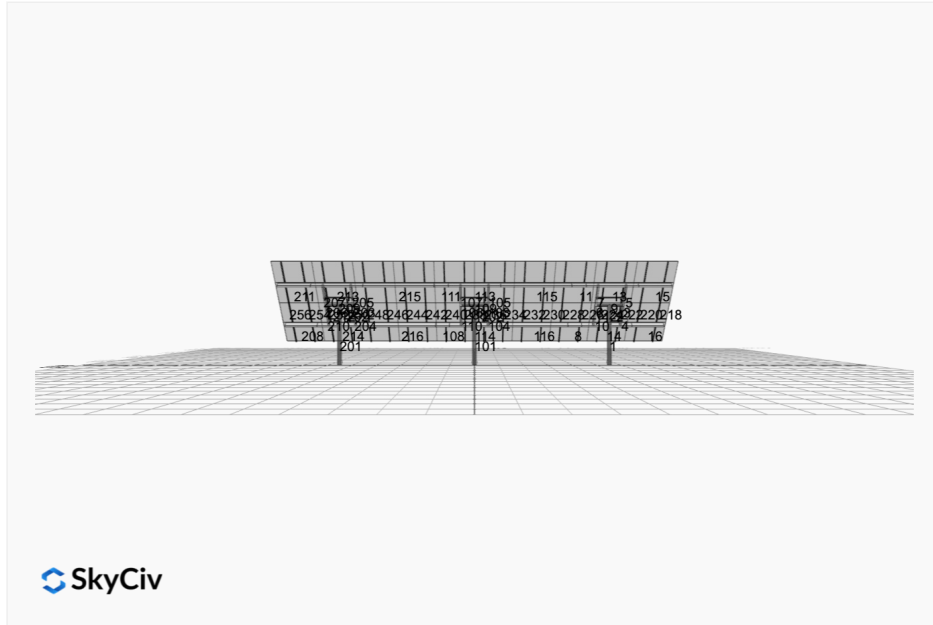


# Project Details



**Project Name:** MTSOLAR\_11025FLK2FE22      **Date:** Mon Nov 10 2025  
**Location:** 55 Fox Rd, Red Lodge, MT 59068, USA      **Number of Modules:** 40  
**Unique ID:** 3P-19.75-6TOP-HD-57-L-4Hx10W-A464      **Number of Poles:** 3  
**Dealer:** \_\_\_\_\_      **Date Sold:** \_\_\_\_\_



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Array Dimensions N/S	15.03 ft
Array Dimensions E/W	57.33 ft
Winter Tilt Angle (Degrees)	50
Front Edge Clearance	3

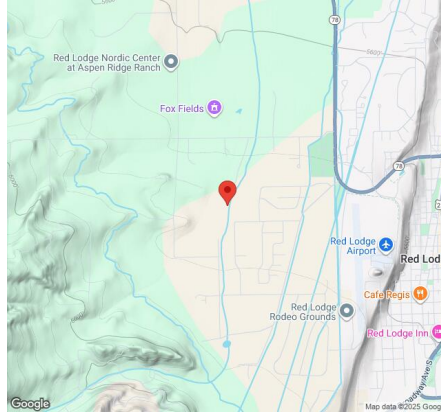
## MT Solar Bill of Materials (3P-19.75-6TOP-HD-57-L-4Hx10W-A464)

Part	Short Description	BOM Qty
MTS-PC-6	6IN Pole Cap Assembly	3
MTS-HF-HD	H-Frame Assembly-HD	3
MTS-HD-Wing-57	57IN HD Wing	4
MTS-HD-Splice-90	90IN HD Splice	4
MTS-HD-Splice-57	57IN HD Splice	4
MTS-CLAMP-HOOK-4PK	Hook Clamp	10

## Rail Bill of Materials

Part	Qty
Rails (180in Long)	20x
Rail Attachment	40x
Module Mid Clamp	60x
Module End Clamp	40x
Ground Lug	10x

## Site Details:



**Site Address:** 55 Fox Rd, Red Lodge, MT 59068, USA

### Array Specifications

<b>Duty Classification:</b>	HD
<b>Module Width:</b>	44.60 in
<b>Module Length:</b>	67.80 in
<b>Number of Rows:</b>	4
<b>Number of Columns:</b>	10
<b>Total Number of Modules:</b>	40
<b>Winter Tilt Angle:</b>	50
<b>Front Edge Clearance:</b>	3
<b>Total Array Height at Tilt:</b>	14.52 ft
<b>Total Frame Length:</b>	56.50 ft
<b>Module Info/Notes:</b>	
<b>Array Dimensions N/S:</b>	15.03 ft
<b>Array Dimensions E/W:</b>	57.33 ft
<b>Rail Length:</b>	180.40 in
<b>Rail Spacing:</b>	2.87 ft

### Support Specifications

<b>Pole Size:</b>	6in Pipe Sch 40
<b>Pole Length above Grade:</b>	8.76 ft
<b>Number of Poles:</b>	3
<b>Pole Spacing:</b>	19.75 ft

### Foundation Specifications

<b>Foundation Type:</b>	rectangular
<b>Foundation Dimensions:</b>	48x48 in
<b>Foundation Depth (below grade):</b>	5.8 ft
<b>Foundation Volume:</b>	92.00 ft <sup>3</sup>

### Site Info

<b>Risk Category:</b>	I
<b>Exposure:</b>	C
<b>Soil Classification:</b>	sand
<b>Site Location:</b>	55 Fox Rd, Red Lodge, MT 59068, USA
<b>Wind Speed:</b>	102 mph

**Snow Load:**

109 psf

### **Design Disclaimer**

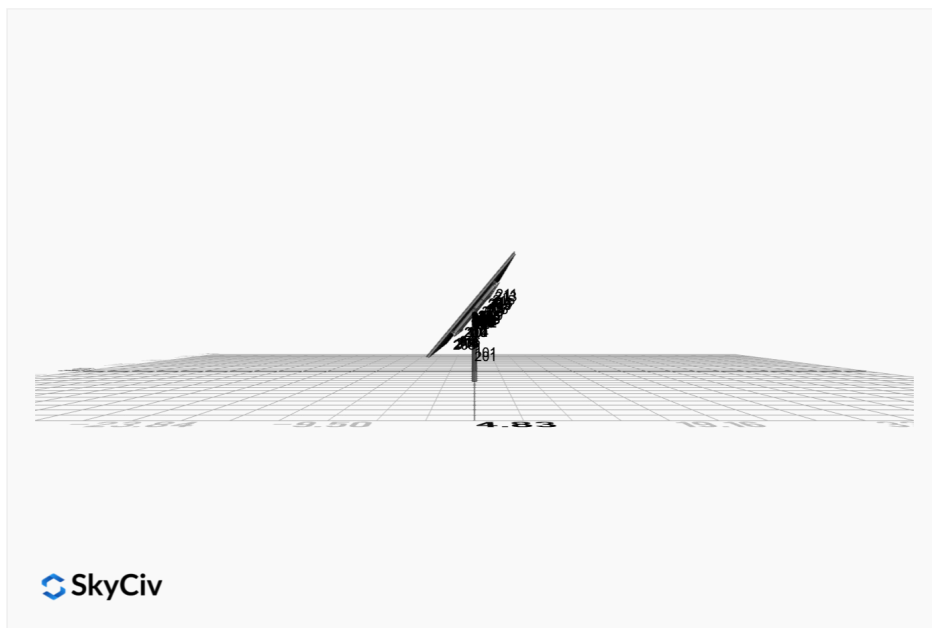
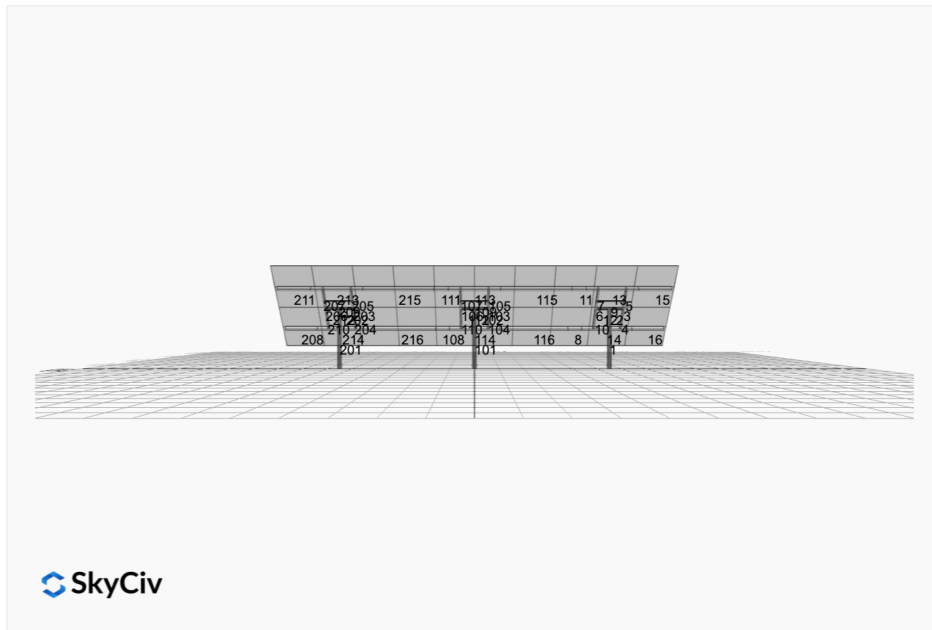
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

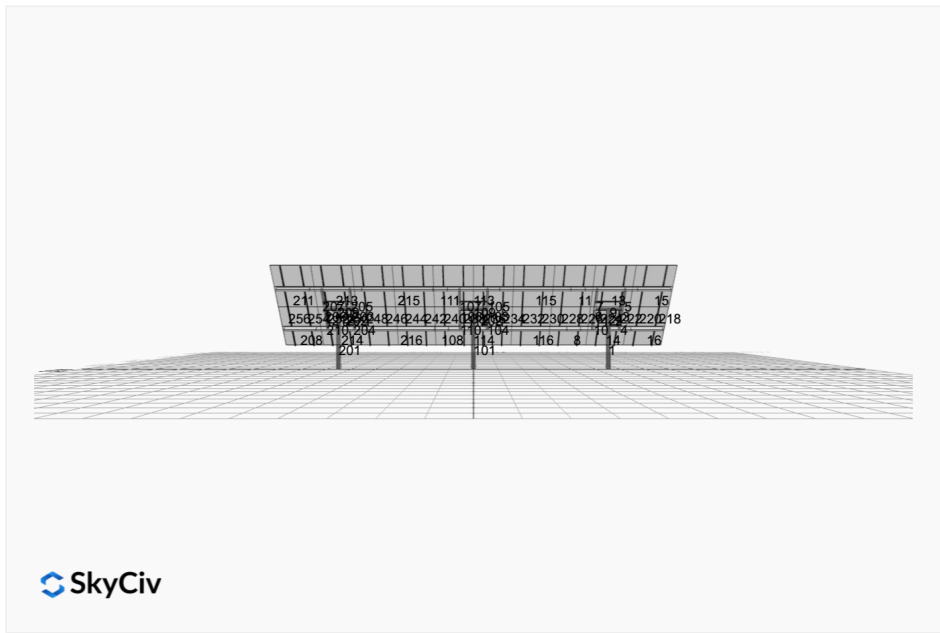
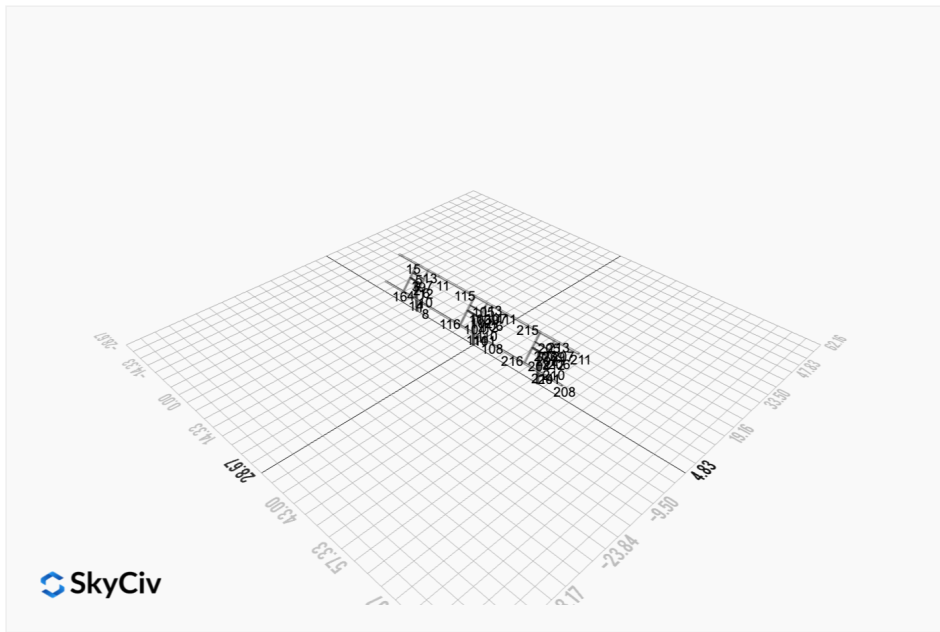
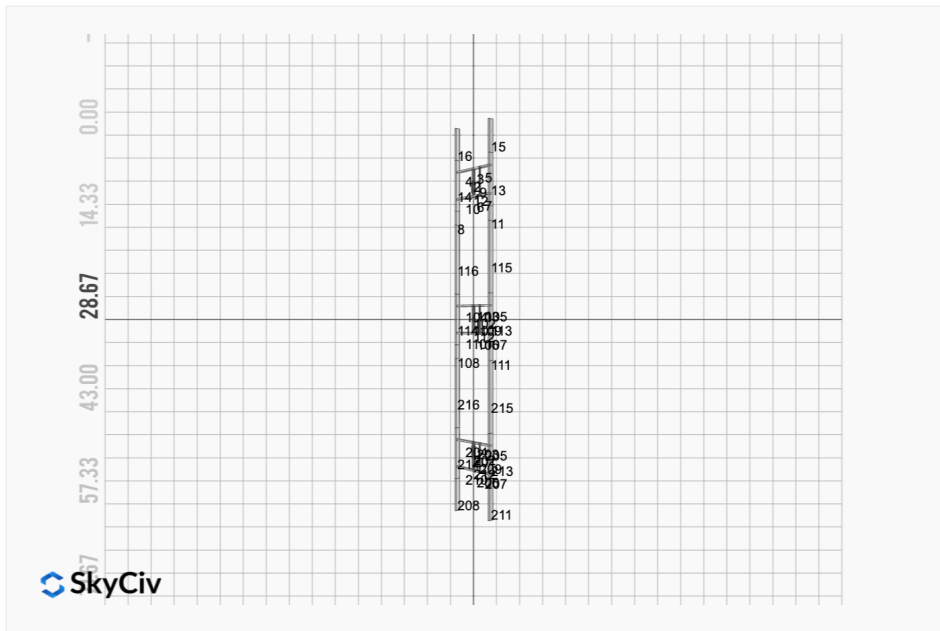
## AutoDesigner Input

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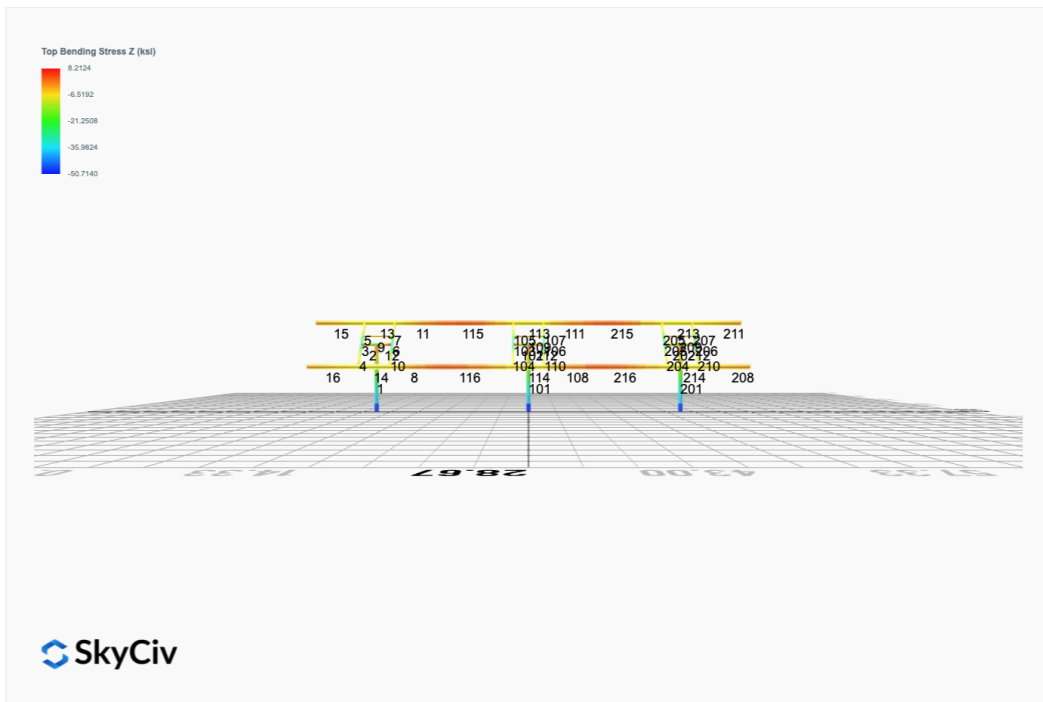
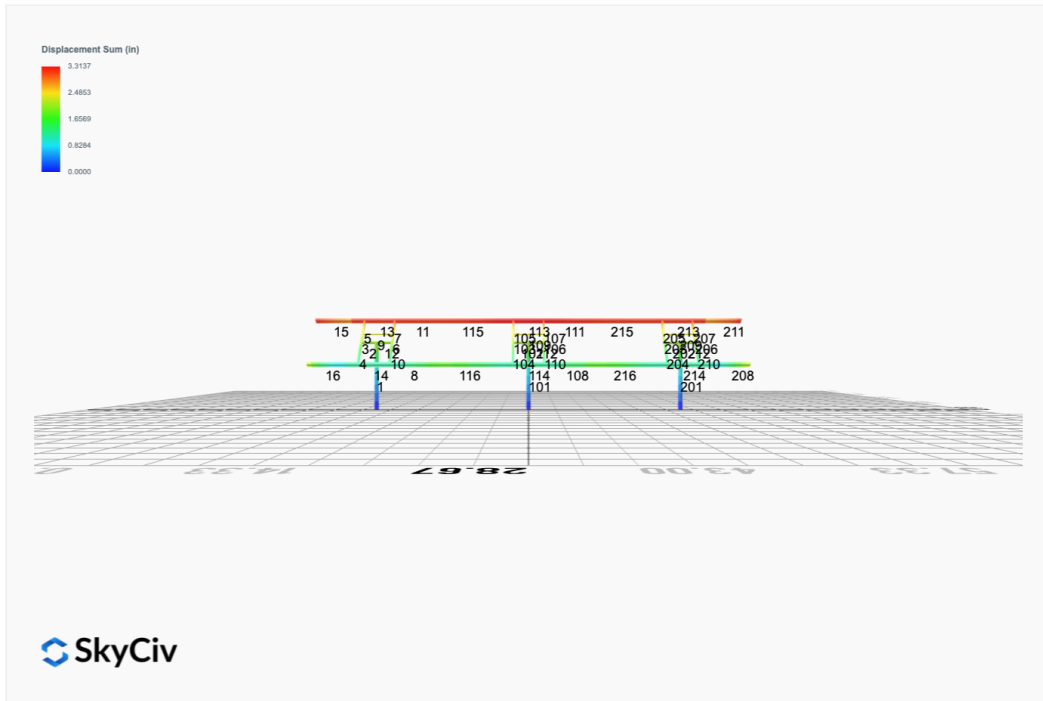
## Design Notes:

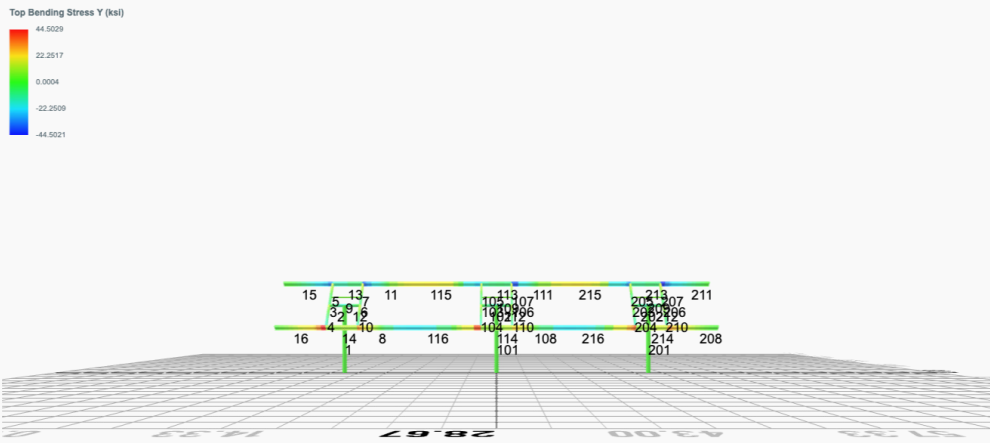
- Deflection checks are set to L/1 due to manufacturer structural design intent
- Foundation Soil Parameters used in this Autodesign are all estimates, proper geotechnical reports are required to confirm soil profiles
- Wind speeds, snow loads and other site specific results are based on ASCE 7-16
- 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



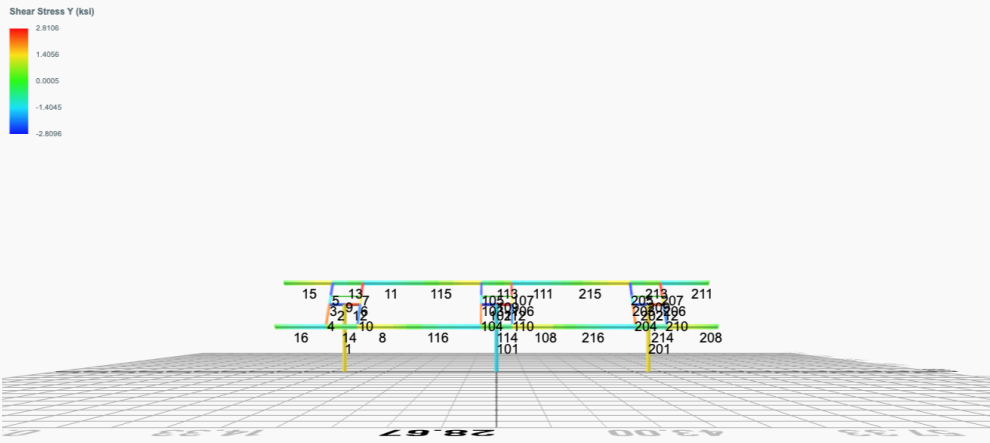


# FEM Results (Envelope Worst Case)

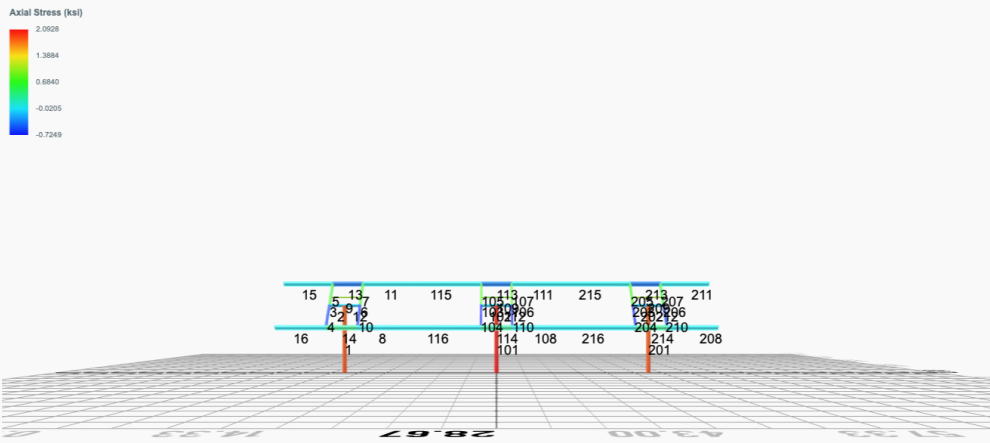




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## Reaction Forces for Foundation 1 (Node ID#1), (kip, kip-ft)

### LRFD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. 1.4D	-0.0068	2.8971	-0.0026	-0.0037	0.0393	0.0841
ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R)	-0.0120	4.6489	-0.0044	-0.0061	0.0692	0.1353
ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R)	-0.0058	2.4833	-0.0022	-0.0032	0.0336	0.0710
ULS: 3. 1.2D + 1.6(S or Lr or R) + L	-0.0254	9.4132	-0.0093	-0.0124	0.1475	0.3262
ULS: 5. 1.2D + E + L + 0.2S	-0.0083	3.3495	-0.0031	-0.0044	0.0479	0.0951
ULS: 7. 0.9D + 1.0E	-0.0044	1.8625	-0.0017	-0.0024	0.0252	0.0520
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only	-3.8536	7.8643	-0.0056	-0.0101	0.0671	35.1458
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only	-0.0120	4.6489	-0.0044	-0.0061	0.0692	0.1353
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only	3.8286	1.4340	-0.0023	0.0001	0.0684	-33.8300
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only	-0.0120	4.6489	-0.0044	-0.0061	0.0692	0.1353
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only	-3.8470	5.6984	-0.0038	-0.0079	0.0327	34.6952
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only	-0.0058	2.4833	-0.0022	-0.0032	0.0336	0.0710
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only	3.8343	-0.7314	0.0002	0.0037	0.0319	-33.5343
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only	-0.0058	2.4833	-0.0022	-0.0032	0.0336	0.0710
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only	-1.9467	11.0212	-0.0097	-0.0138	0.1456	18.1332
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only	-0.0254	9.4132	-0.0093	-0.0124	0.1475	0.3262
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only	1.8956	7.8054	-0.0087	-0.0104	0.1487	-17.2042
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only	-0.0254	9.4132	-0.0093	-0.0124	0.1475	0.3262
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only	-1.9263	4.0908	-0.0031	-0.0058	0.0335	17.2523
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only	-0.0058	2.4833	-0.0022	-0.0032	0.0336	0.0710
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only	1.9143	0.8759	-0.0011	0.0000	0.0331	-16.8556
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only	-0.0058	2.4833	-0.0022	-0.0032	0.0336	0.0710
ULS: 6. 0.9D + 1.0W_Wind downforce Case A only	-3.8454	5.0775	-0.0033	-0.0073	0.0245	34.5685
ULS: 6. 0.9D + 1.0W_Wind downforce Case B only	-0.0044	1.8625	-0.0017	-0.0024	0.0252	0.0520
ULS: 6. 0.9D + 1.0W_Wind uplift Case A only	3.8356	-1.3521	0.0008	0.0047	0.0232	-33.4528
ULS: 6. 0.9D + 1.0W_Wind uplift Case B only	-0.0044	1.8625	-0.0017	-0.0024	0.0252	0.0520

### ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	-0.0049	2.0694	-0.0018	-0.0027	0.0280	0.0582
ULS: 2. D + L	-0.0049	2.0694	-0.0018	-0.0027	0.0280	0.0582
ULS: 3. D + (S or Lr or R)	-0.0171	6.4006	-0.0063	-0.0085	0.0992	0.1961
ULS: 3. D + (S or Lr or R)	-0.0049	2.0694	-0.0018	-0.0027	0.0280	0.0582
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0141	5.3178	-0.0052	-0.0070	0.0814	0.1565
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0049	2.0694	-0.0018	-0.0027	0.0280	0.0582
ULS: 5b. D + 0.7E	-0.0049	2.0694	-0.0018	-0.0027	0.0280	0.0582
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0141	5.3178	-0.0052	-0.0070	0.0814	0.1565
ULS: 8. 0.6D + 0.7E	-0.0029	1.2416	-0.0011	-0.0016	0.0168	0.0339
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.3094	3.9984	-0.0029	-0.0059	0.0279	20.6644
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.0049	2.0694	-0.0018	-0.0027	0.0280	0.0582
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.2993	0.1406	-0.0005	0.0013	0.0272	-20.1829
ULS: 5a. D + 0.6W_Wind uplift Case B only	-0.0049	2.0694	-0.0018	-0.0027	0.0280	0.0582
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.7428	6.7647	-0.0058	-0.0090	0.0806	15.8323
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0141	5.3178	-0.0052	-0.0070	0.0814	0.1565
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.7144	3.8710	-0.0043	-0.0046	0.0815	-15.3061
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0141	5.3178	-0.0052	-0.0070	0.0814	0.1565

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	-1.7332	3.5161	-0.0027	-0.0051	0.0280	15.4780
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0049	2.0694	-0.0018	-0.0027	0.0280	0.0582
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.7233	0.6228	-0.0008	0.0002	0.0275	-15.1562
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0049	2.0694	-0.0018	-0.0027	0.0280	0.0582
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.3073	3.1706	-0.0022	-0.0049	0.0169	20.5556
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.0029	1.2416	-0.0011	-0.0016	0.0168	0.0339
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.3011	-0.6871	0.0003	0.0025	0.0158	-20.1263
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	-0.0029	1.2416	-0.0011	-0.0016	0.0168	0.0339

### Worst Case Reactions (LRFD)

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

Result	Value (kip, kip-ft)
Axial	11.0212
Shear X	-3.8536
Shear Z	-0.0097
Moment X	-0.0138
Moment Y (Twist)	0.1487
Moment Z	35.1458

### Worst Case Reactions (ASD)

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

Result	Value (kip, kip-ft)
Axial	6.7647
Shear X	-2.3094
Shear Z	-0.0063
Moment X	-0.0090
Moment Y (Twist)	0.0992
Moment Z	20.6644

## 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	0.0136	3.0540	0.0002	0.0004	0.0004	-0.0654
ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R)	0.0239	4.9271	0.0003	0.0006	0.0007	-0.1281
ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R)	0.0117	2.6177	0.0001	0.0003	0.0003	-0.0571
ULS: 3. 1.2D + 1.6(S or Lr or R) + L	0.0508	10.0078	0.0006	0.0014	0.0015	-0.2374
ULS: 5. 1.2D + E + L + 0.2S	0.0166	3.5415	0.0002	0.0004	0.0005	-0.0870
ULS: 7. 0.9D + 1.0E	0.0088	1.9633	0.0001	0.0002	0.0003	-0.0439
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only	-3.9457	8.2741	0.0002	-0.0001	0.0005	35.9045
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only	0.0239	4.9271	0.0003	0.0006	0.0007	-0.1281
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only	3.9956	1.5790	0.0004	0.0013	0.0009	-35.0813
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only	0.0239	4.9271	0.0003	0.0006	0.0007	-0.1281
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only	-3.9589	5.9653	0.0000	-0.0004	0.0001	35.5737
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only	0.0117	2.6177	0.0001	0.0003	0.0003	-0.0571
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only	3.9843	-0.7309	0.0003	0.0010	0.0005	-34.6357
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only	0.0117	2.6177	0.0001	0.0003	0.0003	-0.0571
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only	-1.9331	11.6809	0.0006	0.0010	0.0014	18.0940
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only	0.0508	10.0078	0.0006	0.0014	0.0015	-0.2374
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only	2.0352	8.3345	0.0007	0.0017	0.0016	-18.2830
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only	0.0508	10.0078	0.0006	0.0014	0.0015	-0.2374
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only	-1.9739	4.2916	0.0001	-0.0000	0.0002	17.6232
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only	0.0117	2.6177	0.0001	0.0003	0.0003	-0.0571
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only	1.9978	0.9436	0.0002	0.0006	0.0004	-17.4744
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only	0.0117	2.6177	0.0001	0.0003	0.0003	-0.0571
ULS: 6. 0.9D + 1.0W_Wind downforce Case A only	-3.9621	5.3110	-0.0000	-0.0005	0.0001	35.4751
ULS: 6. 0.9D + 1.0W_Wind downforce Case B only	0.0088	1.9633	0.0001	0.0002	0.0003	-0.0439
ULS: 6. 0.9D + 1.0W_Wind uplift Case A only	3.9817	-1.3854	0.0002	0.0009	0.0004	-34.5184
ULS: 6. 0.9D + 1.0W_Wind uplift Case B only	0.0088	1.9633	0.0001	0.0002	0.0003	-0.0439

## ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	0.0097	2.1814	0.0001	0.0003	0.0003	-0.0484
ULS: 2. D + L	0.0097	2.1814	0.0001	0.0003	0.0003	-0.0484
ULS: 3. D + (S or Lr or R)	0.0342	6.8002	0.0004	0.0009	0.0010	-0.1817
ULS: 3. D + (S or Lr or R)	0.0097	2.1814	0.0001	0.0003	0.0003	-0.0484
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0281	5.6455	0.0004	0.0007	0.0008	-0.1533
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0097	2.1814	0.0001	0.0003	0.0003	-0.0484
ULS: 5b. D + 0.7E	0.0097	2.1814	0.0001	0.0003	0.0003	-0.0484
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0281	5.6455	0.0004	0.0007	0.0008	-0.1533
ULS: 8. 0.6D + 0.7E	0.0058	1.3089	0.0001	0.0001	0.0002	-0.0300
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.3730	4.1901	0.0001	-0.0002	0.0002	21.1560
ULS: 5a. D + 0.6W_Wind downforce Case B only	0.0097	2.1814	0.0001	0.0003	0.0003	-0.0484
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.3932	0.1724	0.0002	0.0007	0.0004	-20.8760
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.0097	2.1814	0.0001	0.0003	0.0003	-0.0484
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.7583	7.1517	0.0003	0.0004	0.0007	15.9805
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0281	5.6455	0.0004	0.0007	0.0008	-0.1533
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.8150	4.1391	0.0004	0.0011	0.0009	-16.0668
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0281	5.6455	0.0004	0.0007	0.0008	-0.1533
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.7774	3.6880	0.0001	-0.0001	0.0002	15.8189
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0097	2.1814	0.0001	0.0003	0.0003	-0.0484
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.7973	0.6747	0.0002	0.0006	0.0004	-15.7037
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0097	2.1814	0.0001	0.0003	0.0003	-0.0484
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.3771	3.3177	0.0000	-0.0003	0.0001	21.0869
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	0.0058	1.3089	0.0001	0.0001	0.0002	-0.0300
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.3895	-0.7003	0.0001	0.0005	0.0003	-20.7737
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.0058	1.3089	0.0001	0.0001	0.0002	-0.0300

### Worst Case Reactions (LRFD)

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

Result	Value (kip, kip-ft)
Axial	11.6809
Shear X	-3.9956
Shear Z	0.0007
Moment X	0.0017
Moment Y (Twist)	0.0016
Moment Z	35.9045

### Worst Case Reactions (ASD)

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

Result	Value (kip, kip-ft)
Axial	7.1517
Shear X	-2.3932
Shear Z	0.0004
Moment X	0.0011
Moment Y (Twist)	0.0010
Moment Z	21.1560

## Reaction Forces for Foundation 3 (Node ID#201), (kip, kip-ft)

### LRFD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. 1.4D	-0.0068	2.8971	0.0024	0.0032	-0.0401	0.0839
ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R)	-0.0119	4.6489	0.0041	0.0051	-0.0707	0.1349
ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R)	-0.0058	2.4833	0.0021	0.0027	-0.0344	0.0708
ULS: 3. 1.2D + 1.6(S or Lr or R) + L	-0.0253	9.4132	0.0087	0.0103	-0.1509	0.3254
ULS: 5. 1.2D + E + L + 0.2S	-0.0083	3.3495	0.0029	0.0037	-0.0489	0.0948
ULS: 7. 0.9D + 1.0E	-0.0044	1.8624	0.0015	0.0020	-0.0258	0.0519
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only	-3.8535	7.8642	0.0055	0.0085	-0.0699	35.1459

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only	-0.0119	4.6489	0.0041	0.0051	-0.0707	0.1349
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only	3.8286	1.4340	0.0019	-0.0006	-0.0688	-33.8307
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only	-0.0119	4.6489	0.0041	0.0051	-0.0707	0.1349
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only	-3.8469	5.6984	0.0037	0.0069	-0.0346	34.6955
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only	-0.0058	2.4833	0.0021	0.0027	-0.0344	0.0708
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only	3.8342	-0.7313	-0.0005	-0.0037	-0.0314	-33.5349
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only	-0.0058	2.4833	0.0021	0.0027	-0.0344	0.0708
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only	-1.9466	11.0211	0.0091	0.0113	-0.1496	18.1326
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only	-0.0253	9.4132	0.0087	0.0103	-0.1509	0.3254
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only	1.8956	7.8054	0.0080	0.0086	-0.1514	-17.2052
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only	-0.0253	9.4132	0.0087	0.0103	-0.1509	0.3254
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only	-1.9262	4.0907	0.0030	0.0051	-0.0349	17.2523
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only	-0.0058	2.4833	0.0021	0.0027	-0.0344	0.0708
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only	1.9143	0.8759	0.0009	-0.0002	-0.0332	-16.8560
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only	-0.0058	2.4833	0.0021	0.0027	-0.0344	0.0708
ULS: 6. 0.9D + 1.0W_Wind downforce Case A only	-3.8453	5.0775	0.0033	0.0065	-0.0263	34.5686
ULS: 6. 0.9D + 1.0W_Wind downforce Case B only	-0.0044	1.8624	0.0015	0.0020	-0.0258	0.0519
ULS: 6. 0.9D + 1.0W_Wind uplift Case A only	3.8356	-1.3521	-0.0011	-0.0046	-0.0226	-33.4531
ULS: 6. 0.9D + 1.0W_Wind uplift Case B only	-0.0044	1.8624	0.0015	0.0020	-0.0258	0.0519

#### ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	-0.0049	2.0694	0.0017	0.0023	-0.0287	0.0581
ULS: 2. D + L	-0.0049	2.0694	0.0017	0.0023	-0.0287	0.0581
ULS: 3. D + (S or Lr or R)	-0.0171	6.4006	0.0058	0.0070	-0.1014	0.1955
ULS: 3. D + (S or Lr or R)	-0.0049	2.0694	0.0017	0.0023	-0.0287	0.0581
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0140	5.3178	0.0048	0.0058	-0.0832	0.1560
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0049	2.0694	0.0017	0.0023	-0.0287	0.0581
ULS: 5b. D + 0.7E	-0.0049	2.0694	0.0017	0.0023	-0.0287	0.0581
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0140	5.3178	0.0048	0.0058	-0.0832	0.1560
ULS: 8. 0.6D + 0.7E	-0.0029	1.2416	0.0010	0.0014	-0.0172	0.0338
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.3093	3.9984	0.0029	0.0051	-0.0292	20.6644
ULS: 5a. D + 0.6W_Wind downforce Case B only	-0.0049	2.0694	0.0017	0.0023	-0.0287	0.0581
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.2992	0.1406	0.0003	-0.0014	-0.0271	-20.1832
ULS: 5a. D + 0.6W_Wind uplift Case B only	-0.0049	2.0694	0.0017	0.0023	-0.0287	0.0581
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.7427	6.7647	0.0055	0.0075	-0.0830	15.8320
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0140	5.3178	0.0048	0.0058	-0.0832	0.1560
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.7144	3.8710	0.0039	0.0037	-0.0828	-15.3067
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0140	5.3178	0.0048	0.0058	-0.0832	0.1560
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.7332	3.5161	0.0026	0.0045	-0.0292	15.4780
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-0.0049	2.0694	0.0017	0.0023	-0.0287	0.0581
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.7232	0.6228	0.0007	-0.0004	-0.0276	-15.1565
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	-0.0049	2.0694	0.0017	0.0023	-0.0287	0.0581
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.3073	3.1705	0.0022	0.0044	-0.0180	20.5555
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-0.0029	1.2416	0.0010	0.0014	-0.0172	0.0338
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.3011	-0.6871	-0.0005	-0.0025	-0.0155	-20.1264
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	-0.0029	1.2416	0.0010	0.0014	-0.0172	0.0338

#### Worst Case Reactions (LRFD)

#### Worst Case Reactions (ASD)

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

Result	Value (kip, kip-ft)
Axial	11.0211
Shear X	-3.8535
Shear Z	0.0091
Moment X	0.0113
Moment Y (Twist)	0.1514
Moment Z	35.1459

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

Result	Value (kip, kip-ft)
Axial	6.7647
Shear X	-2.3093
Shear Z	0.0058
Moment X	0.0075
Moment Y (Twist)	0.1014
Moment Z	20.6644

# Project Details

Design Code: AISC 360-16 LRFD  
 Provision: LRFD  
 Country: United States  
 User Name: sales@mtsolar.us  
 Project Name: MTSOLAR\_11025FLK2FE22  
 Unit System: imperial

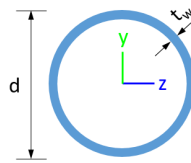


## Design Input Information

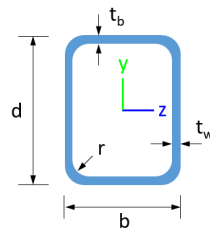
Design Factors			
$\Phi_t$	$\Phi_c$	$\Phi_b$	$\Phi_v$
0.9	0.9	0.9	0.9

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

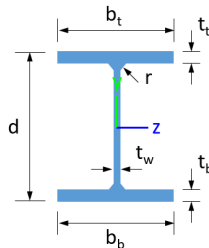
### Section Dimensions



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				
7	6in Pipe Sch 40	6.63	0.28				



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



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







206	116.10	115.41	15.79	11.10	42.08	23.28
207	116.10	114.23	15.79	11.10	42.08	23.28
208	133.20	32.95	32.87	6.12	40.24	43.62
209	61.16	54.71	3.51	3.51	18.35	18.35
210	116.10	111.33	15.79	11.10	42.08	23.28
211	133.20	32.95	32.87	6.12	40.24	43.62
212	182.47	181.10	20.19	20.19	54.74	54.74
213	133.20	85.85	25.02	6.12	40.24	43.62
214	133.20	85.85	25.11	6.12	40.24	43.62
215	133.20	31.52	18.28	6.12	40.24	43.62
216	133.20	31.52	18.18	6.12	40.24	43.62

## Design Ratio

Member ID	P	M <sub>z</sub>	M <sub>y</sub>	V <sub>y</sub>	V <sub>z</sub>	(P,M <sub>z</sub> ,M <sub>y</sub> )	Worst LC	KL/r	δ	Status
1	0.051	0.903	0.002	0.056	0.000	0.922	#13	0.152	Not Required	Pass
2	0.006	0.401	0.204	0.098	0.036	0.560	#21	0.035	Not Required	Pass
3	0.015	0.507	0.078	0.050	0.007	0.592	#21	0.045	Not Required	Pass
4	0.015	0.502	0.258	0.050	0.053	0.669	#21	0.080	Not Required	Pass
5	0.015	0.314	0.269	0.050	0.067	0.381	#21	0.074	Not Required	Pass
6	0.016	0.502	0.090	0.050	0.010	0.599	#21	0.045	Not Required	Pass
7	0.016	0.312	0.274	0.049	0.070	0.390	#21	0.074	Not Required	Pass
8	0.001	0.038	0.232	0.035	0.026	0.265	#21	0.063	Not Required	Pass
9	0.026	0.035	0.062	0.002	0.000	0.100	#21	0.204	Not Required	Pass
10	0.015	0.496	0.265	0.050	0.057	0.683	#21	0.080	Not Required	Pass
11	0.001	0.038	0.237	0.035	0.026	0.269	#21	0.095	Not Required	Pass
12	0.006	0.398	0.201	0.100	0.036	0.550	#21	0.035	Not Required	Pass
13	0.012	0.199	0.643	0.045	0.034	0.831	#21	0.286	Not Required	Pass
14	0.014	0.202	0.643	0.045	0.034	0.831	#21	0.286	Not Required	Pass
15	0.000	0.077	0.343	0.026	0.020	0.420	#21	Not Required	Not Required	Pass
16	0.000	0.077	0.343	0.026	0.020	0.420	#21	Not Required	Not Required	Pass
101	0.054	0.923	0.000	0.058	0.000	0.942	#13	0.152	Not Required	Pass
102	0.005	0.422	0.206	0.105	0.036	0.577	#21	0.035	Not Required	Pass
103	0.016	0.530	0.098	0.052	0.015	0.636	#21	0.045	Not Required	Pass
104	0.016	0.524	0.253	0.052	0.054	0.702	#21	0.080	Not Required	Pass
105	0.016	0.329	0.262	0.052	0.066	0.398	#21	0.074	Not Required	Pass
106	0.016	0.530	0.098	0.052	0.015	0.636	#21	0.045	Not Required	Pass
107	0.016	0.329	0.262	0.052	0.066	0.397	#21	0.074	Not Required	Pass
108	0.001	0.046	0.230	0.033	0.026	0.253	#21	0.063	Not Required	Pass
109	0.022	0.030	0.057	0.001	0.000	0.093	#21	0.204	Not Required	Pass
110	0.016	0.523	0.253	0.052	0.054	0.702	#21	0.080	Not Required	Pass
111	0.001	0.047	0.234	0.033	0.026	0.257	#21	0.095	Not Required	Pass
112	0.005	0.422	0.206	0.105	0.037	0.577	#21	0.035	Not Required	Pass
113	0.011	0.159	0.607	0.043	0.034	0.751	#21	0.286	Not Required	Pass
114	0.014	0.161	0.603	0.043	0.034	0.746	#21	0.190	Not Required	Pass
115	0.002	0.178	0.336	0.033	0.026	0.516	#21	0.728	Not Required	Pass
116	0.001	0.179	0.339	0.033	0.026	0.518	#21	0.486	Not Required	Pass
201	0.051	0.903	0.002	0.056	0.000	0.921	#13	0.152	Not Required	Pass
202	0.006	0.398	0.201	0.100	0.036	0.550	#21	0.035	Not Required	Pass
203	0.016	0.502	0.090	0.050	0.010	0.599	#21	0.045	Not Required	Pass
204	0.015	0.496	0.265	0.050	0.057	0.683	#21	0.080	Not Required	Pass

Z04	0.015	0.490	0.205	0.050	0.057	0.085	#21	0.080	Not Required	Pass
205	0.016	0.312	0.274	0.049	0.070	0.390	#21	0.074	Not Required	Pass
206	0.015	0.507	0.078	0.050	0.007	0.592	#21	0.045	Not Required	Pass
207	0.015	0.314	0.269	0.050	0.067	0.381	#21	0.074	Not Required	Pass
208	0.000	0.077	0.343	0.026	0.020	0.420	#21	Not Required	Not Required	Pass
209	0.026	0.035	0.062	0.002	0.000	0.100	#21	0.204	Not Required	Pass
210	0.015	0.502	0.259	0.050	0.053	0.669	#21	0.080	Not Required	Pass
211	0.000	0.077	0.343	0.026	0.020	0.420	#21	Not Required	Not Required	Pass
212	0.006	0.401	0.204	0.098	0.036	0.560	#21	0.035	Not Required	Pass
213	0.012	0.199	0.643	0.045	0.034	0.831	#21	0.190	Not Required	Pass
214	0.014	0.202	0.643	0.045	0.034	0.831	#21	0.190	Not Required	Pass
215	0.002	0.176	0.337	0.035	0.026	0.515	#21	0.728	Not Required	Pass
216	0.001	0.177	0.340	0.035	0.026	0.517	#21	0.486	Not Required	Pass

## Definitions

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



IBC 2018 Pile Design



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 depth	48 in

Material Properties

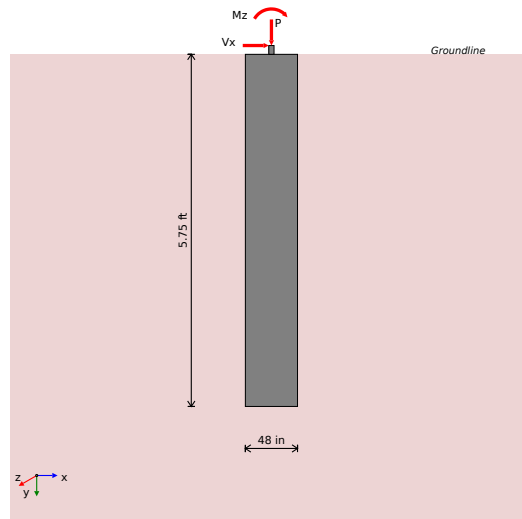
Input	Description	Value
$f'_{ck}$	Concrete compressive strength	2.5 ksi
$f_{yk}$	Yield strength of steel	60 ksi
$d_b$	Rebar diameter	#5 (0.625) in
cover	Concrete cover	3 in

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	6.765 kip	11.02 kip
V <sub>x</sub>	-2.309 kip	-3.854 kip
V <sub>z</sub>	0.006 kip	0.009 kip
M <sub>x</sub>	0.008 kip-ft	0.011 kip-ft
M <sub>z</sub>	20.66 kip-ft	35.15 kip-ft



Required depth to resist lateral loads (ASD)

Allowable lateral pressure

$$R = 150 \text{ psf/ft}$$

Point of application of lateral load:

$$H = h_1 + h_2 + h_e = 0 + 0 + 0 = 0 \text{ ft}$$

Considering x-direction:

Lateral force per section length

$$H_o = \frac{V_x}{1.57 \times D} = \frac{-2.309}{1.57 \times 48} = -0.368 \frac{\text{kip}}{\text{ft}}$$

Moment per section length

$$M_o = \frac{M_z + (V_z \times H)}{1.57 \times D} = \frac{20.66 + (-2.309 \times 0)}{1.57 \times 48} = 3.291 \frac{\text{kip-ft}}{\text{ft}}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$$L_{e,z} = 5.276 \text{ ft}$$

**Considering z-direction:**

Lateral force per section length

$$H_o = \frac{V_z}{1.57 \times b} = \frac{0.006}{1.57 \times 48} = 0.001 \frac{\text{kip}}{\text{ft}}$$

Moment per section length

$$M_o = \frac{M_z + (V_z \times H)}{1.57 \times b} = \frac{0.008 + (0.006 \times 0)}{1.57 \times 48} = 0.001 \frac{\text{kip-ft}}{\text{ft}}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$$L_{e,z} = 0.498 \text{ ft}$$

**Minimum embedded depth**

Depth of pile required

$$L_{e,req} = \text{MAX}[L_{e,x}, L_{e,z}] = \text{MAX}[5.276, 0.498] = 5.276 \text{ ft}$$

Actual embedded length

$$L_e = L - h_2 - h_e = 5.75 - 0 - 0 = 5.75 \text{ ft}$$

Utilisation

$$\text{Ratio} = \frac{L_{e,req}}{L_e} = \frac{5.276}{5.75} = 0.918$$

UTILITY: 0.92

## REFERENCES

## CALCULATIONS

## RESULTS

### End-bearing Capacity (ASD)

Allowable bearing pressure  
Unit weight of concrete

$q_a = 2000 \text{ psf}$   
 $w_c = 0.15 \text{ kip/ft}^3$

Cross-sectional area:

$$A = b \times D = 48 \times 48 = 16 \text{ ft}^2$$

End-bearing pressure:

$$q = \frac{P}{A} = \frac{6.765}{16} = 422.8 \text{ psf}$$

Utilisation

$$\text{Ratio} = \frac{q}{q_a} = \frac{422.8}{2000} = 0.211$$

UTILITY: 0.21

### Lateral Soil Pressure (ASD)

Allowable lateral pressure

$R = 150 \text{ psf/ft}$

Length to least lateral dimension ratio:

$$\frac{L}{\text{MIN}[b, D]} = \frac{5.75}{\text{MIN}[4, 4]} = 1.438$$

L/D ratio  $\leq 10$ . This pile is classified as a short pile.

**Considering x-direction:**

Distance from resting surface to pivot point:

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

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

$$a = \frac{(4 \times 3.291 \times 5.75) + (3 \times 0.368 \times 5.75^2)}{(6 \times 3.291) + (4 \times 0.368 \times 5.75)} = 3.977 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times 3.291) + (3 \times -0.368 \times 5.75)]^2}{5.75^2 \times [(3 \times 3.291) + (2 \times -0.368 \times 5.75)]} = 0.187 \frac{\text{kip}}{\text{ft}^2}$$

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

$$p_a = R \times \frac{a}{2} = 0.15 \times \frac{3.977}{2} = 0.298 \frac{\text{kip}}{\text{ft}^2}$$

Utilisation - pressure at a depth of a/2

$$\text{Ratio} = \frac{p}{p_a} = \frac{0.187}{0.298} = 0.627$$

UTILITY: 0.63

Earth pressure against the pile at distance  $L_e$ :

$$s = \frac{6 \times [(2 \times M_o) + (H_o \times L_e)]}{L_e^2} = \frac{6 \times [(2 \times 3.291) + (-0.368 \times 5.75)]}{5.75^2} = 0.811 \frac{\text{kip}}{\text{ft}^2}$$

Allowable lateral soil pressure at a depth of  $L_e$ :

$$p_s = R \times L_e = 0.15 \times 5.75 = 0.862 \frac{\text{kip}}{\text{ft}^2}$$

Utilisation - pressure at a depth of  $L_e$

$$\text{Ratio} = \frac{s}{p_s} = \frac{0.811}{0.862} = 0.94$$

UTILITY: 0.94

#### Considering z-direction:

Distance from resting surface to pivot point:

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

$$a = \frac{(4 \times 0.001 \times 5.75) + (3 \times 0.001 \times 5.75^2)}{(6 \times 0.001) + (4 \times 0.001 \times 5.75)} = 4.192 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times 0.001) + (3 \times 0.001 \times 5.75)]^2}{5.75^2 \times [(3 \times 0.001) + (2 \times 0.001 \times 5.75)]} = 0.001 \frac{\text{kip}}{\text{ft}^2}$$

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

$$p_a = R \times \frac{a}{2} = 0.15 \times \frac{4.192}{2} = 0.314 \frac{\text{kip}}{\text{ft}^2}$$

Utilisation - pressure at a depth of a/2

$$\text{Ratio} = \frac{p}{p_a} = \frac{0.001}{0.314} = 0.002$$

UTILITY: 0.00

Earth pressure against the pile at distance  $L_e$ :

$$s = \frac{6 \times [(2 \times M_o) + (H_o \times L_e)]}{L_e^2} = \frac{6 \times [(2 \times 0.001) + (0.001 \times 5.75)]}{5.75^2} = 0.001 \frac{\text{kip}}{\text{ft}^2}$$

Allowable lateral soil pressure at a depth of  $L_e$ :

$$p_s = R \times L_e = 0.15 \times 5.75 = 0.862 \frac{\text{kip}}{\text{ft}^2}$$

Utilisation - pressure at a depth of  $L_e$

$$\text{Ratio} = \frac{s}{p_s} = \frac{0.001}{0.862} = 0.002$$

UTILITY: 0.00

REFERENCES

CALCULATIONS

RESULTS

Shear force and bending moment (LRFD)

Considering x-direction:

Lateral force per section length

$$H_o = \frac{V_z}{1.57 \times D} = \frac{-3.854}{1.57 \times 48} = -0.614 \frac{\text{kip}}{\text{ft}}$$

Moment per section length

$$M_o = \frac{M_z + (V_z \times H)}{1.57 \times D} = \frac{35.15 + (-3.854 \times 0)}{1.57 \times 48} = 5.596 \frac{\text{kip-ft}}{\text{ft}}$$

Distance from resting surface to pivot point:

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

$$a = \frac{(4 \times 5.596 \times 5.75) + (3 \times 0.614 \times 5.75^2)}{(6 \times 5.596) + (4 \times 0.614 \times 5.75)} = 3.975 \text{ ft}$$

Max shear force located at depth a:

$$E = \frac{M_o}{H_o} = \frac{5.596}{-0.614} = 9.12 \text{ ft}$$

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

$$V_{max,x} = (-0.614 \times 48) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times 9.12}{5.75} + 3 \right) \times \left( \frac{3.975}{5.75} \right)^2 \right] + \left[ 4 \times \left( \frac{3 \times 9.12}{5.75} + 2 \right) \times \left( \frac{3.975}{5.75} \right)^3 \right] \right]$$

$$V_{max,x} = 8.508 \text{ kip}$$

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

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

$$M_{max,x} = (-0.614 \times 48 \times 5.75) \times \left[ \left( \frac{9.12}{5.75} + \frac{3.975}{2 \times 5.75} \right) - \left[ \left( \frac{4 \times 9.12}{5.75} + 3 \right) \times \left( \frac{3.975}{2 \times 5.75} \right)^3 \right] + \left[ \left( \frac{3 \times 9.12}{5.75} + 2 \right) \times \left( \frac{3.975}{2 \times 5.75} \right)^4 \right] \right]$$

$$M_{max,x} = 23.18 \text{ kip-ft}$$

Considering z-direction:

Lateral force per section length

$$H_o = \frac{V_z}{1.57 \times b} = \frac{0.009}{1.57 \times 48} = 0.001 \frac{\text{kip}}{\text{ft}}$$

Moment per section length

$$M_o = \frac{M_z + (V_z \times H)}{1.57 \times b} = \frac{0.011 + (0.009 \times 0)}{1.57 \times 48} = 0.002 \frac{\text{kip-ft}}{\text{ft}}$$

Distance from resting surface to pivot point:

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

$$a = \frac{(4 \times 0.002 \times 5.75) + (3 \times 0.001 \times 5.75^2)}{(6 \times 0.002) + (4 \times 0.001 \times 5.75)} = 4.195 \text{ ft}$$

Max shear force located at depth a:

$$E = \frac{M_o}{H_o} = \frac{0.002}{0.001} = 1.248 \text{ ft}$$

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

$$V_{max,z} = (0.001 \times 48) \times [1 - [3 \times (\frac{4 \times 1.248}{5.75} + 3) \times (\frac{4.195}{5.75})] + [4 \times (\frac{5 \times 1.248}{5.75} + 2) \times (\frac{4.195}{5.75})^2]]$$

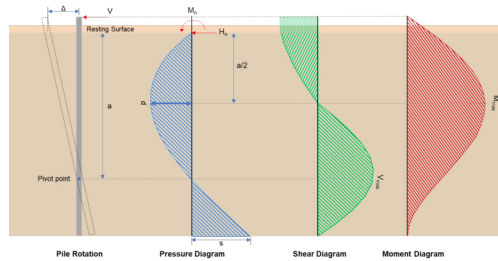
$$V_{max,z} = 0.006 \text{ kip}$$

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

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

$$M_{max,z} = (0.001 \times 48 \times 5.75) \times [(\frac{1.248}{5.75} + \frac{4.195}{2 \times 5.75}) - [(\frac{4 \times 1.248}{5.75} + 3) \times (\frac{4.195}{2 \times 5.75})^3] + [(\frac{3 \times 1.248}{5.75} + 2) \times (\frac{4.195}{2 \times 5.75})^4]]$$

$$M_{max,z} = 0.015 \text{ kip-ft}$$



## Minimum Reinforcement Check (LRFD)

Gross area of concrete:

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

### Main Reinforcement

22.4.2.2 Required reinforcement:

$$A_{st,req} = \frac{P - (0.85 \times f'_{ck} \times A_g)}{f_{yk} - (0.85 \times f'_{ck})} = \frac{11.02 - (0.85 \times 2.5 \times 2304)}{60 - (0.85 \times 2.5)} = -84.41 \text{ in}^2$$

10.6.1.1 Maximum reinforcement:

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

7.6.1.1 Minimum reinforcement:

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

Governing minimum reinforcement area:

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

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

Minimum number of reinforcements:

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

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

25.2.3 Minimum spacing:

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

Use:  $n = 16$  pcs at 1.5 in minimum spacing

Total reinforcement area:

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

### Shear Reinforcement

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

Maximum spacing of shear Reinforcements:

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

### Detailing Summary

Main reinforcement

#5 (0.625 in) - 16pcs at 1.5 in min. spacing

## Axial Compression Strength (LRFD)

22.4.2.2 Allowable axial compressive strength:

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

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

Utilisation

$$\text{Ratio} = \frac{P}{\phi P_N} = \frac{11.02}{2694} = 0.004$$

UTILITY: 0.00

## Shear Strength LRFD)

Effective shear width	$b_w = 48 \text{ in}$
Effective shear depth	$d = 44.31 \text{ in}$
Shear reinforcement area	$A_v = 0.221 \text{ in}^2$
Shear reinforcement spacing	$s = 10 \text{ in}$
Concrete type factor (Normal concrete)	$\lambda = 1$
Strength reduction factor for shear	$\phi = 0.75$
Maximum shear in the x-direction	$V_{max,x} = 8.508 \text{ kip}$
Maximum shear in the z-direction	$V_{max,z} = 0.006 \text{ kip}$

22.5.5.1.1 Max shear strength of concrete:

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

Table 22.5.5.1 Shear strength of concrete:

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

$$V_{c,a} = \left( 2 \times 1 \times \sqrt{2.5} + \text{MIN} \left[ \frac{11.02}{6 \times 2304}, (0.05 \times 2.5) \right] \right) \times (48 \times 44.31) = 214.4 \text{ kip}$$

Governing shear strength of concrete:

$$V_c = \text{MIN}[V_{c,max}, V_{c,a}] = \text{MIN}[531.8, 214.4] = 214.4 \text{ kip}$$

22.5.1.2 Shear strength of steel (a):

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

22.5.8.5.3 Shear strength of steel (b):

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

Governing shear strength of steel:

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

22.5.1.1 Allowable shear strength:

$$\phi V_n = \phi \times (V_c + V_s) = 0.75 \times (214.4 + 58.73) = 204.8 \text{ kip}$$

$$V_{max} = \text{MAX}[8.508, 0.006] = 8.508 \text{ kip}$$

Utilisation

$$\text{Ratio} = \frac{V_{max}}{\phi V_n} = \frac{8.508}{204.8} = 0.042$$

UTILITY: 0.04

## Flexural Strength (LRFD)

Concrete type factor (Normal concrete)	$\lambda = 1$
Strength reduction factor for flexure	$\phi = 0.65$
Modulus of steel reinforcement	$E_s = 200 \times 10^3 \text{ ksi}$
Maximum concrete strain	$\epsilon_c = 0.0030$
Yield strain of steel $f_y/E_s$	$\epsilon_y = 0.0003$
Section width	$b = 48 \text{ in}$
Distance to the compression rebar	$d_c = 3.688 \text{ in}$
Distance to the tension rebar	$d = 44.31 \text{ in}$
Total bar area	$A_s = 4.909 \text{ in}^2$
Maximum applied axial load	$P = 11.02 \text{ kip}$
Maximum moment in the x-direction	$M_{max,x} = 23.18 \text{ kip-ft}$
Maximum moment in the z-direction	$M_{max,z} = 0.015 \text{ kip-ft}$

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:

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

$$\epsilon_1 = (c - d_s) \times \frac{\epsilon_c}{c}$$

$$f_1 = E_s \times \epsilon_1 \quad (\epsilon_1 < \epsilon_{sy}), \quad f_1 = f_y \quad (\epsilon_1 \geq \epsilon_{sy})$$

Tensile force due to bars in tension:

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

$$\epsilon_2 = (d - c) \times \frac{\epsilon_{cu}}{c}$$

$$f_2 = E_s \times \epsilon_2 \quad (\epsilon_2 < \epsilon_{sy}), \quad f_2 = \phi_s \times f_y \quad (\epsilon_2 \geq \epsilon_{sy})$$

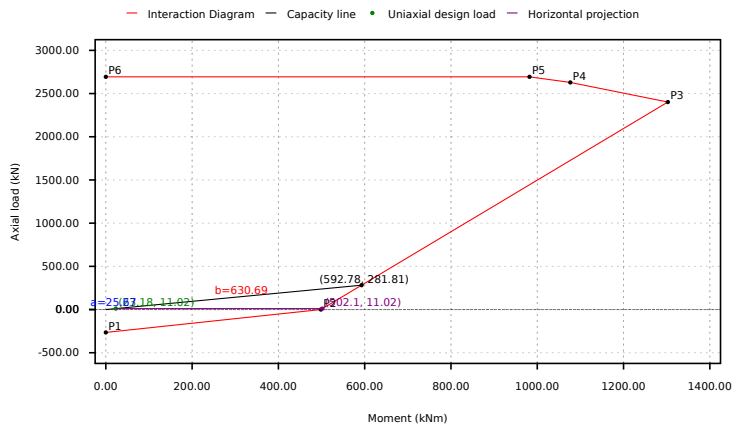
### Interaction Diagram Summary

Point	Case	M <sub>r</sub>	P <sub>r</sub>
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

$$M_f = \text{MAX}[23.18, 0.015] = 23.18 \text{ kip-ft}$$

#### Interaction Diagram



Segment	Signed Distance
P1 - P2	232.9
P2 - P3	454.1
P3 - P4	2594
P4 - P5	2755
P5 - P6	2683
Status	PASS: Point lies inside the curve

Utilisation

$$\text{Ratio} = \frac{a}{a + b} = \frac{25.67}{25.67 + 630.7} = 0.039$$

UTILITY: 0.04

### Biaxial Bending Check

Maximum moment in the x-direction

$$M_{max,x} = 23.18 \text{ kip-ft}$$

Maximum moment in the z-direction

$$M_{max,z} = 0.015 \text{ kip-ft}$$

Nominal uniaxial moment strength about the x-axis

$$M_{nox} = 502.1 \text{ kip-ft}$$

Nominal uniaxial moment strength about the z-axis

$$M_{noz} = 502.1 \text{ kip-ft}$$

Interaction exponent

$$\alpha = 1$$

Bresler (1960)

According to Bresler (method B):

$$\left(\frac{M_{max,x}}{M_{nox}}\right)^\alpha + \left(\frac{M_{max,z}}{M_{noz}}\right)^\alpha = 1.0$$

$$\left(\frac{23.18}{502.1}\right)^1 + \left(\frac{0.015}{502.1}\right)^1 = 0.046$$

UTILITY: 0.05

REFERENCES

CALCULATIONS

RESULTS

Results Summary

Result Name	Results
PILE DETAILS	
Length of the pile	5.75 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	0.92
End-bearing capacity	0.21
P <sub>a</sub>	0.63
P <sub>s</sub>	0.94
Axial compression strength	0.00
Shear strength	0.04
Uniaxial bending strength	0.04
Biaxial bending strength	0.05