Project Details

Project Name: MTSOLAR_HEDH516LE922

Date: Fri Nov 07 2025

Location: 20 Sherry Rd, Harvard, MA 01451, USA

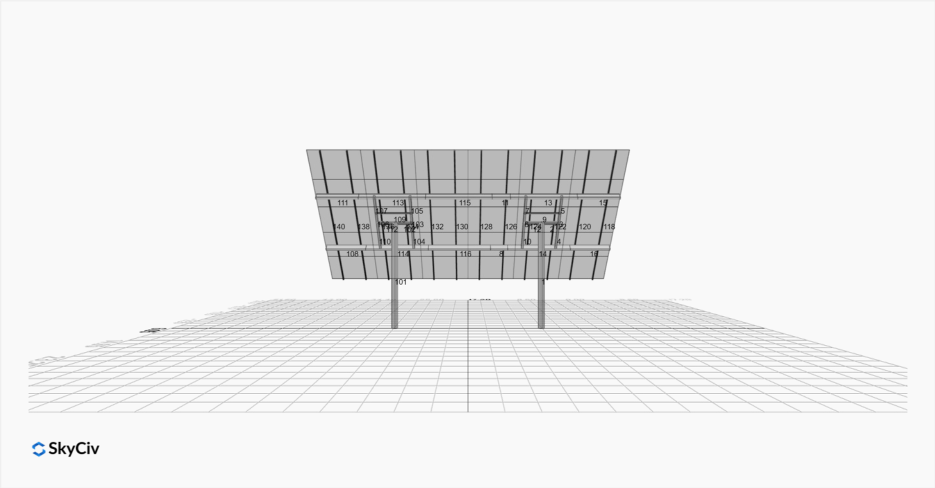
Number of Modules: 30

Unique ID: 2P-17-8TOP-HD-57-L-5Hx6W-KL7A

Number of Poles: 2

Dealer: ______________________________

Date Sold: ______________________________



Array Dimensions N/S	18.83 ft
Array Dimensions E/W	34.40 ft
Winter Tilt Angle (Degrees)	50
Front Edge Clearance	5

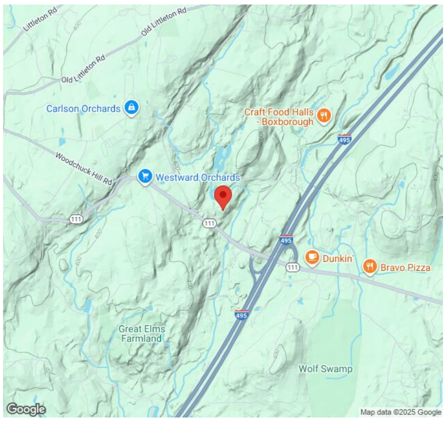
MT Solar Bill of Materials (2P-17-8TOP-HD-57-L-5Hx6W-KL7A)

Part	Short Description	BOM Qty
MTS-PC-8	8IN Pole Cap Assembly	2
MTS-HF-HD	H-Frame Assembly-HD	2
MTS-HD-Wing-57	57IN HD Wing	4
MTS-HD-Splice-57	57IN HD Splice	4
MTS-CLAMP-ANGLE-4PK	Angle Clamp	6

Rail Bill of Materials

Part	Qty
Rails (226in Long)	12x
Rail Attachment	48x
Module Mid Clamp	48x
Module End Clamp	24x
Ground Lug	6x

Site Details:



Site Address: 20 Sherry Rd, Harvard, MA 01451, USA

Array Specifications

Duty Classification:	HD
Module Width:	44.70 in
Module Length:	67.80 in
Number of Rows:	5
Number of Columns:	6
Total Number of Modules:	30
Winter Tilt Angle:	50
Front Edge Clearance:	5
Total Array Height at Tilt:	19.43 ft
Total Frame Length:	34.00 ft
Module Info/Notes:	teleson
Array Dimensions N/S:	18.83 ft
Array Dimensions E/W:	34.40 ft
Rail Length:	226.00 in
Rail Spacing:	2.87 ft

Support Specifications

Pole Size:	8in Pipe Sch 80
Pole Length above Grade:	12.21 ft
Number of Poles:	2
Pole Spacing:	17 ft

Foundation Specifications

Foundation Type:	rectangular
Foundation Dimensions:	48x48 in
Foundation Depth (below grade):	8.0 ft
Foundation Volume:	128.00 ft^3

Site Info

Risk Category:	I
Exposure:	C
Soil Classification:	sand
Site Location:	20 Sherry Rd, Harvard, MA 01451, USA
Wind Speed:	116 mph

Snow Load:	50 psf

Design Disclaimer

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

AutoDesigner Input

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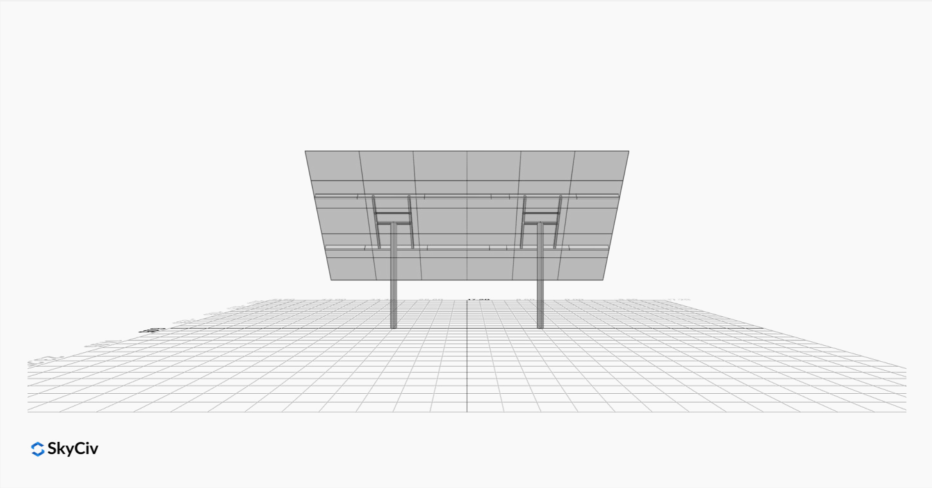
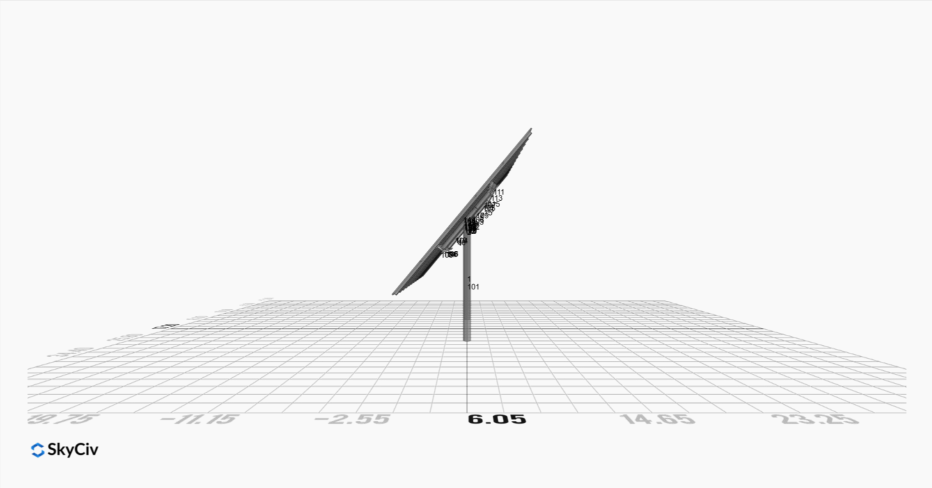
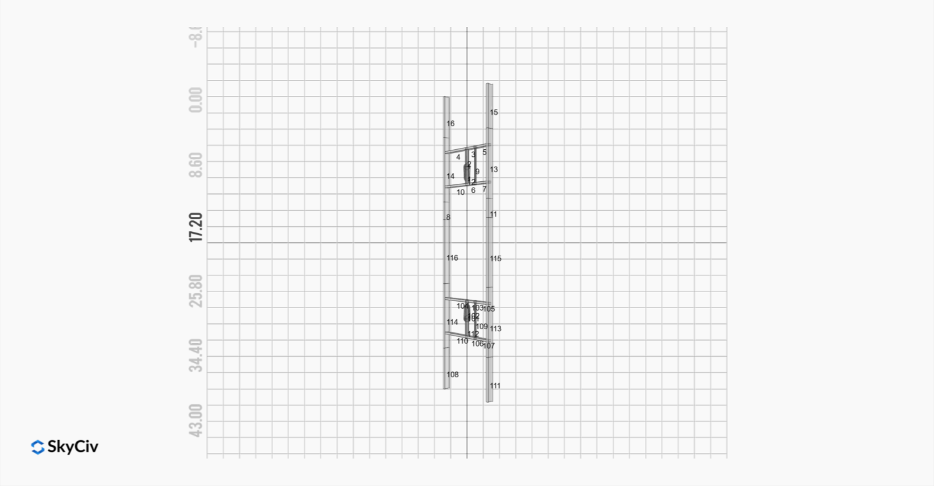
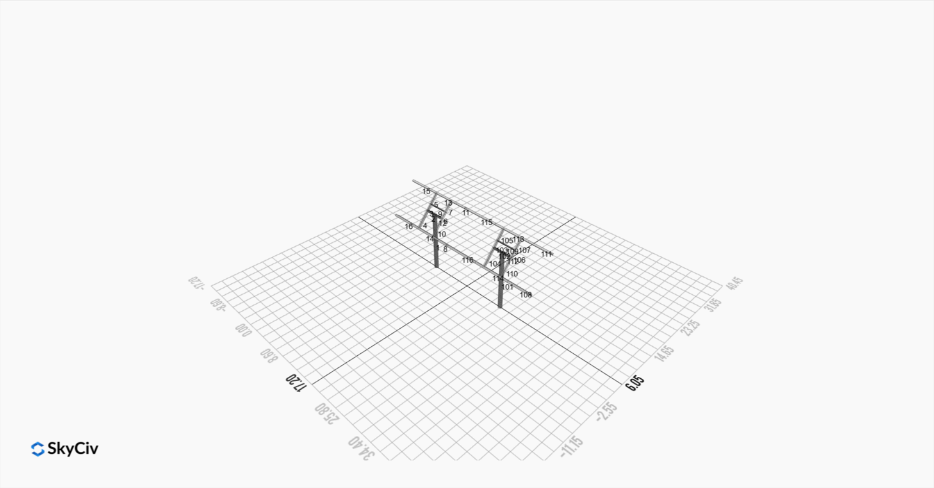
Design Notes:

- Deflection checks are set to L/1 due to manufacturer structural design intent
- Foundation Soil Parameters used in this Autodesign are all estimates, proper geotechnical reports are required to confirm soil profiles
- Wind speeds, snow loads and other site specific results are based on ASCE 7-16
- Steel frame design checks are based on AISC 360-16 LRFD
- Design / analysis of fixings and connections are not carried out by this module.
- Impacts of eccentrically applied, partial or pattern loading are not considered by this module.
- Foundation Design and Sizing is approximate only






SkyCiv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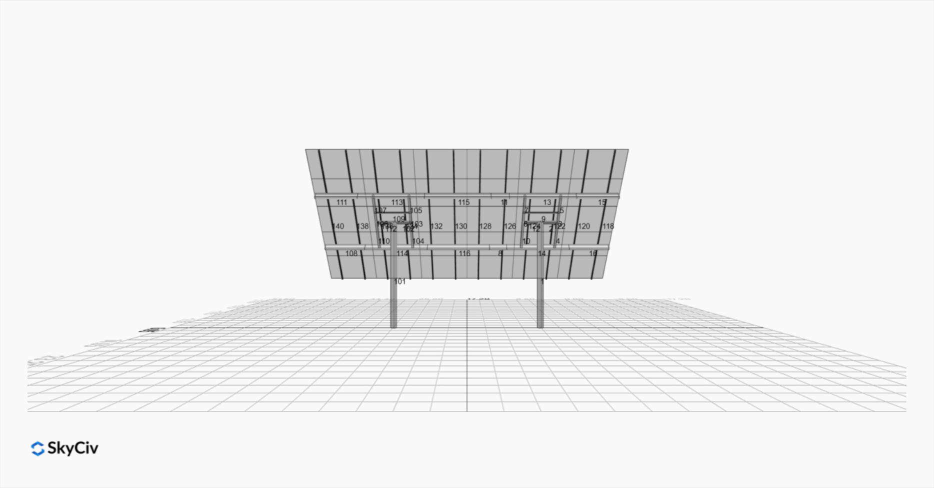
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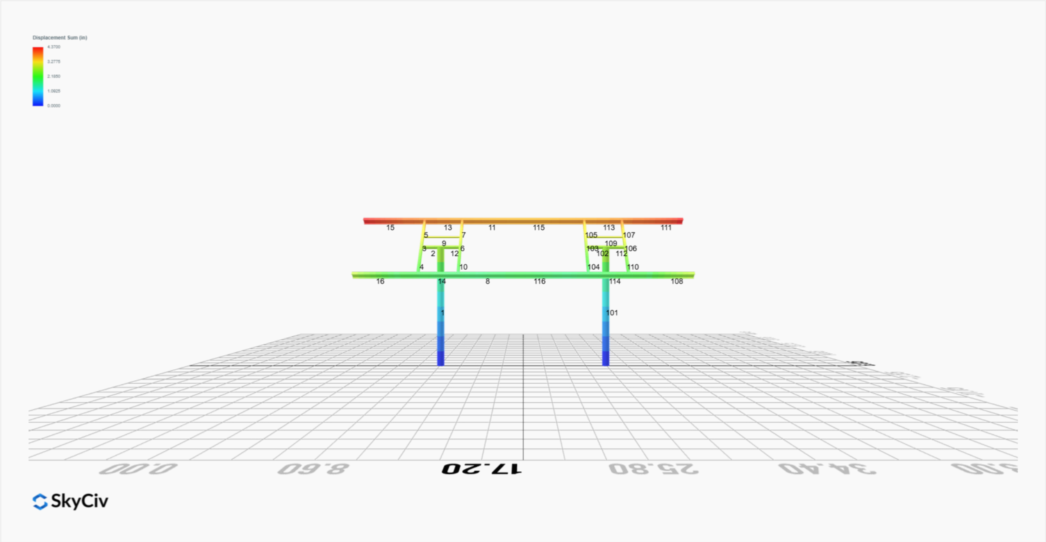
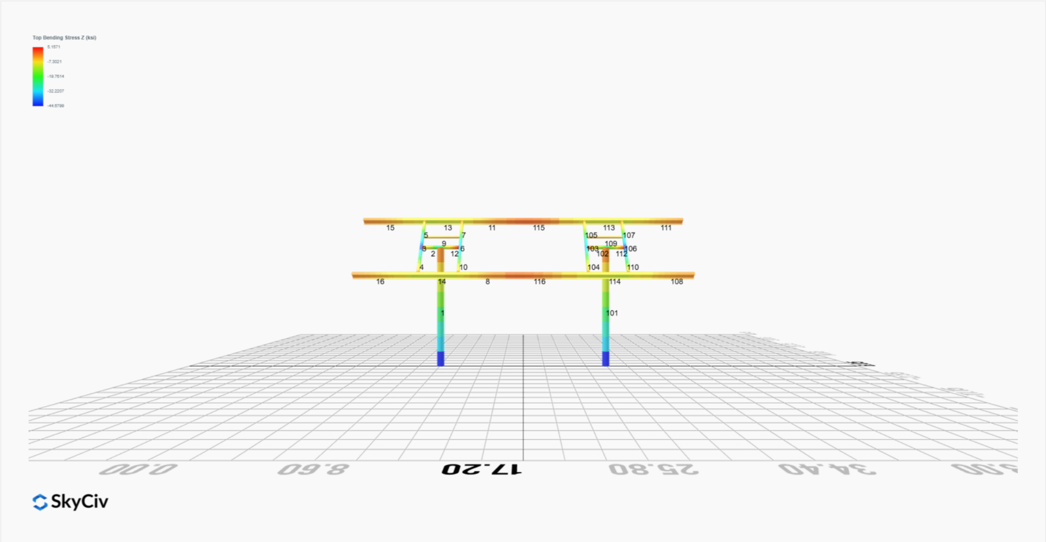
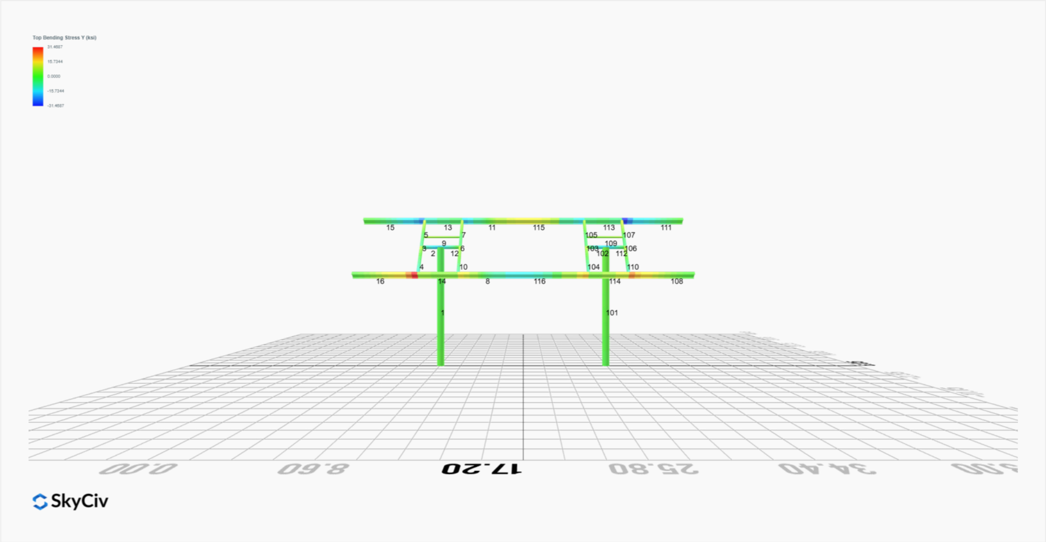
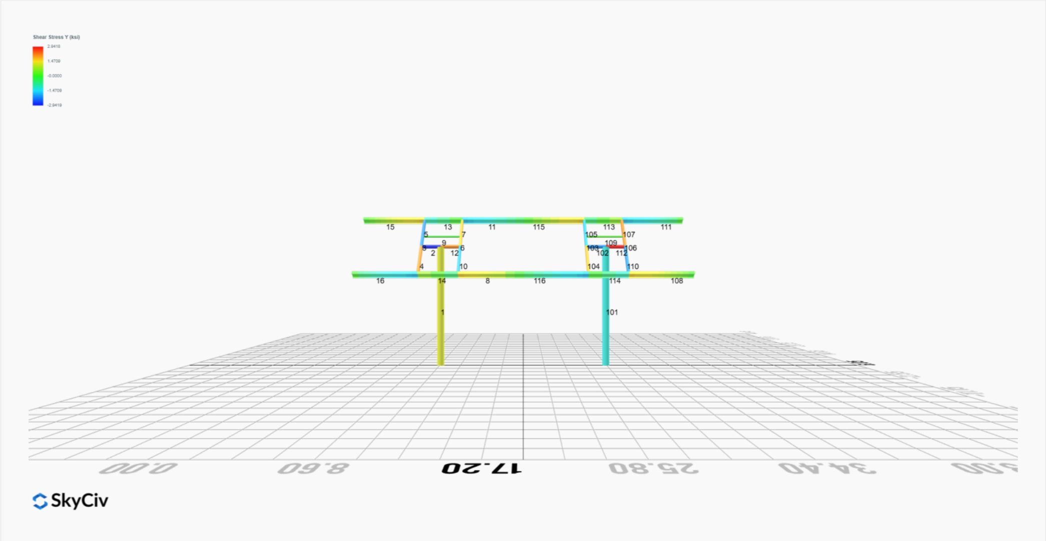
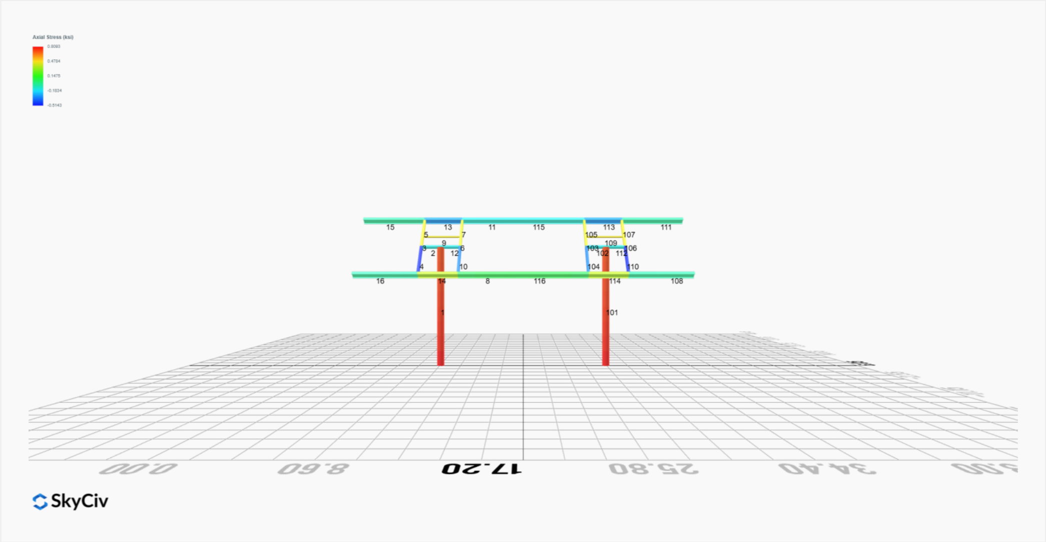
FEM Results (Envelope Worst Case)








Shear Stress Y (ksi)
2.9418
1.4709
-0.0000
-1.4709
-2.9419
SkyCiv


Axial Stress (ksi)
0.8093
0.4784
0.1475
-0.1834
-0.5143
SkyCiv

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

LRFD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. 1.4D	0.0000	3.5845	-0.0493	-0.1714	0.1862	0.0348
ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R)	0.0000	4.2173	-0.0644	-0.2238	0.2430	0.0372
ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R)	0.0000	3.0725	-0.0423	-0.1468	0.1596	0.0287
ULS: 3. 1.2D + 1.6(S or Lr or R) + L	0.0000	6.7359	-0.1132	-0.3938	0.4263	0.0680
ULS: 5. 1.2D + E + L + 0.2S	0.0000	3.5304	-0.0511	-0.1776	0.1929	0.0317
ULS: 7. 0.9D + 1.0E	0.0000	2.3044	-0.0317	-0.1101	0.1197	0.0203
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only	-7.2834	10.3288	-0.2954	-0.9973	1.5826	91.2722
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only	0.0000	4.2173	-0.0644	-0.2238	0.2430	0.0372
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only	7.2834	-1.8942	0.1661	0.5463	-1.0981	-88.5928
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only	0.0000	4.2173	-0.0644	-0.2238	0.2430	0.0372
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only	-7.2834	9.1840	-0.2733	-0.9202	1.4999	90.9893
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only	0.0000	3.0725	-0.0423	-0.1468	0.1596	0.0287
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only	7.2834	-3.0391	0.1882	0.6231	-1.1820	-88.3447
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only	0.0000	3.0725	-0.0423	-0.1468	0.1596	0.0287
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only	-3.6417	9.7917	-0.2286	-0.7803	1.0957	45.6517
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only	0.0000	6.7359	-0.1132	-0.3938	0.4263	0.0680
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only	3.6417	3.6802	0.0021	-0.0081	-0.2434	-44.8546
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only	0.0000	6.7359	-0.1132	-0.3938	0.4263	0.0680
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only	-3.6417	6.1282	-0.1577	-0.5331	0.8299	45.1772
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only	0.0000	3.0725	-0.0423	-0.1468	0.1596	0.0287
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only	3.6417	0.0167	0.0731	0.2386	-0.5110	-44.4731
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only	0.0000	3.0725	-0.0423	-0.1468	0.1596	0.0287
ULS: 6. 0.9D + 1.0W_Wind downforce Case A only	-7.2834	8.4159	-0.2627	-0.8834	1.4603	90.8017
ULS: 6. 0.9D + 1.0W_Wind downforce Case B only	0.0000	2.3044	-0.0317	-0.1101	0.1197	0.0203
ULS: 6. 0.9D + 1.0W_Wind uplift Case A only	7.2834	-3.8072	0.1988	0.6598	-1.2222	-88.1857
ULS: 6. 0.9D + 1.0W_Wind uplift Case B only	0.0000	2.3044	-0.0317	-0.1101	0.1197	0.0203

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	0.0000	2.5604	-0.0352	-0.1223	0.1330	0.0230
ULS: 2. D + L	0.0000	2.5604	-0.0352	-0.1223	0.1330	0.0230
ULS: 3. D + (S or Lr or R)	0.0000	4.8501	-0.0795	-0.2763	0.2997	0.0411
ULS: 3. D + (S or Lr or R)	0.0000	2.5604	-0.0352	-0.1223	0.1330	0.0230
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	4.2776	-0.0684	-0.2377	0.2580	0.0352
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	2.5604	-0.0352	-0.1223	0.1330	0.0230
ULS: 5b. D + 0.7E	0.0000	2.5604	-0.0352	-0.1223	0.1330	0.0230
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0000	4.2776	-0.0684	-0.2377	0.2580	0.0352
ULS: 8. 0.6D + 0.7E	0.0000	1.5362	-0.0211	-0.0733	0.0798	0.0127
ULS: 5a. D + 0.6W_Wind downforce Case A only	-4.3701	6.2273	-0.1738	-0.5859	0.9375	54.2095
ULS: 5a. D + 0.6W_Wind downforce Case B only	0.0000	2.5604	-0.0352	-0.1223	0.1330	0.0230
ULS: 5a. D + 0.6W_Wind uplift Case A only	4.3701	-1.1065	0.1032	0.3400	-0.6719	-53.2351
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.0000	2.5604	-0.0352	-0.1223	0.1330	0.0230
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-3.2775	7.0278	-0.1723	-0.5854	0.8610	40.7680
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0000	4.2776	-0.0684	-0.2377	0.2580	0.0352
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	3.2776	1.5275	0.0354	0.1092	-0.3452	-40.1700
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0000	4.2776	-0.0684	-0.2377	0.2580	0.0352

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	-3.2775	5.3106	-0.1391	-0.4699	0.7364	40.5742
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0000	2.5604	-0.0352	-0.1223	0.1330	0.0230
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	3.2776	-0.1898	0.0686	0.2246	-0.4707	-40.0060
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0000	2.5604	-0.0352	-0.1223	0.1330	0.0230
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-4.3701	5.2031	-0.1597	-0.5368	0.8845	54.0583
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	0.0000	1.5362	-0.0211	-0.0733	0.0798	0.0127
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	4.3701	-2.1307	0.1172	0.3889	-0.7254	-53.1102
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.0000	1.5362	-0.0211	-0.0733	0.0798	0.0127

Worst Case Reactions (LRFD)

Note: Downforce / downwind wind load cases are assumed to govern.

Result	Value (kip, kip-ft)
Axial	10.3288
Shear X	-7.2834
Shear Z	-0.2954
Moment X	-0.9973
Moment Y (Twist)	1.5826
Moment Z	91.2722

Worst Case Reactions (ASD)

Note: Downforce / downwind wind load cases are assumed to govern.

Result	Value (kip, kip-ft)
Axial	7.0278
Shear X	-4.3701
Shear Z	-0.1738
Moment X	-0.5859
Moment Y (Twist)	0.9375
Moment Z	54.2095

Reaction Forces for Foundation 2 (Node ID#101), (kip, kip-ft)

LRFD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. 1.4D	-0.0000	3.5846	0.0493	0.1714	-0.1862	0.0349
ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R)	-0.0000	4.2173	0.0644	0.2239	-0.2429	0.0372
ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R)	-0.0000	3.0725	0.0423	0.1469	-0.1596	0.0287
ULS: 3. 1.2D + 1.6(S or Lr or R) + L	-0.0000	6.7359	0.1132	0.3939	-0.4262	0.0681
ULS: 5. 1.2D + E + L + 0.2S	-0.0000	3.5304	0.0511	0.1776	-0.1929	0.0317
ULS: 7. 0.9D + 1.0E	-0.0000	2.3044	0.0317	0.1101	-0.1197	0.0203
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only	-7.2834	10.3288	0.2954	0.9974	-1.5829	91.2733
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only	-0.0000	4.2173	0.0644	0.2239	-0.2429	0.0372
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only	7.2834	-1.8942	-0.1661	-0.5463	1.0984	-88.5937
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only	-0.0000	4.2173	0.0644	0.2239	-0.2429	0.0372
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only	-7.2834	9.1840	0.2733	0.9203	-1.5001	90.9904
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only	-0.0000	3.0725	0.0423	0.1469	-0.1596	0.0287
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only	7.2834	-3.0390	-0.1882	-0.6231	1.1823	-88.3456
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only	-0.0000	3.0725	0.0423	0.1469	-0.1596	0.0287
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only	-3.6417	9.7917	0.2286	0.7805	-1.0957	45.6522
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only	-0.0000	6.7359	0.1132	0.3939	-0.4262	0.0681
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only	3.6417	3.6802	-0.0021	0.0082	0.2436	-44.8550
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only	-0.0000	6.7359	0.1132	0.3939	-0.4262	0.0681
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only	-3.6417	6.1282	0.1577	0.5331	-0.8300	45.1777
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only	-0.0000	3.0725	0.0423	0.1469	-0.1596	0.0287
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only	3.6417	0.0167	-0.0731	-0.2385	0.5112	-44.4735
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only	-0.0000	3.0725	0.0423	0.1469	-0.1596	0.0287
ULS: 6. 0.9D + 1.0W_Wind downforce Case A only	-7.2834	8.4159	0.2627	0.8834	-1.4605	90.8025
ULS: 6. 0.9D + 1.0W_Wind downforce Case B only	-0.0000	2.3044	0.0317	0.1101	-0.1197	0.0203
ULS: 6. 0.9D + 1.0W_Wind uplift Case A only	7.2834	-3.8072	-0.1988	-0.6598	1.2224	-88.1863
ULS: 6. 0.9D + 1.0W_Wind uplift Case B only	-0.0000	2.3044	0.0317	0.1101	-0.1197	0.0203

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	-0.0000	2.5604	0.0352	0.1223	-0.1330	0.0230
ULS: 2. D + L	-0.0000	2.5604	0.0352	0.1223	-0.1330	0.0230
ULS: 3. D + (S or Lr or R)	-0.0000	4.8501	0.0795	0.2764	-0.2996	0.0411
ULS: 3. D + (S or Lr or R)	-0.0000	2.5604	0.0352	0.1223	-0.1330	0.0230
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0000	4.2776	0.0684	0.2378	-0.2580	0.0353
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0000	2.5604	0.0352	0.1223	-0.1330	0.0230
ULS: 5b. D + 0.7E	-0.0000	2.5604	0.0352	0.1223	-0.1330	0.0230
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0000	4.2776	0.0684	0.2378	-0.2580	0.0353
ULS: 8. 0.6D + 0.7E	-0.0000	1.5362	0.0211	0.0733	-0.0798	0.0127
ULS: 5a. D + 0.6W_Wind downforce Case A only	-4.3701	6.2273	0.1738	0.5859	-0.9376	54.2100
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.0000	2.5604	0.0352	0.1223	-0.1330	0.0230
ULS: 5a. D + 0.6W_Wind uplift Case A only	4.3700	-1.1065	-0.1032	-0.3400	0.6721	-53.2355
ULS: 5a. D + 0.6W_Wind uplift Case B only	-0.0000	2.5604	0.0352	0.1223	-0.1330	0.0230
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-3.2775	7.0278	0.1723	0.5855	-0.8611	40.7684
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0000	4.2776	0.0684	0.2378	-0.2580	0.0353
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	3.2775	1.5275	-0.0354	-0.1092	0.3454	-40.1703
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0000	4.2776	0.0684	0.2378	-0.2580	0.0353
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-3.2775	5.3106	0.1391	0.4699	-0.7365	40.5746
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0000	2.5604	0.0352	0.1223	-0.1330	0.0230
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	3.2775	-0.1898	-0.0686	-0.2245	0.4708	-40.0064
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0000	2.5604	0.0352	0.1223	-0.1330	0.0230
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-4.3701	5.2032	0.1597	0.5368	-0.8846	54.0586
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.0000	1.5362	0.0211	0.0733	-0.0798	0.0127
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	4.3701	-2.1307	-0.1172	-0.3889	0.7255	-53.1104
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	-0.0000	1.5362	0.0211	0.0733	-0.0798	0.0127

Worst Case Reactions (LRFD)

Note: Downforce / downwind wind load cases are assumed to govern.

Result	Value (kip, kip-ft)
Axial	10.3288
Shear X	-7.2834
Shear Z	0.2954
Moment X	0.9974
Moment Y (Twist)	1.5829
Moment Z	91.2733

Worst Case Reactions (ASD)

Note: Downforce / downwind wind load cases are assumed to govern.

Result	Value (kip, kip-ft)
Axial	7.0278
Shear X	-4.3701
Shear Z	0.1738
Moment X	0.5859
Moment Y (Twist)	0.9376
Moment Z	54.2100

Project Details

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

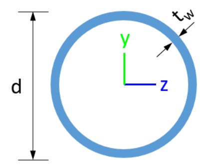
User Name: sales@mtsolar.us
Unit System: imperial

Design Input Information

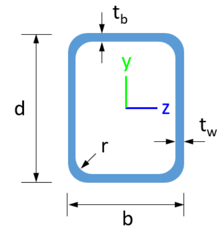
Design Factors			
Φ_t	Φ_c	Φ_b	Φ_v
0.9	0.9	0.9	0.9

Design Materials			
ID	E (ksi)	F_y (ksi)	F_u (ksi)
1	29000	50	65
2	29000	46	62
4	29000	50	62

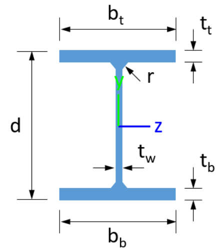
Section Dimensions



ID	Name	d (in)	t_w (in)					
2	2in Pipe Sch 80	2.38	0.22					
5	4in Pipe Sch 80	4.50	0.34					
10	8in Pipe Sch 80	8.63	0.50					



ID	Name	d (in)	b (in)	t_w (in)	t_b (in)	r (in)		
16	HSS5x3x3/16	5.00	3.00	0.17	0.17	0.17		



ID	Name	d (in)	t_w (in)	b_t (in)	b_b (in)	t_t (in)	t_b (in)	r (in)
19	W8x10	7.89	0.17	3.94	3.94	0.20	0.20	0.30

Section Properties

Section Properties

ID	Name	A (in^2)	J (in^4)	I_{yp} (in^4)	I_{zp} (in^4)	I_w (in^6)	S_{yp} (in^3)	S_{zp} (in^3)
2	2in Pipe Sch 80	1.48	1.74	0.87	0.87	0.00	1.02	1.02
5	4in Pipe Sch 80	4.41	19.22	9.61	9.61	0.00	5.85	5.85
10	8in Pipe Sch 80	12.76	211.43	105.72	105.72	0.00	33.05	33.05
16	HSS5x3x3/16	2.58	8.64	3.85	8.53	0.73	2.96	4.21
19	W8x10	2.96	0.04	2.09	30.80	30.90	1.66	8.87

Member Properties

Member ID	Section ID	K_zL (ft)	K_yL (ft)	L_b (ft)	C_b	LST	LSC	LD
1	10	7.94	7.94	12.21	-	300	200	250
2	5	1.30	1.30	2.00	-	300	200	250
3	16	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.19,1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.18,1.18,1.18,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19	300	200	250
4	16	2.44	2.44	3.75	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.65,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.67,1.68,1.68,1.68,1.67,1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68	300	200	250
5	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.67,1.68,1.67,1.67,1.65,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.67,1.68,1.68,1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.67,1.68	300	200	250
6	16	0.92	0.92	1.42	1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.16,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18	300	200	250
7	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.65,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.68,1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68	300	200	250
8	19	1.33	1.33	2.05	1.96,1.96,1.96,1.96,1.96,1.96,1.92,1.96,1.91,1.96,1.92,1.96,1.91,1.96,1.93,1.96,1.78,1.96,1.93,1.96,1.90,1.96,1.92,1.96,1.92,1.96,1.96,1.96,1.96,1.96,1.96,1.96,1.96,1.96,1.96,1.92,1.96,1.91,1.96,1.93,1.96,1.87,1.96,1.93,1.96,1.90,1.96,1.92,1.96,1.91,1.96	300	200	250
9	2	2.60	2.60	4.00	-	300	200	250
10	16	2.44	2.44	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.67,1.64,1.67,1.67,1.69,1.66,1.69,1.67,1.69,1.66,1.69,1.69,1.69,1.68,1.69,1.68,1.69,1.69,1.68,1.68,1.67,1.69,1.66,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.68,1.66,1.68	300	200	250
11	19	1.33	1.33	2.05	1.98,1.98,1.98,1.98,1.98,1.98,1.94,1.98,1.92,1.98,1.94,1.98,1.93,1.98,1.95,1.98,1.80,1.98,1.95,1.98,1.92,1.98,1.94,1.98,1.93,1.98,1.98,1.98,1.98,1.98,1.98,1.98,1.98,1.98,1.98,1.94,1.98,1.92,1.98,1.95,1.98,1.89,1.98,1.94,1.98,1.92,1.98,1.94,1.98,1.93,1.98	300	200	250
12	5	1.30	1.30	2.00	-	300	200	250
13	19	4.88	4.00	7.50	1.09,1.10,1.09,1.10,1.09,1.09,1.09,1.10,1.09,1.10,1.09,1.09,1.09,1.09,1.09,1.10,1.08,1.10,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.10,1.09,1.10,1.09,1.09,1.10,1.09,1.09,1.09,1.09,1.09,1.09,1.10,1.09,1.10,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09	300	200	250
14	19	4.88	4.00	7.50	1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.08,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09	300	200	250
15	19	9.97	9.97	4.75	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	250
16	19	9.97	9.97	4.75	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	250
101	10	7.94	7.94	12.21	-	300	200	250
102	5	1.30	1.30	2.00	-	300	200	250
103	16	0.92	0.92	1.42	1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.16,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18,1.18,1.18,1.17,1.18	300	200	250
104	16	2.4	2.4	3.	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.67,1.64,1.67,1.67,1.69,1.66,1.69,1.67,1.69,1.	3	2	2

104	16	44	44	75	66,1.69,1.69,1.69,1.68,1.69,1.68,1.69,1.69,1.68,1.69,1.67,1.69,1.66,1.69,1.67,1.68,1.66,1.68,1.67,1.69,1.66,1.69,1.67,1.69,1.66,1.69	00	00	50
105	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.65,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.68,1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68	300	200	250
106	16	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.19,1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.18,1.18,1.18,1.18,1.19,1.18,1.19,1.18,1.19,1.18,1.19	300	200	250
107	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.67,1.68,1.67,1.67,1.65,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.67,1.68,1.68,1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.67,1.68	300	200	250
108	19	9.97	9.97	4.75	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	250
109	2	2.60	2.60	4.00	-	300	200	250
110	16	2.44	2.44	3.75	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.65,1.67,1.67,1.68,1.66,1.68,1.67,1.68,1.67,1.68,1.68,1.68,1.67,1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68	300	200	250
111	19	9.97	9.97	4.75	2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33	300	200	250
112	5	1.30	1.30	2.00	-	300	200	250
113	19	4.88	4.00	7.50	1.09,1.10,1.09,1.10,1.09,1.09,1.09,1.10,1.09,1.10,1.09,1.09,1.09,1.09,1.09,1.10,1.08,1.10,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.10,1.09,1.10,1.09,1.09,1.10,1.09,1.09,1.09,1.09,1.09,1.09,1.10,1.09,1.10,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09	300	200	250
114	19	4.88	4.00	7.50	1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.08,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09	300	200	250
115	19	4.84	4.84	7.45	1.90,1.90,1.90,1.90,1.90,1.90,1.98,1.90,2.03,1.90,1.98,1.90,2.02,1.90,1.95,1.90,2.24,1.90,1.97,1.90,2.04,1.90,1.99,1.90,2.01,1.90,1.90,1.90,1.90,1.90,1.90,1.90,1.90,1.90,1.90,1.98,1.90,2.02,1.90,1.96,1.90,2.08,1.90,1.97,1.90,2.03,1.90,1.98,1.90,2.01,1.90	300	200	250
116	19	4.84	4.84	7.45	1.93,1.94,1.93,1.94,1.93,1.93,2.03,1.94,2.05,1.94,2.03,1.93,2.04,1.93,2.00,1.94,2.27,1.94,2.02,1.93,2.06,1.93,2.03,1.93,2.04,1.93,1.93,1.93,1.94,1.93,1.94,1.93,1.93,1.94,1.93,2.02,1.93,2.05,1.93,2.01,1.94,2.10,1.94,2.02,1.93,2.06,1.93,2.03,1.93,2.04,1.93	300	200	250

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	528.38	490.83	114.02	114.02	158.51	158.51
2	182.47	181.10	20.19	20.19	54.74	54.74
3	116.10	115.41	15.79	11.10	42.08	23.28
4	116.10	111.33	15.79	11.10	42.08	23.28
5	116.10	114.23	15.79	11.10	42.08	23.28
6	116.10	115.41	15.79	11.10	42.08	23.28
7	116.10	114.23	15.79	11.10	42.08	23.28
8	133.20	123.95	32.87	6.12	40.24	43.62
9	61.16	54.71	3.51	3.51	18.35	18.35
10	116.10	111.33	15.79	11.10	42.08	23.28
11	133.20	123.95	32.87	6.12	40.24	43.62
12	182.47	181.10	20.19	20.19	54.74	54.74
13	133.20	85.85	24.82	6.12	40.24	43.62
14	133.20	85.85	24.79	6.12	40.24	43.62
15	133.20	32.95	32.87	6.12	40.24	43.62
16	133.20	32.95	32.87	6.12	40.24	43.62
101	528.38	490.83	114.02	114.02	158.51	158.51
102	182.47	181.10	20.19	20.19	54.74	54.74
103	116.10	115.41	15.79	11.10	42.08	23.28
104	116.10	111.33	15.79	11.10	42.08	23.28
105	116.10	114.23	15.79	11.10	42.08	23.28

106	116.10	115.41	15.79	11.10	42.08	23.28
107	116.10	114.23	15.79	11.10	42.08	23.28
108	133.20	32.95	32.87	6.12	40.24	43.62
109	61.16	54.71	3.51	3.51	18.35	18.35
110	116.10	111.33	15.79	11.10	42.08	23.28
111	133.20	32.95	32.87	6.12	40.24	43.62
112	182.47	181.10	20.19	20.19	54.74	54.74
113	133.20	85.85	24.81	6.12	40.24	43.62
114	133.20	85.85	24.81	6.12	40.24	43.62
115	133.20	86.20	32.87	6.12	40.24	43.62
116	133.20	86.20	32.87	6.12	40.24	43.62

Design Ratio

Member ID	P	M_z	M_y	V_y	V_z	(P,M_z,M_y)	Worst LC	KL/r	δ	Status
1	0.021	0.800	0.023	0.046	0.002	0.820	#13	0.166	Not Required	Pass
2	0.003	0.464	0.389	0.098	0.072	0.853	#13	0.035	Not Required	Pass
3	0.011	0.763	0.077	0.077	0.015	0.815	#13	0.045	Not Required	Pass
4	0.011	0.760	0.183	0.076	0.038	0.806	#13	0.080	Not Required	Pass
5	0.011	0.473	0.186	0.076	0.046	0.498	#13	0.074	Not Required	Pass
6	0.009	0.638	0.050	0.063	0.004	0.665	#13	0.045	Not Required	Pass
7	0.009	0.397	0.132	0.064	0.034	0.418	#13	0.074	Not Required	Pass
8	0.002	0.074	0.089	0.040	0.014	0.131	#21	0.095	Not Required	Pass
9	0.013	0.067	0.092	0.002	0.002	0.162	#13	0.204	Not Required	Pass
10	0.009	0.635	0.141	0.064	0.032	0.715	#13	0.080	Not Required	Pass
11	0.002	0.073	0.088	0.040	0.014	0.130	#21	0.063	Not Required	Pass
12	0.004	0.335	0.310	0.079	0.061	0.646	#13	0.035	Not Required	Pass
13	0.008	0.296	0.455	0.055	0.020	0.666	#21	0.190	Not Required	Pass
14	0.010	0.301	0.455	0.055	0.020	0.666	#21	0.190	Not Required	Pass
15	0.000	0.118	0.243	0.040	0.014	0.329	#21	Not Required	Not Required	Pass
16	0.000	0.118	0.243	0.040	0.014	0.329	#21	Not Required	Not Required	Pass
101	0.021	0.801	0.023	0.046	0.002	0.820	#13	0.166	Not Required	Pass
102	0.004	0.335	0.310	0.079	0.061	0.646	#13	0.035	Not Required	Pass
103	0.009	0.638	0.050	0.063	0.004	0.665	#13	0.045	Not Required	Pass
104	0.009	0.635	0.141	0.064	0.032	0.715	#13	0.080	Not Required	Pass
105	0.009	0.397	0.132	0.064	0.034	0.418	#13	0.074	Not Required	Pass
106	0.011	0.763	0.077	0.077	0.015	0.815	#13	0.045	Not Required	Pass
107	0.011	0.473	0.186	0.076	0.046	0.498	#13	0.074	Not Required	Pass
108	0.000	0.118	0.243	0.040	0.014	0.329	#21	Not Required	Not Required	Pass
109	0.013	0.067	0.092	0.002	0.002	0.162	#13	0.204	Not Required	Pass
110	0.011	0.760	0.183	0.076	0.038	0.806	#13	0.080	Not Required	Pass
111	0.000	0.118	0.243	0.040	0.014	0.329	#21	Not Required	Not Required	Pass
112	0.003	0.464	0.389	0.098	0.072	0.853	#13	0.035	Not Required	Pass
113	0.008	0.296	0.455	0.055	0.020	0.666	#21	0.190	Not Required	Pass
114	0.010	0.301	0.455	0.055	0.020	0.666	#21	0.286	Not Required	Pass
115	0.002	0.073	0.166	0.040	0.014	0.199	#21	0.231	Not Required	Pass
116	0.003	0.074	0.167	0.040	0.014	0.199	#21	0.346	Not Required	Pass

Definitions

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

REFERENCES	CALCULATIONS	RESULTS

IBC 2018 Pile Design

Powered by SkyCiv

Input	Description
Region	American Standard
Concrete design code	American Concrete Institute (ACI 318:2019)

Cross-section

Input	Description	Value
Shape	Cross-sectional shape	Square
b	Section width	48 in
D	Section deph	48 in

Material Properties

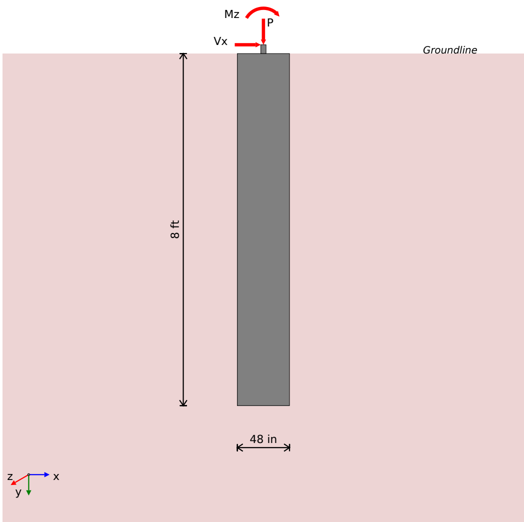
Input	Description	Value
f'_{ck}	Concrete compressive strength	2.5 ksi
f_{yk}	Yield strength of steel	60 ksi
d_b	Rebar diameter	#5 (0.625) in
cover	Concrete cover	3 in

Soil Parameters (IBC 1806)

Input	Description	Value
Soil type	Sand, silty sand, clayey sand, silty gravel & clayey gravel	
q_a	Allowable bearing pressure	2000 psf
R	Allowable lateral pressure	150 psf/ft

Loading

Load	ASD	LRFD
P	7.028 kip	10.33 kip
Vx	-4.37 kip	-7.283 kip
Vz	0.174 kip	0.295 kip
Mx	0.586 kip-ft	0.997 kip-ft
Mz	54.21 kip-ft	91.27 kip-ft



REFERENCES	CALCULATIONS	RESULTS

Required depth to resist lateral loads (ASD)

Allowable lateral pressure $R =$ 150 psf/ft

Point of application of lateral load:

$$H = h_1 + h_2 + h_e = 0 + 0 + 0 = 0\ ft$$

Considering x-direction:

Lateral force per section length

$$H_o = \frac{V_x}{1.57 \times D} = \frac{-4.37}{1.57 \times 48} = -0.696\ \frac{kip}{ft}$$

Moment per section length

$$M_o = \frac{M_z + (V_x \times H)}{1.57 \times D} = \frac{54.21 + (-4.37 \times 0)}{1.57 \times 48} = 8.632 \, \frac{kip - ft}{ft}$$

Required depth of embedment in earth:

$$L_x^3 - \left(9 \times \frac{H_o \times L_x}{R}\right) - \left(12 \times \frac{M_o}{R}\right) = 0$$

Solving the cubic equation:

$$L_{e,x} = 7.284 \, ft$$

Considering z-direction:

Lateral force per section length

$$H_o = \frac{V_z}{1.57 \times b} = \frac{0.174}{1.57 \times 48} = 0.028 \, \frac{kip}{ft}$$

Moment per section length

$$M_o = \frac{M_x + (V_z \times H)}{1.57 \times b} = \frac{0.586 + (0.174 \times 0)}{1.57 \times 48} = 0.093 \, \frac{kip - ft}{ft}$$

Required depth of embedment in earth:

$$L_z^3 - \left(9 \times \frac{H_o \times L_z}{R}\right) - \left(12 \times \frac{M_o}{R}\right) = 0$$

Solving the cubic equation:

$$L_{e,z} = 2.236 \, ft$$

Minimum embedded depth

Depth of pile required

$$L_{e,req} = MAX[L_{e,x}, L_{e,z}] = MAX[7.284, 2.236] = 7.284 \, ft$$

Actual embedded length

$$L_e = L - h_2 - h_e = 8 - 0 - 0 = 8 \, ft$$

Utilisation

$$Ratio = \frac{L_{e,req}}{L_e} = \frac{7.284}{8} = 0.91$$

UTILITY: 0.91

REFERENCES	CALCULATIONS	RESULTS

End-bearing Capacity (ASD)

Allowable bearing pressure	$q_a =$	2000 psf
Unit weight of concrete	$w_c =$	0.15 kip/ft^3

Cross-sectional area:

$$A = b \times D = 48 \times 48 = 16 \, ft^2$$

End-bearing pressure:

$$q = \frac{P}{A} = \frac{7.028}{16} = 439.2 \, psf$$

Utilisation

$$Ratio = \frac{q}{q_a} = \frac{439.2}{2000} = 0.22$$

UTILITY: 0.22

Lateral Soil Pressure (ASD)

Allowable lateral pressure	$R =$	150 psf/ft

Length to least lateral dimension ratio:

$$\frac{L}{MIN[b, D]} = \frac{8}{MIN[4, 4]} = 2$$

L/D ratio ≤ 10. This pile is classified as a short pile.

Considering x-direction:

Distance from resting surface to pivot point:

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

$$(6 \times M_o) + (4 \times H_o \times L_e)$$

$$a = \frac{(4 \times 8.632 \times 8) + \left(3 \times 0.696 \times 8^2\right)}{(6 \times 8.632) + (4 \times 0.696 \times 8)} = 5.534\ ft$$

Earth pressure against the pile at a distance a/2 from the resting surface:

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

$$p = \frac{0.75 \times [(4 \times 8.632) + (3 \times -0.696 \times 8)]^2}{8^2 \times [(3 \times 8.632) + (2 \times -0.696 \times 8)]} = 0.252\ \frac{kip}{ft^2}$$

Allowable lateral soil pressure at a depth of a/2:

$$p_a = R \times \frac{a}{2} = 0.15 \times \frac{5.534}{2} = 0.415\ \frac{kip}{ft^2}$$

Utilisation - pressure at a depth of a/2

$$Ratio = \frac{p}{p_a} = \frac{0.252}{0.415} = 0.608$$

UTILITY: 0.61

Earth pressure against the pile at distance L_e:

$$s = \frac{6 \times [(2 \times M_o) + (H_o \times L_e)]}{L_e^2} = \frac{6 \times [(2 \times 8.632) + (-0.696 \times 8)]}{8^2} = 1.097\ \frac{kip}{ft^2}$$

Allowable lateral soil pressure at a depth of L_e:

$$p_s = R \times L_e = 0.15 \times 8 = 1.2\ \frac{kip}{ft^2}$$

Utilisation - pressure at a depth of L_e

$$Ratio = \frac{s}{p_s} = \frac{1.097}{1.2} = 0.914$$

UTILITY: 0.91

Considering z-direction:

Distance from resting surface to pivot point:

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

$$a = \frac{(4 \times 0.093 \times 8) + \left(3 \times 0.028 \times 8^2\right)}{(6 \times 0.093) + (4 \times 0.028 \times 8)} = 5.742\ ft$$

Earth pressure against the pile at a distance a/2 from the resting surface:

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

$$p = \frac{0.75 \times [(4 \times 0.093) + (3 \times 0.028 \times 8)]^2}{8^2 \times [(3 \times 0.093) + (2 \times 0.028 \times 8)]} = 0.017\ \frac{kip}{ft^2}$$

Allowable lateral soil pressure at a depth of a/2:

$$p_a = R \times \frac{a}{2} = 0.15 \times \frac{5.742}{2} = 0.431\ \frac{kip}{ft^2}$$

Utilisation - pressure at a depth of a/2

$$Ratio = \frac{p}{p_a} = \frac{0.017}{0.431} = 0.041$$

UTILITY: 0.04

Earth pressure against the pile at distance L_e:

$$s = \frac{6 \times [(2 \times M_o) + (H_o \times L_e)]}{L_e^2} = \frac{6 \times [(2 \times 0.093) + (0.028 \times 8)]}{8^2} = 0.038\ \frac{kip}{ft^2}$$

Allowable lateral soil pressure at a depth of L_e:

$$p_s = R \times L_e = 0.15 \times 8 = 1.2\ \frac{kip}{ft^2}$$

Utilisation - pressure at a depth of L_e

$$Ratio = \frac{s}{p_s} = \frac{0.038}{1.2} = 0.032$$

UTILITY: 0.03

REFERENCES	CALCULATIONS	RESULTS

Shear force and bending moment (LRFD)

Considering x-direction:

Lateral force per section length

$$H_o = \frac{V_x}{1.57 \times D} = \frac{-7.283}{1.57 \times 48} = -1.16\ \frac{kip}{ft}$$

Moment per section length

$$M_o = \frac{M_z + (V_x \times H)}{1.57 \times D} = \frac{91.27 + (-7.283 \times 0)}{1.57 \times 48} = 14.53\ \frac{kip - ft}{ft}$$

Distance from resting surface to pivot point:

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

$$a = \frac{(4 \times 14.53 \times 8) + \left(3 \times 1.16 \times 8^2\right)}{(6 \times 14.53) + (4 \times 1.16 \times 8)} = 5.532\ ft$$

Max shear force located at depth a:

$$E = \frac{M_o}{H_o} = \frac{14.53}{-1.16} = 12.53\ ft$$

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

$$V_{max,x} = (-1.16 \times 48) \times [1 - [3 \times \left(\frac{4 \times 12.53}{8} + 3\right) \times \left(\frac{5.532}{8}\right)^2] + [4 \times \left(\frac{3 \times 12.53}{8} + 2\right) \times \left(\frac{5.532}{8}\right)^3]]$$

$$V_{max,x} = 15.92\ kip$$

Max bending moment located at a depth of a/2:

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

$$M_{max,x} = (-1.16 \times 48 \times 8) \times [\left(\frac{12.53}{8} + \frac{5.532}{2 \times 8}\right) - [\left(\frac{4 \times 12.53}{8} + 3\right) \times \left(\frac{5.532}{2 \times 8}\right)^3] + [\left(\frac{3 \times 12.53}{8} + 2\right) \times \left(\frac{5.532}{2 \times 8}\right)^4]]$$

$$M_{max,x} = 60.31\ kip - ft$$

Considering z-direction:

Lateral force per section length

$$H_o = \frac{V_z}{1.57 \times b} = \frac{0.295}{1.57 \times 48} = 0.047\ \frac{kip}{ft}$$

Moment per section length

$$M_o = \frac{M_x + (V_z \times H)}{1.57 \times b} = \frac{0.997 + (0.295 \times 0)}{1.57 \times 48} = 0.159\ \frac{kip - ft}{ft}$$

Distance from resting surface to pivot point:

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

$$a = \frac{(4 \times 0.159 \times 8) + \left(3 \times 0.047 \times 8^2\right)}{(6 \times 0.159) + (4 \times 0.047 \times 8)} = 5.742\ ft$$

Max shear force located at depth a:

$$E = \frac{M_o}{H_o} = \frac{0.159}{0.047} = 3.376\ ft$$

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

$$V_{max,z} = (0.047 \times 48) \times [1 - [3 \times \left(\frac{4 \times 3.376}{8} + 3\right) \times \left(\frac{5.742}{8}\right)] + [4 \times \left(\frac{3 \times 3.376}{8} + 2\right) \times \left(\frac{5.742}{8}\right)]]$$

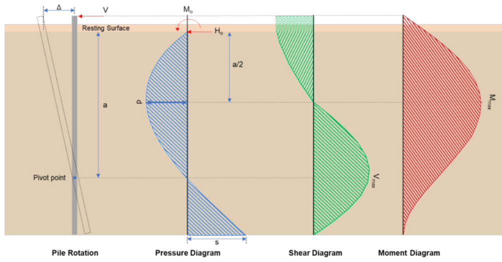
$$V_{max,z} = 0.266\ kip$$

Max bending moment located at a depth of a/2:

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

$$M_{max,z} = (0.047 \times 48 \times 8) \times [\left(\frac{3.376}{8} + \frac{5.742}{2 \times 8}\right) - [\left(\frac{4 \times 3.376}{8} + 3\right) \times \left(\frac{5.742}{2 \times 8}\right)^3] + [\left(\frac{3 \times 3.376}{8} + 2\right) \times \left(\frac{5.742}{2 \times 8}\right)^4]]$$

$$M_{max,z} = 0.931\ kip - ft$$



Minimum Reinforcement Check (LRFD)

Gross area of concrete:

$$A_g = b \times D = 48 \times 48 = 2304\ in^2$$

Main Reinforcement

22.4.2.2 Required reinforcement:

$$A_{st,req} = \frac{P - (0.85 \times f'_{ck} \times A_g)}{f_{yk} - (0.85 \times f'_{ck})} = \frac{10.33 - (0.85 \times 2.5 \times 2304)}{60 - (0.85 \times 2.5)} = -84.42\ in^2$$

10.6.1.1 Maximum reinforcement:

$$A_{st,max} = 0.08 \times A_g = 0.08 \times 2304 = 184.3 in^2$$

7.6.1.1 Minimum reinforcement:

$$A_{st,min} = 0.0018 \times A_g = 0.0018 \times 2304 = 4.147 in^2$$

Governing minimum reinforcement area:

$$(0.0018 \times A_g) \leq A_{st,req} \leq (0.08 \times A_g)$$

$$A_{min} = 4.147\ in^2$$

Minimum number of reinforcements:

$$A_{bar} = 0.307\ in^2$$

$$n_{min} = \frac{A_{min}}{A_{bar}} = \frac{4.147}{0.307} = 14$$

25.2.3 Minimum spacing:

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

$$\text{Use: } n = 16 \text{pcs at } 1.5 \text{ in minimum spacing}$$

Total reinforcement area:

$$A_{st} = 16 \times 0.307 = 4.909\ in^2$$

Shear Reinforcement

25.7.2.2 For main reinforcement $\leq$ 1.41 in: Use #3(0.375 in)

Maximum spacing of shear Reinforcements:

$$s = MIN[16 \times d_b, 48 \times d_{b,ties}, MIN(b, D)] = MIN[(16 \times 0.625), (48 \times 0.375), MIN(48, 48)] = 10\ in$$

Detailing Summary	
Main reinforcement	#5 (0.625 in) - 16pcs at 1.5 in min. spacing

Shear reinforcement	#3 (0.375 in) at 10 in max. spacing

Axial Compression Strength (LRFD)

22.4.2.2 Allowable axial compressive strength:

$$\phi P_N = \phi \times 0.8 \times [(0.85 \times f'_{ck} \times [A_g - A_{st}]) + (f_{yk} \times A_{st})]$$

$$\phi P_N = 0.65 \times 0.8 \times [(0.85 \times 2.5 \times [2304 - 4.909]) + (60 \times 4.909)] = 2694\ kip$$

Utilisation

$$Ratio = \frac{P}{\phi P_N} = \frac{10.33}{2694} = 0.004$$

UTILITY: 0.00

Shear Strength LRFD)

Effective shear width	$b_w =$	48 in
Effective shear depth	$d =$	44.31 in
Shear reinforcement area	$A_v =$	0.221 in^2
Shear reinforcement spacing	$s =$	10 in
Concrete type factor (Normal concrete)	$\lambda =$	1
Strength reduction factor for shear	$\phi =$	0.75
Maximum shear in the x-direction	$V_{max,x} =$	15.92 kip
Maximum shear in the z-direction	$V_{max,z} =$	0.266 kip

22.5.5.1.1 Max shear strength of concrete:

$$V_{c,max} = 5 \times \lambda \times \sqrt{f'_{ck}} \times b_w \times d = 5 \times 1 \times \sqrt{2.5} \times 48 \times 44.31 = 531.8\ kip$$

Table 22.5.5.1 Shear strength of concrete:

$$V_{c,a} = \left(2 \times \lambda \times \sqrt{f'_{ck}} + MIN[\frac{P}{6 \times A_g}, (0.05 \times f'_{ck})]\right) \times (b_w \times d)$$

$$V_{c,a} = \left(2 \times 1 \times \sqrt{2.5} + MIN[\frac{10.33}{6 \times 2304}, (0.05 \times 2.5)]\right) \times (48 \times 44.31) = 214.3\ kip$$

Governing shear strength of concrete:

$$V_c = MIN[V_{c,max}, V_{c,a}] = MIN[531.8, 214.3] = 214.3\ kip$$

22.5.1.2 Shear strength of steel (a):

$$V_{s,a} = 8 \times \sqrt{f'_{ck}} \times b_w \times d = 8 \times \sqrt{2.5} \times 48 \times 44.31 = 850.8\ kip$$

22.5.8.5.3 Shear strength of steel (b):

$$V_{s,b} = \frac{A_v \times f_{yk} \times d}{s} = \frac{0.221 \times 60 \times 44.31}{10} = 58.73\ kip$$

Governing shear strength of steel:

$$V_s = MIN[V_{s,a}, V_{s,b}] = MIN[850.8, 58.73] = 58.73\ kip$$

22.5.1.1 Allowable shear strength:

$$\phi V_n = \phi \times (V_c + V_s) = 0.75 \times (214.3 + 58.73) = 204.8\ kip$$

$$V_{max} = MAX[15.92, 0.266] = 15.92\ kip$$

Utilisation

$$Ratio = \frac{V_{max}}{\phi V_n} = \frac{15.92}{204.8} = 0.078$$

UTILITY: 0.08

Flexural Strength (LRFD)

Concrete type factor (Normal concrete)	$\lambda =$	1
Strength reduction factor for flexure	$\phi =$	0.65
Modulus of steel reinforcement	$E_s =$	200e3 ksi
Maximum concrete strain	$\varepsilon_c =$	0.0030
Yield strain of steel f_y/E_s	$\varepsilon_y =$	0.0003
Section width	$b =$	48 in
Distance to the compression rebar	$d_s =$	3.688 in
Distance to the tension rebar	$d =$	44.31 in
Total bar area	$A_s =$	4.909 in^2
Maximum applied axial load	$P =$	10.33 kip
Maximum moment in the x-direction	$M_{max,x} =$	60.31 kip-ft
Maximum moment in the z-direction	$M_{max,z} =$	0.931 kip-ft

Compressive force due to concrete:

$$\beta_1 = 0.85$$

$$C_{rc} = 0.85 \times \beta_1 \times f'_c \times b \times c$$

Compressive force due to bars in compression:

$$C_{rs} = f_1 \times A_{sc}$$

$$\varepsilon_1 = (c - d_s) \times \frac{\varepsilon_c}{c}$$

$$f_1 = E_s \times \varepsilon_1 \ (\varepsilon_1 < \varepsilon_{sy}),\ f_1 = f_y \ (\varepsilon_1 \geq \varepsilon_{sy})$$

Tensile force due to bars in tension:

$$T_{rs} = f_2 \times A_{st}$$

$$\varepsilon_2 = (d - c) \times \frac{\varepsilon_{cu}}{c}$$

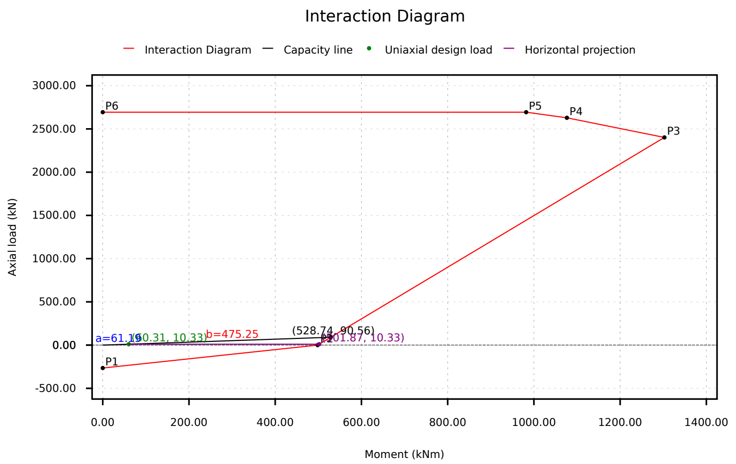
$$f_2 = E_s \times \varepsilon_2 \ (\varepsilon_2 < \varepsilon_{sy}),\ f_2 = \phi_s \times f_y \ (\varepsilon_2 \geq \varepsilon_{sy})$$

Interaction Diagram Summary

Point	Case	M_r	P_r
P1	Pure Tension	0	-265.1
P2	Pure Bending	498.4	0
P3	Balanced Failure	1303	2402
P4	Decompression	1077	2629
P5	Compression Limit	982	2694
P6	Pure Compression	0	2694

Uniaxial Bending Check

$$M_f = MAX[60.31, 0.931] = 60.31\ kip - ft$$



Segment	Signed Distance
P1 - P2	214.8
P2 - P3	418.7
P3 - P4	2568
P4 - P5	2734
P5 - P6	2683
Status	PASS: Point lies inside the curve

Utilisation

$$Ratio = \frac{a}{a+b} = \frac{61.19}{61.19 + 475.3} = 0.114$$

UTILITY: 0.11

Biaxial Bending Check

Maximum moment in the x-direction	$M_{max,x} =$	60.31 kip-ft
Maximum moment in the z-direction	$M_{max,z} =$	0.931 kip-ft
Nominal uniaxial moment strength about the x-axis	$M_{nox} =$	501.9 kip-ft
Nominal uniaxial moment strength about the z-axis	$M_{noz} =$	501.9 kip-ft
Interaction exponent	$\alpha =$	1

Bresler (1960)	According to Bresler (method B): $$\left(\frac{M_{max,x}}{M_{nox}}\right)^{\alpha}+\left(\frac{M_{max,z}}{M_{noz}}\right)^{\alpha}=1.0$$ $$\left(\frac{60.31}{501.9}\right)^{1}+\left(\frac{0.931}{501.9}\right)^{1}=0.122$$	**UTILITY: 0.12**

REFERENCES	CALCULATIONS	RESULTS

Results Summary

Result Name	Results
PILE DETAILS	
Length of the pile	8.00 ft
Dimensions	48 x 48 in
Main bar reinforcement	#5-16pcs at 1.5 in min.
Shear reinforcement	#3 at 10 in max.
UTILISATIONS	
Required depth	0.91
End-bearing capacity	0.22
p_a	0.61
p_s	0.91
Axial compression strength	0.00
Shear strength	0.08
Uniaxial bending strength	0.11
Biaxial bending strength	0.12