 \times [(3 \times (0.1828 \text{ kipft/ft})) + (2 \times (0.068949 \text{ kip/ft}) \times (5.75 \text{ ft}))]}$ $p = 0.062382 \text{ kip/ft}^2$ <p>s - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.1828 \text{ kipft/ft})) + ((0.068949 \text{ kip/ft}) \times (5.75 \text{ ft}))]}{(5.75 \text{ ft})^2}$ $s = 0.13829 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p>p_a - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.1166 \text{ ft})}{2}$ $p_a = 0.30874 \text{ kip/ft}^2$ <p><i>Ratio</i> - Lateral soil capacity</p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.062382 \text{ kip/ft}^2)}{(0.30874 \text{ kip/ft}^2)}$ $Ratio = 0.20205$ Status: PASS Ratio: 0.200 <p>p_s - Allowable lateral soil pressure at depth L_e,</p> $p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (5.75 \text{ ft})$ $p_s = 0.8625 \text{ kip/ft}^2$ <p><i>Ratio</i> - Lateral soil capacity</p> $Ratio = \frac{s}{p_s}$

$$Ratio = \frac{(0.13829 \text{ kip}/\text{ft}^2)}{(0.8625 \text{ kip}/\text{ft}^2)}$$

$$Ratio = 0.16034$$

Status: **PASS**
Ratio: **0.160**



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-1.031 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.16417 \text{ kip}/\text{ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(25.97 \text{ kipft}) + ((-1.031 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 4.1354 \text{ kipft}/\text{ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(4.1354 \text{ kipft}/\text{ft})}{(-0.16417 \text{ kip}/\text{ft})}$$

$$E = 25.189 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (4.1354 \text{ kipft}/\text{ft}) \times (5.75 \text{ ft})) + (3 \times (-0.16417 \text{ kip}/\text{ft}) \times (5.75 \text{ ft})^2)}{(6 \times (4.1354 \text{ kipft}/\text{ft})) + (4 \times (-0.16417 \text{ kip}/\text{ft}) \times (5.75 \text{ ft}))}$$

$$a = 3.8966 \text{ ft}$$

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

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

$$V_{max} = ((-0.16417 \text{ kip}/\text{ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (25.189 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(3.8966 \text{ ft})}{(5.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (25.189 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(3.8966 \text{ ft})}{(5.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 5.5326 \text{ kip}$$

<p>M_{max} - Max bending moment located at depth $a/2$,</p> $M_{max} = (H_o D L_e) \left[\left(\frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[\left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{2 L_e} \right)^3 \right] + \left[\left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{2 L_e} \right)^4 \right] \right]$ $M_{max} = ((-0.16417 \text{ kip/ft}) \times (48 \text{ in}) \times (5.75 \text{ ft})) \times \left[\left(\frac{(25.189 \text{ ft})}{(5.75 \text{ ft})} + \frac{(3.8966 \text{ ft})}{2 \times (5.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (25.189 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{3.8966 \text{ ft}}{2 \times (5.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (25.189 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{3.8966 \text{ ft}}{2 \times (5.75 \text{ ft})} \right)^4 \right] \right]$ $M_{max} = 15.56 \text{ kipft}$
<p>Shear force and Bending moment (z-direction, LRFD)</p> <p>H_o - Lateral force per length of pile,</p> $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(0.675 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = 0.10748 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(1.79 \text{ kipft}) + ((0.675 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.28503 \text{ kipft/ft}$ <p>E - Distance from lateral load to resisting surface,</p> $E = \frac{M_o}{H_o}$ $E = \frac{(0.28503 \text{ kipft/ft})}{(0.10748 \text{ kip/ft})}$ $E = 2.6519 \text{ ft}$ <p>a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.28503 \text{ kipft/ft}) \times (5.75 \text{ ft})) + (3 \times (0.10748 \text{ kip/ft}) \times (5.75 \text{ ft})^2)}{(6 \times (0.28503 \text{ kipft/ft})) + (4 \times (0.10748 \text{ kip/ft}) \times (5.75 \text{ ft}))}$ $a = 4.1166 \text{ ft}$ <p>V_{max} - Max shear force located at depth a,</p> $V_{max} = (H_o b) \left[1 - \left[3 \left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{L_e} \right)^2 \right] + \left[4 \left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{L_e} \right)^3 \right] \right]$ $V_{max} = ((0.10748 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (2.6519 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.1166 \text{ ft})}{(5.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (2.6519 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.1166 \text{ ft})}{(5.75 \text{ ft})} \right)^3 \right] \right]$ $V_{max} = 0.63767 \text{ kip}$ <p>M_{max} - Max bending moment located at depth $a/2$,</p> $M_{max} = (H_o b L_e) \left[\left(\frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[\left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{2 L_e} \right)^3 \right] + \left[\left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{2 L_e} \right)^4 \right] \right]$ $M_{max} = ((0.10748 \text{ kip/ft}) \times (48 \text{ in}) \times (5.75 \text{ ft})) \times \left[\left(\frac{(2.6519 \text{ ft})}{(5.75 \text{ ft})} + \frac{(4.1166 \text{ ft})}{2 \times (5.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (2.6519 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.1166 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (2.6519 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.1166 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^4 \right] \right]$

	$M_{max} = 1.613 \text{ kipft}$	
	<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	$A_{st,required} = Min \left[\frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = Min \left[\frac{\frac{(10.853 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (3 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -101.9 \text{ in}^2$ <p>A_{min} - Governing minimum reinforcement area,</p> $A_{min} = Max [A_{st,required}, (0.0018 A_g)]$ $A_{min} = Max [(-101.9 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ <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> $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(10.853 \text{ kip})}{(3183.4 \text{ kip})}$ $Ratio = 0.0034092$	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 $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$, $P = 10.853 \text{ kip} \rightarrow 10853 \text{ lbf}$,</p> <p>$V_{c,a}$ - Shear strength of concrete (a)</p> $V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + \frac{(10853 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 131.24 \text{ kip}$ <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> $V_c = Min [V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = Min [(324.49 \text{ kip}), (131.24 \text{ kip}), (406.27 \text{ kip})]$ $V_c = 131.24 \text{ kip}$	
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> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((131.24 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 118.39 \text{ kip}$	
	<p>Considering x-direction:</p> <p>$V_{max} = 5.5326 \text{ kip}$ - Maximum shear force in the x-direction, $Ratio$ - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(5.5326 \text{ kip})}{(118.39 \text{ kip})}$ $Ratio = 0.046733$	Status: PASS Ratio: 0.050
	<p>Considering z-direction:</p> <p>$V_{max} = 0.63767 \text{ kip}$ - Maximum shear force in the z-direction, $Ratio$ - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.63767 \text{ kip})}{(118.39 \text{ kip})}$ $Ratio = 0.0053863$	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> $\phi M_{n,2} = \phi \cdot 0.85 f'_{ck} S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (3 \text{ ksi}) \times (18432 \text{ in}^3)$ $\phi M_{n,2} = 2545.9 \text{ kipft}$ <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>$M_{max} = 15.56 \text{ kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(15.56 \text{ kipft})}{(273.42 \text{ kipft})}$ $Ratio = 0.056908$	Status: PASS Ratio: 0.060
	<p>Considering z-direction:</p> <p>$M_{max} = 1.613 \text{ kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(1.613 \text{ kipft})}{(273.42 \text{ kipft})}$ $Ratio = 0.0058994$	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>7.137</td> <td>10.853</td> </tr> <tr> <td>V_x (kip)</td> <td>-0.612</td> <td>-1.031</td> </tr> <tr> <td>V_z (kip)</td> <td>-0.433</td> <td>-0.675</td> </tr> <tr> <td>M_x (kipft)</td> <td>-1.148</td> <td>-1.790</td> </tr> <tr> <td>M_z (kipft)</td> <td>15.531</td> <td>25.971</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> $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-0.612 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.097452 \text{ kip/ft}$ <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)	7.137	10.853	V_x (kip)	-0.612	-1.031	V_z (kip)	-0.433	-0.675	M_x (kipft)	-1.148	-1.790	M_z (kipft)	15.531	25.971	
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$$M_o = \frac{(15.531 \text{ kipft}) + ((-0.612 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 2.4731 \text{ kipft/ft}$$

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:

$L_{e,x} = 5.4929 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.433 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.068949 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(1.148 \text{ kipft}) + ((-0.433 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.1828 \text{ kipft/ft}$$

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:

$L_{e,z} = 1.8936 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = MAX[(5.4929 \text{ ft}), (1.8936 \text{ ft})]$$

$$L_{e,req} = 5.493 \text{ ft}$$

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

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

$$Ratio = \frac{(5.493 \text{ ft})}{(5.75 \text{ ft})}$$

$$Ratio = 0.9553$$

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

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = b D$$

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

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

q - End-bearing pressure

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

$$q = \frac{(7.137 \text{ kip})}{(16 \text{ ft}^2)}$$

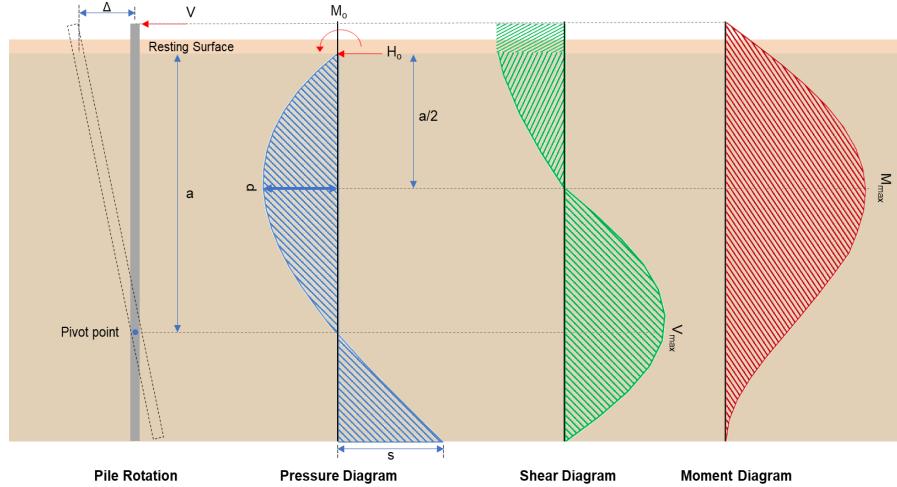
	$q = 0.44606 \text{ kip/ft}^2$	
	<p>Check bearing capacity ratio:</p> <p><i>Ratio - Capacity</i></p> $Ratio = \frac{q}{q_a}$ $Ratio = \frac{(0.44606 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $Ratio = 0.22303$	Status: PASS Ratio: 0.220
Czerniak	<p>Lateral Soil Pressure (ASD):</p> <p><i>L/D - Length to least 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>$H_o = -0.097452 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 2.4731 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (2.4731 \text{ kipft/ft}) \times (5.75 \text{ ft})) + (3 \times (-0.097452 \text{ kip/ft}) \times (5.75 \text{ ft})^2)}{(6 \times (2.4731 \text{ kipft/ft})) + (4 \times (-0.097452 \text{ kip/ft}) \times (5.75 \text{ ft}))}$ $a = 3.8962 \text{ ft}$ <p><i>p</i> - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (2.4731 \text{ kipft/ft})) + (3 \times (-0.097452 \text{ kip/ft}) \times (5.75 \text{ ft}))]^2}{(5.75 \text{ ft})^2 \times [(3 \times (2.4731 \text{ kipft/ft})) + (2 \times (-0.097452 \text{ kip/ft}) \times (5.75 \text{ ft}))]}$ $p = 0.24283 \text{ kip/ft}^2$ <p><i>s</i> - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (2.4731 \text{ kipft/ft})) + ((-0.097452 \text{ kip/ft}) \times (5.75 \text{ ft}))]}{(5.75 \text{ ft})^2}$ $s = 0.79592 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p><i>p_a</i> - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(3.8962 \text{ ft})}{2}$ $p_a = 0.29222 \text{ kip/ft}^2$ <p><i>Ratio - Lateral soil capacity</i></p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.24283 \text{ kip/ft}^2)}{(0.29222 \text{ kip/ft}^2)}$ $Ratio = 0.83101$ <p><i>p_s</i> - Allowable lateral soil pressure at depth L_e,</p>	Status: PASS Ratio: 0.830

	$p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (5.75 \text{ ft})$ $p_s = 0.8625 \text{ kip/ft}^2$ <i>Ratio - Lateral soil capacity</i> $Ratio = \frac{s}{p_s}$ $Ratio = \frac{(0.79592 \text{ kip/ft}^2)}{(0.8625 \text{ kip/ft}^2)}$ $Ratio = 0.9228$ Status: PASS Ratio: 0.920	
	<p>Considering z-direction:</p> <p>$H_o = -0.068949 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 0.1828 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.1828 \text{ kipft/ft}) \times (5.75 \text{ ft})) + (3 \times (-0.068949 \text{ kip/ft}) \times (5.75 \text{ ft})^2)}{(6 \times (0.1828 \text{ kipft/ft})) + (4 \times (-0.068949 \text{ kip/ft}) \times (5.75 \text{ ft}))}$ $a = 4.1166 \text{ ft}$ <p>p - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.1828 \text{ kipft/ft})) + (3 \times (-0.068949 \text{ kip/ft}) \times (5.75 \text{ ft}))]^2}{(5.75 \text{ ft})^2 \times [(3 \times (0.1828 \text{ kipft/ft})) + (2 \times (-0.068949 \text{ kip/ft}) \times (5.75 \text{ ft}))]}$ $p = -0.019475 \text{ kip/ft}^2$ <p>s - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.1828 \text{ kipft/ft})) + ((-0.068949 \text{ kip/ft}) \times (5.75 \text{ ft}))]}{(5.75 \text{ ft})^2}$ $s = -0.0055988 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p>p_a - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.1166 \text{ ft})}{2}$ $p_a = 0.30874 \text{ kip/ft}^2$ <p><i>Ratio - Lateral soil capacity</i></p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(-0.019475 \text{ kip/ft}^2)}{(0.30874 \text{ kip/ft}^2)}$ $Ratio = -0.063077$ Status: PASS Ratio: -0.060	

$$Ratio = \frac{(-0.0055988 \text{ kip}/\text{ft}^2)}{(0.8625 \text{ kip}/\text{ft}^2)}$$

$$Ratio = -0.0064914$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-1.031 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.16417 \text{ kip}/\text{ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(25.971 \text{ kipft}) + ((-1.031 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 4.1355 \text{ kipft}/\text{ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(4.1355 \text{ kipft}/\text{ft})}{(-0.16417 \text{ kip}/\text{ft})}$$

$$E = 25.19 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (4.1355 \text{ kipft}/\text{ft}) \times (5.75 \text{ ft})) + (3 \times (-0.16417 \text{ kip}/\text{ft}) \times (5.75 \text{ ft})^2)}{(6 \times (4.1355 \text{ kipft}/\text{ft})) + (4 \times (-0.16417 \text{ kip}/\text{ft}) \times (5.75 \text{ ft}))}$$

$$a = 3.8966 \text{ ft}$$

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

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

$$V_{max} = ((-0.16417 \text{ kip}/\text{ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (25.19 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(3.8966 \text{ ft})}{(5.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (25.19 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(3.8966 \text{ ft})}{(5.75 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 5.5328 \text{ kip}$$

<p>M_{max} - Max bending moment located at depth $a/2$,</p> $M_{max} = (H_o D L_e) \left[\left(\frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[\left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{2 L_e} \right)^3 \right] + \left[\left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{2 L_e} \right)^4 \right] \right]$ $M_{max} = ((-0.16417 \text{ kip/ft}) \times (48 \text{ in}) \times (5.75 \text{ ft})) \times \left[\left(\frac{(25.19 \text{ ft})}{(5.75 \text{ ft})} + \frac{(3.8966 \text{ ft})}{2 \times (5.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (25.19 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{3.8966 \text{ ft}}{2 \times (5.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (25.19 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{3.8966 \text{ ft}}{2 \times (5.75 \text{ ft})} \right)^4 \right] \right]$ $M_{max} = 15.56 \text{ kipft}$
<p>Shear force and Bending moment (z-direction, LRFD)</p> <p>H_o - Lateral force per length of pile,</p> $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(-0.675 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.10748 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(1.79 \text{ kipft}) + ((-0.675 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.28503 \text{ kipft/ft}$ <p>E - Distance from lateral load to resisting surface,</p> $E = \frac{M_o}{H_o}$ $E = \frac{(0.28503 \text{ kipft/ft})}{(-0.10748 \text{ kip/ft})}$ $E = 2.6519 \text{ ft}$ <p>a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.28503 \text{ kipft/ft}) \times (5.75 \text{ ft})) + (3 \times (-0.10748 \text{ kip/ft}) \times (5.75 \text{ ft})^2)}{(6 \times (0.28503 \text{ kipft/ft})) + (4 \times (-0.10748 \text{ kip/ft}) \times (5.75 \text{ ft}))}$ $a = 4.1166 \text{ ft}$ <p>V_{max} - Max shear force located at depth a,</p> $V_{max} = (H_o b) \left[1 - \left[3 \left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{L_e} \right)^2 \right] + \left[4 \left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{L_e} \right)^3 \right] \right]$ $V_{max} = ((-0.10748 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (2.6519 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.1166 \text{ ft})}{(5.75 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (2.6519 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.1166 \text{ ft})}{(5.75 \text{ ft})} \right)^3 \right] \right]$ $V_{max} = 0.63767 \text{ kip}$ <p>M_{max} - Max bending moment located at depth $a/2$,</p> $M_{max} = (H_o b L_e) \left[\left(\frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[\left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{2 L_e} \right)^3 \right] + \left[\left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{2 L_e} \right)^4 \right] \right]$ $M_{max} = ((-0.10748 \text{ kip/ft}) \times (48 \text{ in}) \times (5.75 \text{ ft})) \times \left[\left(\frac{(2.6519 \text{ ft})}{(5.75 \text{ ft})} + \frac{(4.1166 \text{ ft})}{2 \times (5.75 \text{ ft})} \right) - \left[\left(\frac{4 \times (2.6519 \text{ ft})}{(5.75 \text{ ft})} + 3 \right) \times \left(\frac{(4.1166 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (2.6519 \text{ ft})}{(5.75 \text{ ft})} + 2 \right) \times \left(\frac{(4.1166 \text{ ft})}{2 \times (5.75 \text{ ft})} \right)^4 \right] \right]$

	$M_{max} = 1.613 \text{ kipft}$	
	<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> $A_{st,required} = Min \left[\frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = Min \left[\frac{\frac{(10.853 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (3 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -101.9 \text{ in}^2$ <p>A_{min} - Governing minimum reinforcement area,</p> $A_{min} = Max [A_{st,required}, (0.0018 A_g)]$ $A_{min} = Max [(-101.9 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ <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> $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(10.853 \text{ kip})}{(3183.4 \text{ kip})}$ $Ratio = 0.0034092$	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 $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$, $P = 10.853 \text{ kip} \rightarrow 10853 \text{ lbf}$,</p> <p>$V_{c,a}$ - Shear strength of concrete (a)</p> $V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + \frac{(10853 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 131.24 \text{ kip}$ <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> $V_c = Min [V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = Min [(324.49 \text{ kip}), (131.24 \text{ kip}), (406.27 \text{ kip})]$ $V_c = 131.24 \text{ kip}$	
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 $f'_{ck} = 3$ ksi $\rightarrow 3000$ psi, $V_{s,a}$ - 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> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((131.24 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 118.39 \text{ kip}$	
	<p>Considering x-direction:</p> <p>$V_{max} = 5.5328$ kip - Maximum shear force in the x-direction, $Ratio$ - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(5.5328 \text{ kip})}{(118.39 \text{ kip})}$ $Ratio = 0.046734$	Status: PASS Ratio: 0.050
	<p>Considering z-direction:</p> <p>$V_{max} = 0.63767$ kip - Maximum shear force in the z-direction, $Ratio$ - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.63767 \text{ kip})}{(118.39 \text{ kip})}$ $Ratio = 0.0053863$	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>$M_{max} = 15.56 \text{ kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(15.56 \text{ kipft})}{(273.42 \text{ kipft})}$ $Ratio = 0.05691$	Status: PASS Ratio: 0.060
	<p>Considering z-direction:</p> <p>$M_{max} = 1.613 \text{ kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(1.613 \text{ kipft})}{(273.42 \text{ kipft})}$ $Ratio = 0.0058994$	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 $L = 6.25 \text{ ft}$ - 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>10.355</td> <td>15.863</td> </tr> <tr> <td>V_x (kip)</td> <td>-0.899</td> <td>-1.493</td> </tr> <tr> <td>V_z (kip)</td> <td>-0.057</td> <td>-0.089</td> </tr> <tr> <td>M_x (kipft)</td> <td>-0.163</td> <td>-0.253</td> </tr> <tr> <td>M_z (kipft)</td> <td>21.220</td> <td>35.559</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> $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-0.899 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.14315 \text{ kip/ft}$ <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)	10.355	15.863	V_x (kip)	-0.899	-1.493	V_z (kip)	-0.057	-0.089	M_x (kipft)	-0.163	-0.253	M_z (kipft)	21.220	35.559	
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M_x (kipft)	-0.163	-0.253																										
M_z (kipft)	21.220	35.559																										

	$M_o = \frac{(21.22 \text{ kipft}) + ((-0.899 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 3.379 \text{ kipft/ft}$ <p>Required depth of embedment in earth:</p> $L_{e,x}^3 - \left(14.14 \times \frac{H_o \times L_x}{R} \right) - \left(18.85 \times \frac{M_o}{R} \right) = 0$ <p>Solving the cubic equation: $L_{e,x} = 6.0238 \text{ ft}$ - Required depth in x-direction,</p> <p>Considering z-direction:</p> <p>H_o - Lateral force per length of pile,</p> $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(-0.057 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.0090764 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(0.163 \text{ kipft}) + ((-0.057 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.025955 \text{ kipft/ft}$ <p>Required depth of embedment in earth:</p> $L_z^3 - \left(14.14 \times \frac{H_o \times L_z}{R} \right) - \left(18.85 \times \frac{M_o}{R} \right) = 0$ <p>Solving the cubic equation: $L_{e,z} = 1.1342 \text{ ft}$ - Required depth in z-direction,</p> <p>Minimum embedded depth required:</p> <p>$L_{e,req}$ - Depth of pile required,</p> $L_{e,req} = MAX[L_{e,x}, L_{e,z}]$ $L_{e,req} = MAX[(6.0238 \text{ ft}), (1.1342 \text{ ft})]$ $L_{e,req} = 6.024 \text{ ft}$ <p>L_e - Actual embedded length of pile,</p> $L_e = L - h_e - h_2$ $L_e = (6.25 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 6.25 \text{ ft}$ <p><i>Ratio</i> - Embedded depth</p> $Ratio = \frac{L_{e,req}}{L_e}$ $Ratio = \frac{(6.024 \text{ ft})}{(6.25 \text{ ft})}$ $Ratio = 0.96384$	Status: PASS Ratio: 0.960
	<p>End-bearing Capacity (ASD)</p> <p>A - Pile cross-section area</p> $A = b D$ $A = (48 \text{ in}) \times (48 \text{ in})$ $A = 16 \text{ ft}^2$ <p>q - End-bearing pressure</p> $q = \frac{P_e}{A}$ $q = \frac{(10.355 \text{ kip})}{(16 \text{ ft}^2)}$	

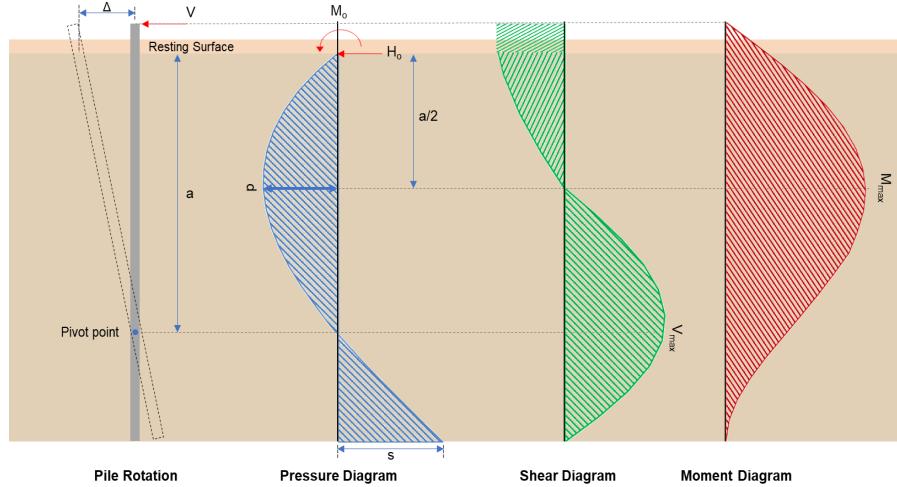
	$q = 0.04719 \text{ kip/in}$	
	<p>Check bearing capacity ratio:</p> <p><i>Ratio - Capacity</i></p> $\text{Ratio} = \frac{q}{q_a}$ $\text{Ratio} = \frac{(0.04719 \text{ kip/in}^2)}{(2000 \text{ psf})}$ $\text{Ratio} = 0.32359$	Status: PASS Ratio: 0.320
Czerniak	<p>Lateral Soil Pressure (ASD):</p> <p><i>L/D</i> - Length to least lateral dimension ratio,</p> $L/D = \frac{L}{D}$ $L/D = \frac{(6.25 \text{ ft})}{(48 \text{ in})}$ $L/D = 1.5625$ <p>Since $L/D \leq 10$,</p> <p style="text-align: center;">Pile is short.</p> <p>Considering x-direction:</p> <p>$H_o = -0.14315 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 3.379 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (3.379 \text{ kipft/ft}) \times (6.25 \text{ ft})) + (3 \times (-0.14315 \text{ kip/ft}) \times (6.25 \text{ ft})^2)}{(6 \times (3.379 \text{ kipft/ft})) + (4 \times (-0.14315 \text{ kip/ft}) \times (6.25 \text{ ft}))}$ $a = 4.2448 \text{ ft}$ <p><i>p</i> - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (3.379 \text{ kipft/ft})) + (3 \times (-0.14315 \text{ kip/ft}) \times (6.25 \text{ ft}))]^2}{(6.25 \text{ ft})^2 \times [(3 \times (3.379 \text{ kipft/ft})) + (2 \times (-0.14315 \text{ kip/ft}) \times (6.25 \text{ ft}))]}$ $p = 0.26986 \text{ kip/ft}^2$ <p><i>s</i> - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (3.379 \text{ kipft/ft})) + ((-0.14315 \text{ kip/ft}) \times (6.25 \text{ ft}))]}{(6.25 \text{ ft})^2}$ $s = 0.9006 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p><i>p_a</i> - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.2448 \text{ ft})}{2}$ $p_a = 0.31836 \text{ kip/ft}^2$ <p><i>Ratio</i> - Lateral soil capacity</p> $\text{Ratio} = \frac{p}{p_a}$ $\text{Ratio} = \frac{(0.26986 \text{ kip/ft}^2)}{(0.31836 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.84767$	Status: PASS Ratio: 0.850
	<p><i>p_s</i> - Allowable lateral soil pressure at depth L_e,</p>	

	$p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (6.25 \text{ ft})$ $p_s = 0.9375 \text{ kip/ft}^2$ <i>Ratio - Lateral soil capacity</i> $Ratio = \frac{s}{p_s}$ $Ratio = \frac{(0.9006 \text{ kip/ft}^2)}{(0.9375 \text{ kip/ft}^2)}$ $Ratio = 0.96064$	Status: PASS Ratio: 0.960
	<p>Considering z-direction:</p> <p>$H_o = -0.0090764 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 0.025955 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.025955 \text{ kipft/ft}) \times (6.25 \text{ ft})) + (3 \times (-0.0090764 \text{ kip/ft}) \times (6.25 \text{ ft})^2)}{(6 \times (0.025955 \text{ kipft/ft})) + (4 \times (-0.0090764 \text{ kip/ft}) \times (6.25 \text{ ft}))}$ $a = 4.4755 \text{ ft}$ <p>p - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.025955 \text{ kipft/ft})) + (3 \times (-0.0090764 \text{ kip/ft}) \times (6.25 \text{ ft}))]^2}{(6.25 \text{ ft})^2 \times [(3 \times (0.025955 \text{ kipft/ft})) + (2 \times (-0.0090764 \text{ kip/ft}) \times (6.25 \text{ ft}))]}$ $p = -0.0023758 \text{ kip/ft}^2$ <p>s - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.025955 \text{ kipft/ft})) + ((-0.0090764 \text{ kip/ft}) \times (6.25 \text{ ft}))]}{(6.25 \text{ ft})^2}$ $s = -0.00073987 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p>p_a - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.4755 \text{ ft})}{2}$ $p_a = 0.33566 \text{ kip/ft}^2$ <p><i>Ratio - Lateral soil capacity</i></p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(-0.0023758 \text{ kip/ft}^2)}{(0.33566 \text{ kip/ft}^2)}$ $Ratio = -0.007078$	Status: PASS Ratio: -0.010

$$Ratio = \frac{(-0.00073987 \text{ kip}/\text{ft}^2)}{(0.9375 \text{ kip}/\text{ft}^2)}$$

$$Ratio = -0.0007892$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-1.493 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.23774 \text{ kip}/\text{ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(35.559 \text{ kipft}) + ((-1.493 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 5.6623 \text{ kipft}/\text{ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(5.6623 \text{ kipft}/\text{ft})}{(-0.23774 \text{ kip}/\text{ft})}$$

$$E = 23.817 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.6623 \text{ kipft}/\text{ft}) \times (6.25 \text{ ft})) + (3 \times (-0.23774 \text{ kip}/\text{ft}) \times (6.25 \text{ ft})^2)}{(6 \times (5.6623 \text{ kipft}/\text{ft})) + (4 \times (-0.23774 \text{ kip}/\text{ft}) \times (6.25 \text{ ft}))}$$

$$a = 4.2442 \text{ ft}$$

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

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

$$V_{max} = ((-0.23774 \text{ kip}/\text{ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (23.817 \text{ ft})}{(6.25 \text{ ft})} + 3 \right) \times \left(\frac{(4.2442 \text{ ft})}{(6.25 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (23.817 \text{ ft})}{(6.25 \text{ ft})} + 2 \right) \times \left(\frac{(4.2442 \text{ ft})}{(6.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 7.0491 \text{ kip}$$

<p>M_{max} - Max bending moment located at depth $a/2$,</p> $M_{max} = (H_o D L_e) \left[\left(\frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[\left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{2 L_e} \right)^3 \right] + \left[\left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{2 L_e} \right)^4 \right] \right]$ $M_{max} = ((-0.23774 \text{ kip/ft}) \times (48 \text{ in}) \times (6.25 \text{ ft})) \times \left[\left(\frac{(23.817 \text{ ft})}{(6.25 \text{ ft})} + \frac{(4.2442 \text{ ft})}{2 \times (6.25 \text{ ft})} \right) - \left[\left(\frac{4 \times (23.817 \text{ ft})}{(6.25 \text{ ft})} + 3 \right) \times \left(\frac{(4.2442 \text{ ft})}{2 \times (6.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (23.817 \text{ ft})}{(6.25 \text{ ft})} + 2 \right) \times \left(\frac{(4.2442 \text{ ft})}{2 \times (6.25 \text{ ft})} \right)^4 \right] \right]$ $M_{max} = 21.484 \text{ kipft}$
<p>Shear force and Bending moment (z-direction, LRFD)</p> <p>H_o - Lateral force per length of pile,</p> $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(-0.089 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.014172 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(0.253 \text{ kipft}) + ((-0.089 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.040287 \text{ kipft/ft}$ <p>E - Distance from lateral load to resisting surface,</p> $E = \frac{M_o}{H_o}$ $E = \frac{(0.040287 \text{ kipft/ft})}{(-0.014172 \text{ kip/ft})}$ $E = 2.8427 \text{ ft}$ <p>a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.040287 \text{ kipft/ft}) \times (6.25 \text{ ft})) + (3 \times (-0.014172 \text{ kip/ft}) \times (6.25 \text{ ft})^2)}{(6 \times (0.040287 \text{ kipft/ft})) + (4 \times (-0.014172 \text{ kip/ft}) \times (6.25 \text{ ft}))}$ $a = 4.4763 \text{ ft}$ <p>V_{max} - Max shear force located at depth a,</p> $V_{max} = (H_o b) \left[1 - \left[3 \left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{L_e} \right)^2 \right] + \left[4 \left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{L_e} \right)^3 \right] \right]$ $V_{max} = ((-0.014172 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (2.8427 \text{ ft})}{(6.25 \text{ ft})} + 3 \right) \times \left(\frac{(4.4763 \text{ ft})}{(6.25 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (2.8427 \text{ ft})}{(6.25 \text{ ft})} + 2 \right) \times \left(\frac{(4.4763 \text{ ft})}{(6.25 \text{ ft})} \right)^3 \right] \right]$ $V_{max} = 0.083448 \text{ kip}$ <p>M_{max} - Max bending moment located at depth $a/2$,</p> $M_{max} = (H_o b L_e) \left[\left(\frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[\left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{2 L_e} \right)^3 \right] + \left[\left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{2 L_e} \right)^4 \right] \right]$ $M_{max} = ((-0.014172 \text{ kip/ft}) \times (48 \text{ in}) \times (6.25 \text{ ft})) \times \left[\left(\frac{(2.8427 \text{ ft})}{(6.25 \text{ ft})} + \frac{(4.4763 \text{ ft})}{2 \times (6.25 \text{ ft})} \right) - \left[\left(\frac{4 \times (2.8427 \text{ ft})}{(6.25 \text{ ft})} + 3 \right) \times \left(\frac{(4.4763 \text{ ft})}{2 \times (6.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (2.8427 \text{ ft})}{(6.25 \text{ ft})} + 2 \right) \times \left(\frac{(4.4763 \text{ ft})}{2 \times (6.25 \text{ ft})} \right)^4 \right] \right]$

	$M_{max} = 0.22921 \text{ kipft}$	
	<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> $A_{st,required} = Min \left[\frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = Min \left[\frac{\frac{(15.863 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (3 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -101.74 \text{ in}^2$ <p>A_{min} - Governing minimum reinforcement area,</p> $A_{min} = Max [A_{st,required}, (0.0018 A_g)]$ $A_{min} = Max [(-101.74 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ <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> $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(15.863 \text{ kip})}{(3183.4 \text{ kip})}$ $Ratio = 0.004983$	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 $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$, $P = 15.863 \text{ kip} \rightarrow 15863 \text{ lbf}$,</p> <p>$V_{c,a}$ - Shear strength of concrete (a)</p> $V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + \frac{(15863 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 131.91 \text{ kip}$ <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> $V_c = Min [V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = Min [(324.49 \text{ kip}), (131.91 \text{ kip}), (406.27 \text{ kip})]$ $V_c = 131.91 \text{ kip}$	
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> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((131.91 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 118.82 \text{ kip}$ <p>Considering x-direction:</p> <p>$V_{max} = 7.0491 \text{ kip}$ - Maximum shear force in the x-direction, $Ratio$ - Capacity</p>	$Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(7.0491 \text{ kip})}{(118.82 \text{ kip})}$ $Ratio = 0.059325$
		Status: PASS Ratio: 0.060
	<p>Considering z-direction:</p> <p>$V_{max} = 0.083448 \text{ kip}$ - Maximum shear force in the z-direction, $Ratio$ - Capacity</p>	$Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.083448 \text{ kip})}{(118.82 \text{ kip})}$ $Ratio = 0.00070229$
		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>$M_{max} = 21.484 \text{ kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(21.484 \text{ kipft})}{(273.42 \text{ kipft})}$ $Ratio = 0.078574$	Status: PASS Ratio: 0.080
	<p>Considering z-direction:</p> <p>$M_{max} = 0.22921 \text{ kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(0.22921 \text{ kipft})}{(273.42 \text{ kipft})}$ $Ratio = 0.00083831$	Status: PASS Ratio: 0.000

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 $L = 6.25 \text{ ft}$ - 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>10.355</td> <td>15.863</td> </tr> <tr> <td>V_x (kip)</td> <td>-0.899</td> <td>-1.493</td> </tr> <tr> <td>V_z (kip)</td> <td>0.057</td> <td>0.089</td> </tr> <tr> <td>M_x (kipft)</td> <td>0.163</td> <td>0.254</td> </tr> <tr> <td>M_z (kipft)</td> <td>21.220</td> <td>35.559</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> $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-0.899 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = -0.14315 \text{ kip/ft}$ <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)	10.355	15.863	V_x (kip)	-0.899	-1.493	V_z (kip)	0.057	0.089	M_x (kipft)	0.163	0.254	M_z (kipft)	21.220	35.559	
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	$M_o = \frac{(21.22 \text{ kipft}) + ((-0.899 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 3.379 \text{ kipft/ft}$ <p>Required depth of embedment in earth:</p> $L_{e,x}^3 - \left(14.14 \times \frac{H_o \times L_x}{R} \right) - \left(18.85 \times \frac{M_o}{R} \right) = 0$ <p>Solving the cubic equation: $L_{e,x} = 6.0238 \text{ ft}$ - Required depth in x-direction,</p> <p>Considering z-direction:</p> <p>H_o - Lateral force per length of pile,</p> $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(0.057 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = 0.0090764 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(0.163 \text{ kipft}) + ((0.057 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.025955 \text{ kipft/ft}$ <p>Required depth of embedment in earth:</p> $L_z^3 - \left(14.14 \times \frac{H_o \times L_z}{R} \right) - \left(18.85 \times \frac{M_o}{R} \right) = 0$ <p>Solving the cubic equation: $L_{e,z} = 1.4177 \text{ ft}$ - Required depth in z-direction,</p> <p>Minimum embedded depth required:</p> <p>$L_{e,req}$ - Depth of pile required,</p> $L_{e,req} = MAX[L_{e,x}, L_{e,z}]$ $L_{e,req} = MAX[(6.0238 \text{ ft}), (1.4177 \text{ ft})]$ $L_{e,req} = 6.024 \text{ ft}$ <p>L_e - Actual embedded length of pile,</p> $L_e = L - h_e - h_2$ $L_e = (6.25 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 6.25 \text{ ft}$ <p><i>Ratio</i> - Embedded depth</p> $Ratio = \frac{L_{e,req}}{L_e}$ $Ratio = \frac{(6.024 \text{ ft})}{(6.25 \text{ ft})}$ $Ratio = 0.96384$	Status: PASS Ratio: 0.960
	<p>End-bearing Capacity (ASD)</p> <p>A - Pile cross-section area</p> $A = b D$ $A = (48 \text{ in}) \times (48 \text{ in})$ $A = 16 \text{ ft}^2$ <p>q - End-bearing pressure</p> $q = \frac{P_e}{A}$ $q = \frac{(10.355 \text{ kip})}{(16 \text{ ft}^2)}$	

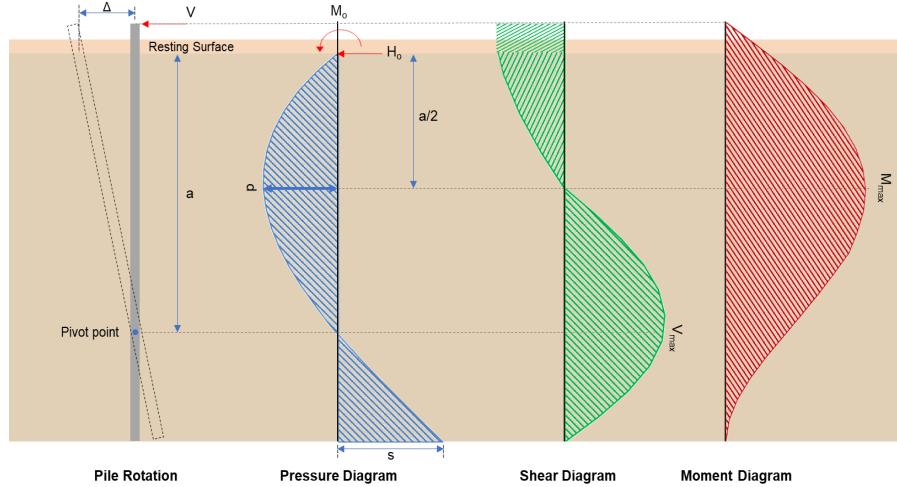
	$q = 0.04719 \text{ kip/in}$	
	<p>Check bearing capacity ratio:</p> <p><i>Ratio - Capacity</i></p> $\text{Ratio} = \frac{q}{q_a}$ $\text{Ratio} = \frac{(0.04719 \text{ kip/in}^2)}{(2000 \text{ psf})}$ $\text{Ratio} = 0.32359$	Status: PASS Ratio: 0.320
Czerniak	<p>Lateral Soil Pressure (ASD):</p> <p><i>L/D</i> - Length to least lateral dimension ratio,</p> $L/D = \frac{L}{D}$ $L/D = \frac{(6.25 \text{ ft})}{(48 \text{ in})}$ $L/D = 1.5625$ <p>Since $L/D \leq 10$,</p> <p>Pile is short.</p> <p>Considering x-direction:</p> <p>$H_o = -0.14315 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 3.379 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (3.379 \text{ kipft/ft}) \times (6.25 \text{ ft})) + (3 \times (-0.14315 \text{ kip/ft}) \times (6.25 \text{ ft})^2)}{(6 \times (3.379 \text{ kipft/ft})) + (4 \times (-0.14315 \text{ kip/ft}) \times (6.25 \text{ ft}))}$ $a = 4.2448 \text{ ft}$ <p><i>p</i> - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (3.379 \text{ kipft/ft})) + (3 \times (-0.14315 \text{ kip/ft}) \times (6.25 \text{ ft}))]^2}{(6.25 \text{ ft})^2 \times [(3 \times (3.379 \text{ kipft/ft})) + (2 \times (-0.14315 \text{ kip/ft}) \times (6.25 \text{ ft}))]}$ $p = 0.26986 \text{ kip/ft}^2$ <p><i>s</i> - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (3.379 \text{ kipft/ft})) + ((-0.14315 \text{ kip/ft}) \times (6.25 \text{ ft}))]}{(6.25 \text{ ft})^2}$ $s = 0.9006 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p><i>p_a</i> - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.2448 \text{ ft})}{2}$ $p_a = 0.31836 \text{ kip/ft}^2$ <p><i>Ratio</i> - Lateral soil capacity</p> $\text{Ratio} = \frac{p}{p_a}$ $\text{Ratio} = \frac{(0.26986 \text{ kip/ft}^2)}{(0.31836 \text{ kip/ft}^2)}$ $\text{Ratio} = 0.84767$	Status: PASS Ratio: 0.850
	<p><i>p_s</i> - Allowable lateral soil pressure at depth L_e,</p>	

	$p_s = R L_e$ $p_s = (150 \text{ psf/ft}) \times (6.25 \text{ ft})$ $p_s = 0.9375 \text{ kip/ft}^2$ <i>Ratio - Lateral soil capacity</i> $Ratio = \frac{s}{p_s}$ $Ratio = \frac{(0.9006 \text{ kip/ft}^2)}{(0.9375 \text{ kip/ft}^2)}$ $Ratio = 0.96064$	Status: PASS Ratio: 0.960
	<p>Considering z-direction:</p> <p>$H_o = 0.0090764 \text{ kip/ft}$ - Lateral force per length of pile, $M_o = 0.025955 \text{ kipft/ft}$ - Overturning moment per length of pile, a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.025955 \text{ kipft/ft}) \times (6.25 \text{ ft})) + (3 \times (0.0090764 \text{ kip/ft}) \times (6.25 \text{ ft})^2)}{(6 \times (0.025955 \text{ kipft/ft})) + (4 \times (0.0090764 \text{ kip/ft}) \times (6.25 \text{ ft}))}$ $a = 4.4755 \text{ ft}$ <p>p - Earth pressure against the pile at distance $a/2$ from resting surface,</p> $p = \frac{0.75 [(4 M_o) + (3 H_o L_e)]^2}{L_e^2 [(3 M_o) + (2 H_o L_e)]}$ $p = \frac{0.75 \times [(4 \times (0.025955 \text{ kipft/ft})) + (3 \times (0.0090764 \text{ kip/ft}) \times (6.25 \text{ ft}))]^2}{(6.25 \text{ ft})^2 \times [(3 \times (0.025955 \text{ kipft/ft})) + (2 \times (0.0090764 \text{ kip/ft}) \times (6.25 \text{ ft}))]}$ $p = 0.0075345 \text{ kip/ft}^2$ <p>s - Earth pressure against the pile at distance L_e,</p> $s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$ $s = \frac{6 \times [(2 \times (0.025955 \text{ kipft/ft})) + ((0.0090764 \text{ kip/ft}) \times (6.25 \text{ ft}))]}{(6.25 \text{ ft})^2}$ $s = 0.016687 \text{ kip/ft}^2$ <p>Check lateral soil pressure capacity:</p> <p>p_a - Allowable lateral soil pressure at depth $a/2$,</p> $p_a = R \frac{a}{2}$ $p_a = (150 \text{ psf/ft}) \times \frac{(4.4755 \text{ ft})}{2}$ $p_a = 0.33566 \text{ kip/ft}^2$ <p><i>Ratio - Lateral soil capacity</i></p> $Ratio = \frac{p}{p_a}$ $Ratio = \frac{(0.0075345 \text{ kip/ft}^2)}{(0.33566 \text{ kip/ft}^2)}$ $Ratio = 0.022446$	Status: PASS Ratio: 0.020

$$Ratio = \frac{(0.016687 \text{ kip}/\text{ft}^2)}{(0.9375 \text{ kip}/\text{ft}^2)}$$

$$Ratio = 0.017799$$

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-1.493 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.23774 \text{ kip}/\text{ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(35.559 \text{ kipft}) + ((-1.493 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 5.6623 \text{ kipft}/\text{ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(5.6623 \text{ kipft}/\text{ft})}{(-0.23774 \text{ kip}/\text{ft})}$$

$$E = 23.817 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.6623 \text{ kipft}/\text{ft}) \times (6.25 \text{ ft})) + (3 \times (-0.23774 \text{ kip}/\text{ft}) \times (6.25 \text{ ft})^2)}{(6 \times (5.6623 \text{ kipft}/\text{ft})) + (4 \times (-0.23774 \text{ kip}/\text{ft}) \times (6.25 \text{ ft}))}$$

$$a = 4.2442 \text{ ft}$$

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

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

$$V_{max} = ((-0.23774 \text{ kip}/\text{ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (23.817 \text{ ft})}{(6.25 \text{ ft})} + 3 \right) \times \left(\frac{(4.2442 \text{ ft})}{(6.25 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (23.817 \text{ ft})}{(6.25 \text{ ft})} + 2 \right) \times \left(\frac{(4.2442 \text{ ft})}{(6.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 7.0491 \text{ kip}$$

<p>M_{max} - Max bending moment located at depth $a/2$,</p> $M_{max} = (H_o D L_e) \left[\left(\frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[\left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{2 L_e} \right)^3 \right] + \left[\left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{2 L_e} \right)^4 \right] \right]$ $M_{max} = ((-0.23774 \text{ kip/ft}) \times (48 \text{ in}) \times (6.25 \text{ ft})) \times \left[\left(\frac{(23.817 \text{ ft})}{(6.25 \text{ ft})} + \frac{(4.2442 \text{ ft})}{2 \times (6.25 \text{ ft})} \right) - \left[\left(\frac{4 \times (23.817 \text{ ft})}{(6.25 \text{ ft})} + 3 \right) \times \left(\frac{(4.2442 \text{ ft})}{2 \times (6.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (23.817 \text{ ft})}{(6.25 \text{ ft})} + 2 \right) \times \left(\frac{(4.2442 \text{ ft})}{2 \times (6.25 \text{ ft})} \right)^4 \right] \right]$ $M_{max} = 21.484 \text{ kipft}$
<p>Shear force and Bending moment (z-direction, LRFD)</p> <p>H_o - Lateral force per length of pile,</p> $H_o = \frac{V_z}{1.57 b}$ $H_o = \frac{(0.089 \text{ kip})}{1.57 \times (48 \text{ in})}$ $H_o = 0.014172 \text{ kip/ft}$ <p>M_o - Moment per length of pile,</p> $M_o = \frac{M_x + (V_z H)}{1.57 b}$ $M_o = \frac{(0.254 \text{ kipft}) + ((0.089 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 0.040446 \text{ kipft/ft}$ <p>E - Distance from lateral load to resisting surface,</p> $E = \frac{M_o}{H_o}$ $E = \frac{(0.040446 \text{ kipft/ft})}{(0.014172 \text{ kip/ft})}$ $E = 2.8539 \text{ ft}$ <p>a - Distance from resting surface to pivot point,</p> $a = \frac{(4 M_o L_e) + (3 H_o L_e^2)}{(6 M_o) + (4 H_o L_e)}$ $a = \frac{(4 \times (0.040446 \text{ kipft/ft}) \times (6.25 \text{ ft})) + (3 \times (0.014172 \text{ kip/ft}) \times (6.25 \text{ ft})^2)}{(6 \times (0.040446 \text{ kipft/ft})) + (4 \times (0.014172 \text{ kip/ft}) \times (6.25 \text{ ft}))}$ $a = 4.4758 \text{ ft}$ <p>V_{max} - Max shear force located at depth a,</p> $V_{max} = (H_o b) \left[1 - \left[3 \left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{L_e} \right)^2 \right] + \left[4 \left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{L_e} \right)^3 \right] \right]$ $V_{max} = ((0.014172 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (2.8539 \text{ ft})}{(6.25 \text{ ft})} + 3 \right) \times \left(\frac{(4.4758 \text{ ft})}{(6.25 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (2.8539 \text{ ft})}{(6.25 \text{ ft})} + 2 \right) \times \left(\frac{(4.4758 \text{ ft})}{(6.25 \text{ ft})} \right)^3 \right] \right]$ $V_{max} = 0.083626 \text{ kip}$ <p>M_{max} - Max bending moment located at depth $a/2$,</p> $M_{max} = (H_o b L_e) \left[\left(\frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[\left(\frac{4 E}{L_e} + 3 \right) \left(\frac{a}{2 L_e} \right)^3 \right] + \left[\left(\frac{3 E}{L_e} + 2 \right) \left(\frac{a}{2 L_e} \right)^4 \right] \right]$ $M_{max} = ((0.014172 \text{ kip/ft}) \times (48 \text{ in}) \times (6.25 \text{ ft})) \times \left[\left(\frac{(2.8539 \text{ ft})}{(6.25 \text{ ft})} + \frac{(4.4758 \text{ ft})}{2 \times (6.25 \text{ ft})} \right) - \left[\left(\frac{4 \times (2.8539 \text{ ft})}{(6.25 \text{ ft})} + 3 \right) \times \left(\frac{(4.4758 \text{ ft})}{2 \times (6.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (2.8539 \text{ ft})}{(6.25 \text{ ft})} + 2 \right) \times \left(\frac{(4.4758 \text{ ft})}{2 \times (6.25 \text{ ft})} \right)^4 \right] \right]$

	$M_{max} = 0.22977 \text{ kipft}$	
	<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> $A_{st,required} = Min \left[\frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = Min \left[\frac{\frac{(15.863 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (3 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -101.74 \text{ in}^2$ <p>A_{min} - Governing minimum reinforcement area,</p> $A_{min} = Max [A_{st,required}, (0.0018 A_g)]$ $A_{min} = Max [(-101.74 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ <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> $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(15.863 \text{ kip})}{(3183.4 \text{ kip})}$ $Ratio = 0.004983$	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 $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$, $P = 15.863 \text{ kip} \rightarrow 15863 \text{ lbf}$,</p> <p>$V_{c,a}$ - Shear strength of concrete (a)</p> $V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + \frac{(15863 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 131.91 \text{ kip}$ <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> $V_c = Min [V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = Min [(324.49 \text{ kip}), (131.91 \text{ kip}), (406.27 \text{ kip})]$ $V_c = 131.91 \text{ kip}$	
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> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((131.91 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 118.82 \text{ kip}$ <p>Considering x-direction:</p> <p>$V_{max} = 7.0491 \text{ kip}$ - Maximum shear force in the x-direction, $Ratio$ - Capacity</p>	$Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(7.0491 \text{ kip})}{(118.82 \text{ kip})}$ $Ratio = 0.059325$
		Status: PASS Ratio: 0.060
	<p>Considering z-direction:</p> <p>$V_{max} = 0.083626 \text{ kip}$ - Maximum shear force in the z-direction, $Ratio$ - Capacity</p>	$Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(0.083626 \text{ kip})}{(118.82 \text{ kip})}$ $Ratio = 0.00070379$
		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>$M_{max} = 21.484 \text{ kipft}$ - Maximum moment in the x-direction, $Ratio$ - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(21.484 \text{ kipft})}{(273.42 \text{ kipft})}$ $Ratio = 0.078574$	Status: PASS Ratio: 0.080
	<p>Considering z-direction:</p> <p>$M_{max} = 0.22977 \text{ kipft}$ - Maximum moment in the z-direction, $Ratio$ - Capacity</p> $Ratio = \frac{M_{max}}{\phi M_n}$ $Ratio = \frac{(0.22977 \text{ kipft})}{(273.42 \text{ kipft})}$ $Ratio = 0.00084034$	Status: PASS Ratio: 0.000