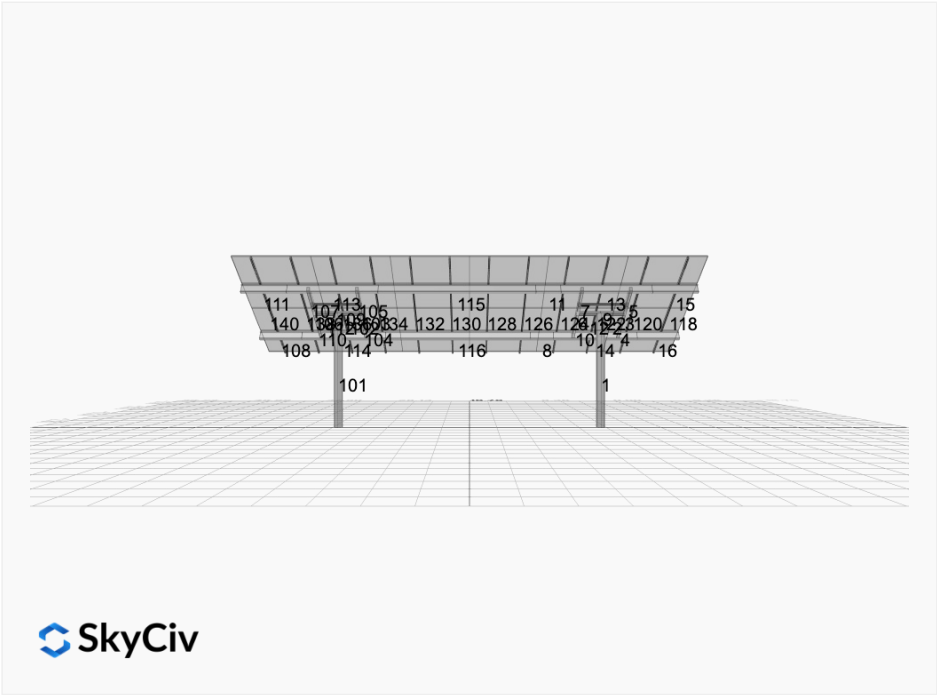
Project Details

Project Name: testing
Location: Herak Rd, Charlo, MT, USA
Unique ID: 2P-22.5-8TOP-HD-45-L-4Hx6W-1761
Dealer: _____

Date: Mon Nov 10 2025
Number of Modules: 24
Number of Poles: 2
Date Sold: _____



Array Dimensions N/S	15.03 ft
Array Dimensions E/W	37.50 ft
Winter Tilt Angle (Degrees)	30
Front Edge Clearance	6

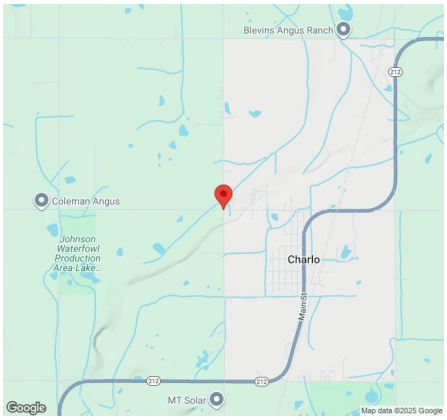
MT Solar Bill of Materials (2P-22.5-8TOP-HD-45-L-4Hx6W-1761)

Part	Short Description	BOM Qty
MTS-PC-8	8IN Pole Cap Assembly	2
MTS-HF-HD	H-Frame Assembly-HD	2
MTS-HD-Wing-45	45IN HD Wing	4
MTS-HD-Splice-90	90IN HD Splice	4
MTS-CLAMP-HOOK-4PK	Hook Clamp	6

Rail Bill of Materials

Part	Qty
Rails (180in Long)	12x
Rail Attachment	24x
Module Mid Clamp	36x
Module End Clamp	24x
Ground Lug	6x

Site Details:



Site Address: Herak Rd, Charlo, MT, USA

Array Specifications

Duty Classification:	HD
Module Width:	44.60 in
Module Length:	74.00 in
Number of Rows:	4
Number of Columns:	6
Total Number of Modules:	24
Winter Tilt Angle:	30
Front Edge Clearance:	6
Total Array Height at Tilt:	13.52 ft
Total Frame Length:	37.50 ft
Module Info/Notes:	
Array Dimensions N/S:	15.03 ft
Array Dimensions E/W:	37.50 ft
Rail Length:	180.40 in
Rail Spacing:	3.13 ft

Support Specifications

Pole Size:	8in Pipe Sch 40
Pole Length above Grade:	9.76 ft
Number of Poles:	2
Pole Spacing:	22.5 ft

Foundation Specifications

Foundation Type:	rectangular
Foundation Dimensions:	48x48 in
Foundation Depth (below grade):	6.3 ft
Foundation Volume:	100.00 ft^3

Site Info

Risk Category:	I
Exposure:	C
Soil Classification:	sand
Site Location:	Herak Rd, Charlo, MT, USA
Wind Speed:	99 mph

Snow Load:	20 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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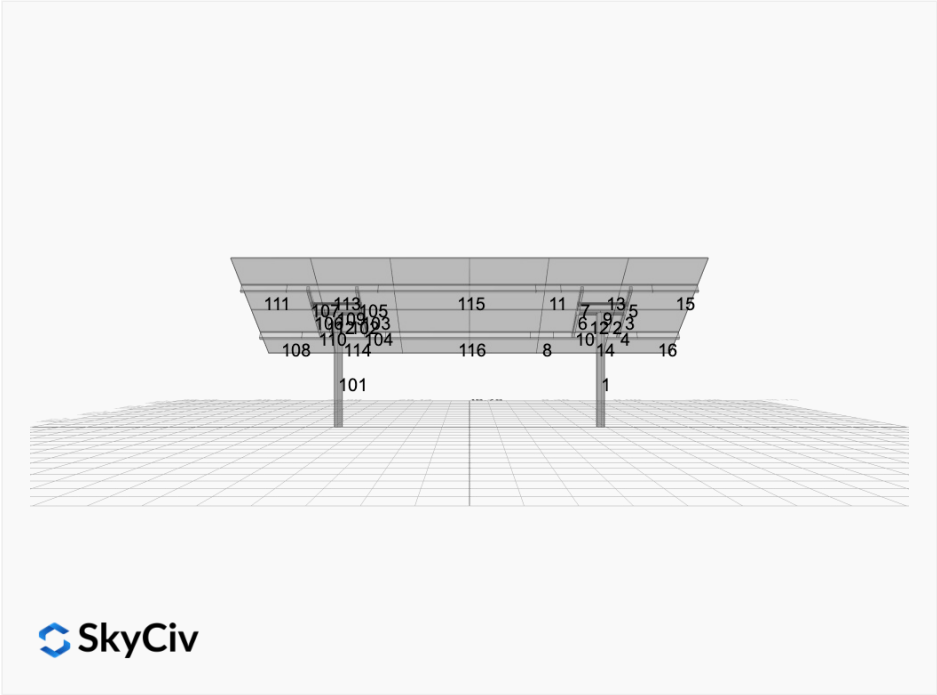
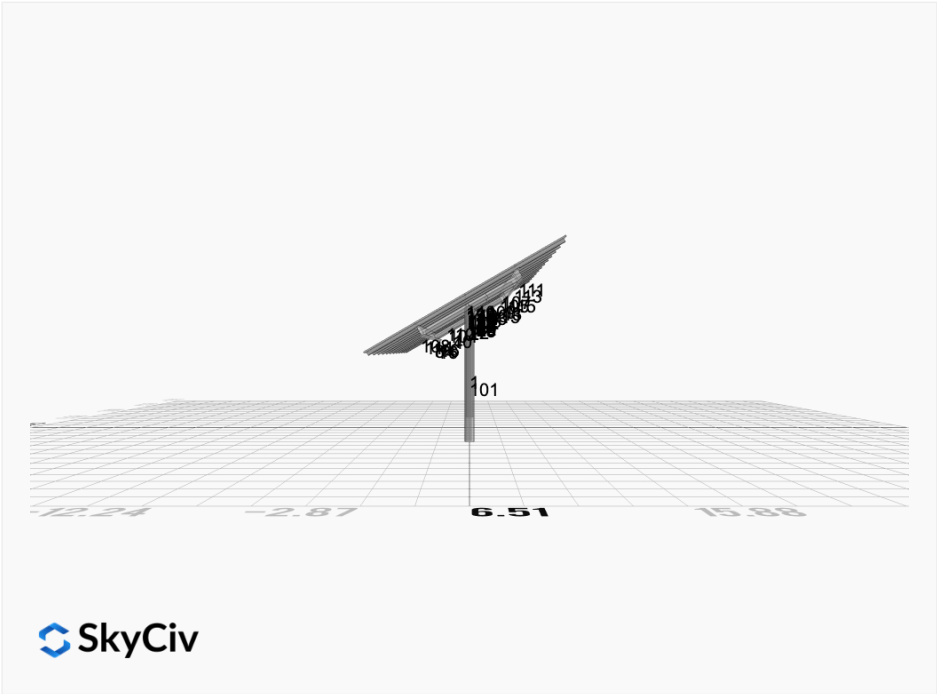
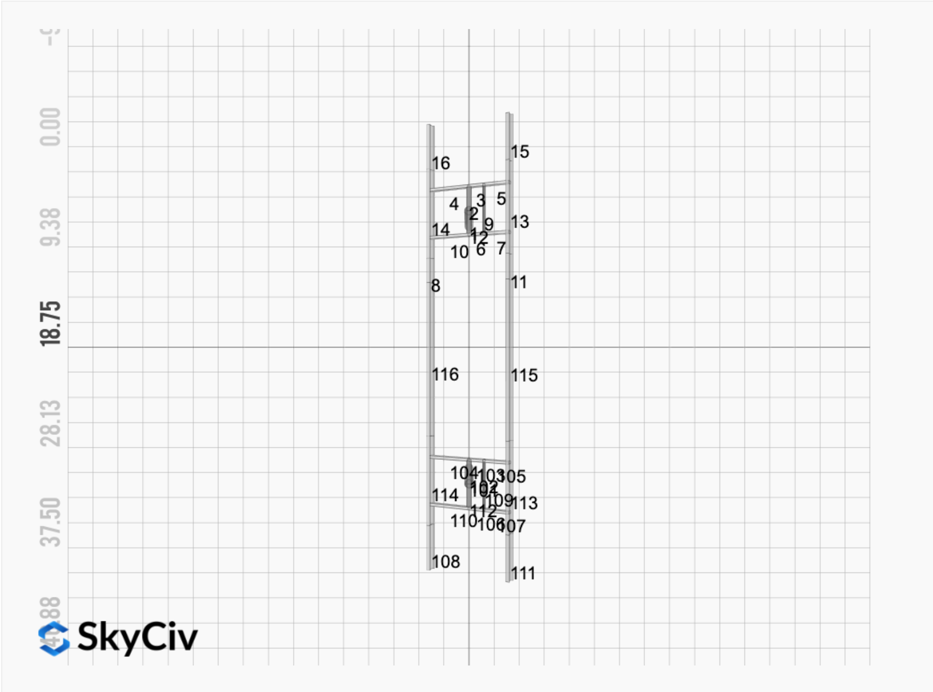
Design Notes:

- 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



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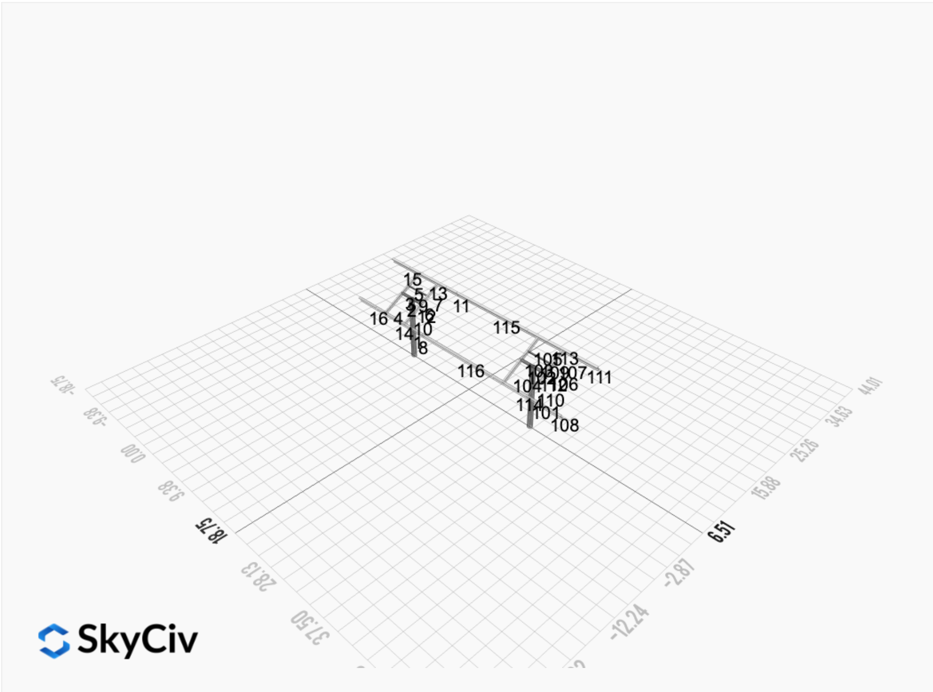
SkyCiv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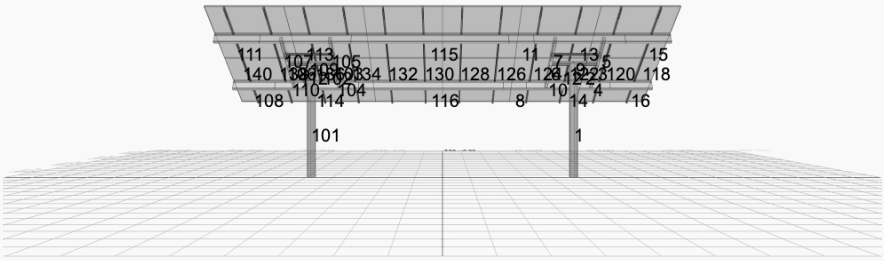
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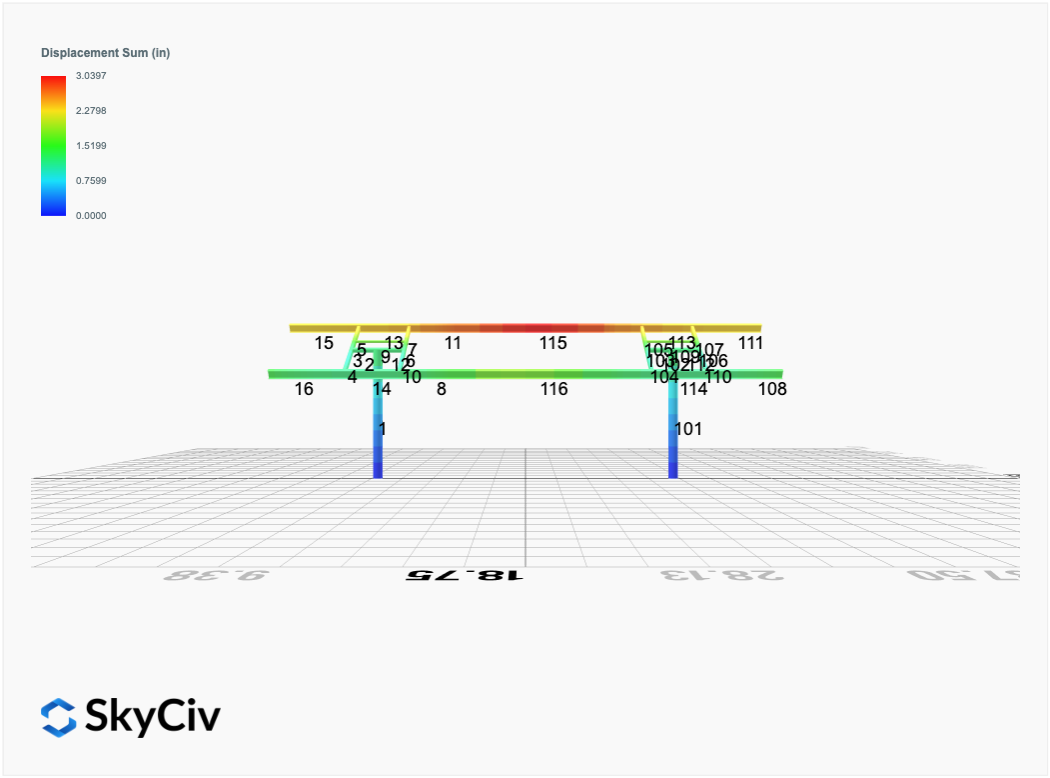
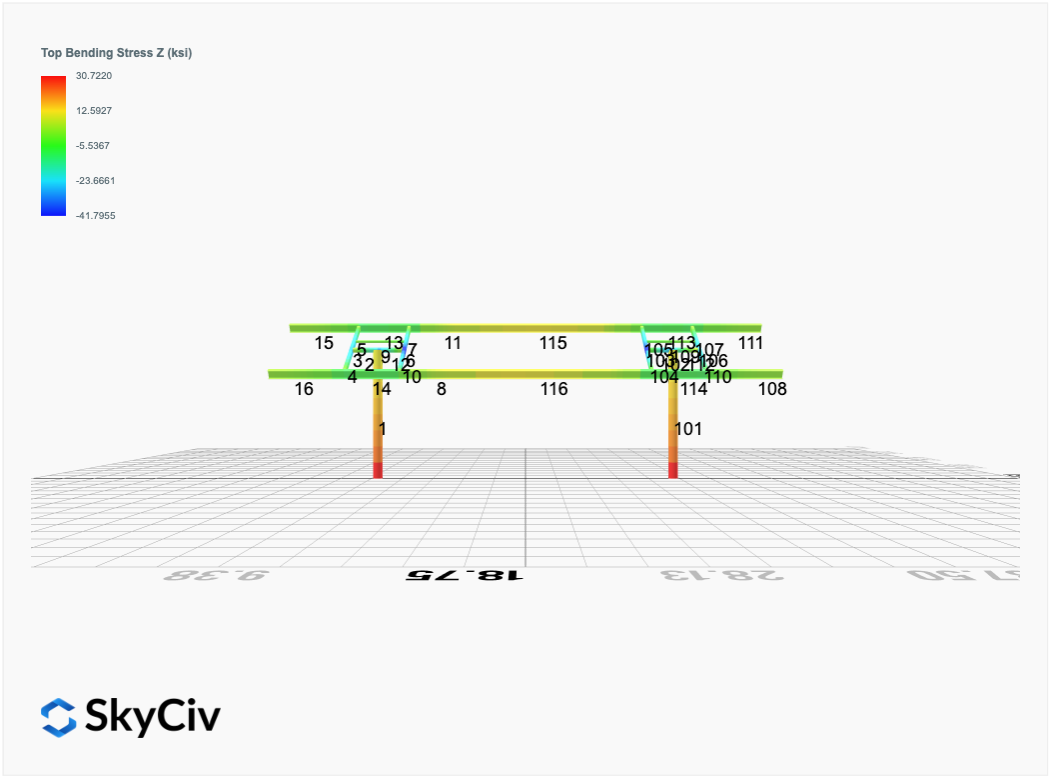
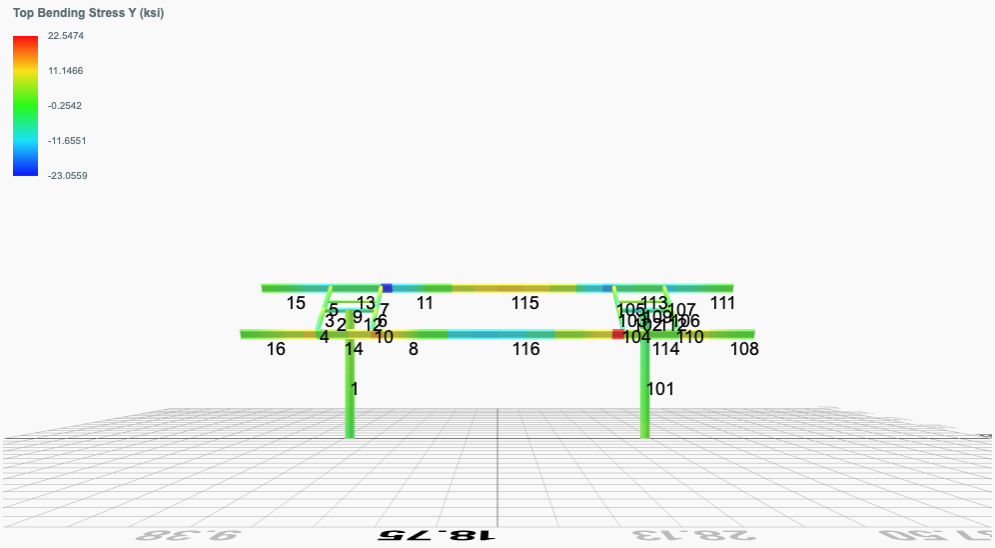
SkyCiv

FEM Results (Envelope Worst Case)







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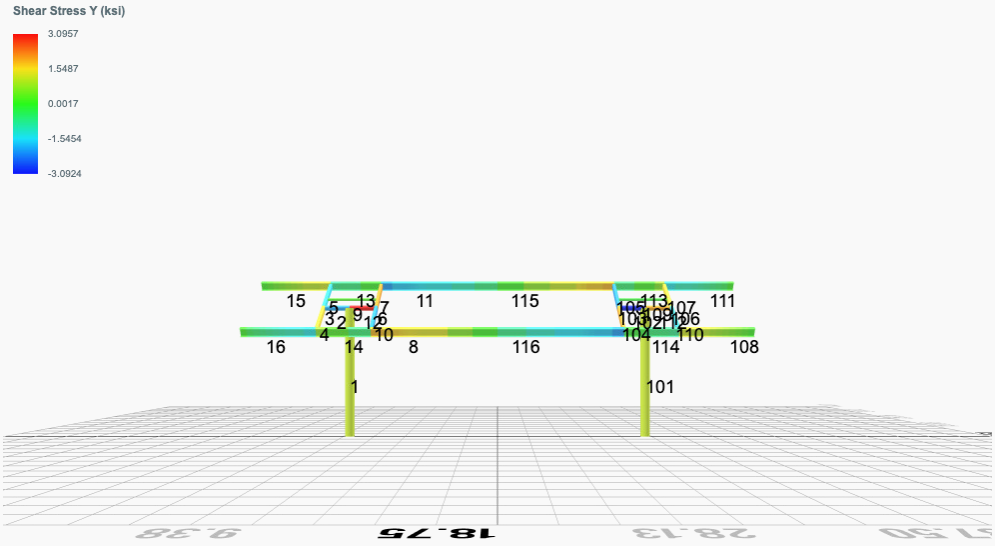

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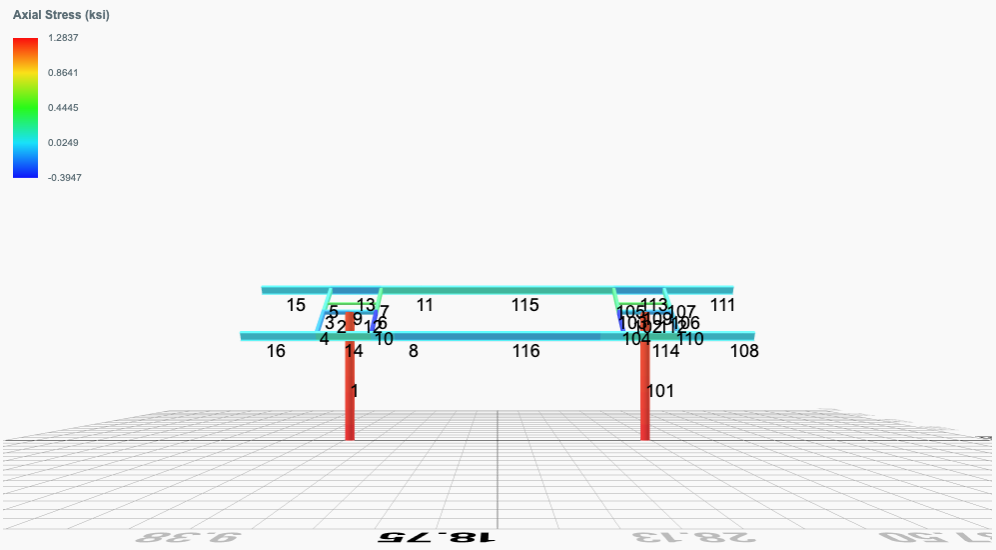
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13
11
115
113
111
16
14
8
116
114
108
1
101

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	-0.0001	3.0465	0.1293	0.3377	-0.1311	0.0426
ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R)	-0.0001	3.6851	0.1699	0.4441	-0.1723	0.0427
ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R)	-0.0001	2.6113	0.1108	0.2893	-0.1124	0.0356
ULS: 3. 1.2D + 1.6(S or Lr or R) + L	-0.0002	6.0475	0.3003	0.7865	-0.3042	0.0680
ULS: 5. 1.2D + E + L + 0.2S	-0.0001	3.0408	0.1344	0.3511	-0.1364	0.0381
ULS: 7. 0.9D + 1.0E	-0.0000	1.9584	0.0830	0.2168	-0.0843	0.0257
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only	-4.0974	10.7818	0.6255	1.5743	-1.2045	41.0276
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only	-4.0974	10.7818	0.6255	1.5743	-1.2045	41.0276
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only	3.5119	-2.3978	-0.2176	-0.5159	0.7087	-34.0808
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only	2.9265	-1.3840	-0.1549	-0.3606	0.5662	-43.0341
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only	-4.0973	9.7079	0.5660	1.4186	-1.1444	40.9094
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only	-4.0973	9.7079	0.5660	1.4186	-1.1444	40.9094
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only	3.5119	-3.4716	-0.2764	-0.6698	0.7685	-33.9987
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only	2.9266	-2.4578	-0.2141	-0.5153	0.6266	-42.9159
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only	-2.0488	9.5959	0.5280	1.3513	-0.8200	20.5197
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only	-2.0488	9.5959	0.5280	1.3513	-0.8200	20.5197
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only	1.7558	3.0061	0.1059	0.3046	0.1369	-17.2074
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only	1.4632	3.5130	0.1378	0.3837	0.0646	-21.7507
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only	-2.0487	6.1596	0.3379	0.8525	-0.6278	20.3114
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only	-2.0487	6.1596	0.3379	0.8525	-0.6278	20.3114
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only	1.7559	-0.4302	-0.0832	-0.1913	0.3285	-17.0940
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only	1.4633	0.0767	-0.0518	-0.1135	0.2572	-21.5785
ULS: 6. 0.9D + 1.0W_Wind downforce Case A only	-4.0973	9.0551	0.5381	1.3456	-1.1162	40.8336
ULS: 6. 0.9D + 1.0W_Wind downforce Case B only	-4.0973	9.0551	0.5381	1.3456	-1.1162	40.8336
ULS: 6. 0.9D + 1.0W_Wind uplift Case A only	3.5119	-4.1244	-0.3040	-0.7419	0.7965	-33.9558
ULS: 6. 0.9D + 1.0W_Wind uplift Case B only	2.9266	-3.1106	-0.2418	-0.5878	0.6549	-42.8508

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	-0.0001	2.1761	0.0923	0.2409	-0.0937	0.0289
ULS: 2. D + L	-0.0001	2.1761	0.0923	0.2409	-0.0937	0.0289
ULS: 3. D + (S or Lr or R)	-0.0001	4.3237	0.2105	0.5507	-0.2136	0.0440
ULS: 3. D + (S or Lr or R)	-0.0001	2.1761	0.0923	0.2409	-0.0937	0.0289
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0001	3.7868	0.1809	0.4730	-0.1836	0.0392
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	-0.0001	2.1761	0.0923	0.2409	-0.0937	0.0289
ULS: 5b. D + 0.7E	-0.0001	2.1761	0.0923	0.2409	-0.0937	0.0289
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	-0.0001	3.7868	0.1809	0.4730	-0.1836	0.0392
ULS: 8. 0.6D + 0.7E	-0.0000	1.3056	0.0553	0.1444	-0.0562	0.0164
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.4584	6.4341	0.3649	0.9170	-0.7122	24.3722
ULS: 5a. D + 0.6W_Wind downforce Case B only	-2.4584	6.4341	0.3649	0.9170	-0.7122	24.3722
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.1071	-1.4737	-0.1403	-0.3354	0.4353	-20.4780
ULS: 5a. D + 0.6W_Wind uplift Case B only	1.7559	-0.8654	-0.1028	-0.2423	0.3499	-25.8442
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.8439	6.9803	0.3855	0.9803	-0.6475	18.3271
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.8439	6.9803	0.3855	0.9803	-0.6475	18.3271
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.5803	1.0495	0.0062	0.0400	0.2133	-15.4326
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.3169	1.5057	0.0346	0.1104	0.1488	-19.4889

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	-1.8438	5.3696	0.2966	0.7476	-0.5574	18.2434
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.8438	5.3696	0.2966	0.7476	-0.5574	18.2434
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.5803	-0.5612	-0.0823	-0.1916	0.3031	-15.3818
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.3169	-0.1050	-0.0541	-0.1217	0.2391	-19.4134
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.4584	5.5636	0.3278	0.8200	-0.6747	24.3080
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-2.4584	5.5636	0.3278	0.8200	-0.6747	24.3080
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.1071	-2.3441	-0.1771	-0.4315	0.4726	-20.4478
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	1.7560	-1.7358	-0.1397	-0.3389	0.3876	-25.7963

Worst Case Reactions (LRFD)

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

Result	Value (kip, kip-ft)
Axial	10.7818
Shear X	-4.0974
Shear Z	0.6255
Moment X	1.5743
Moment Y (Twist)	1.2045
Moment Z	43.0341

Worst Case Reactions (ASD)

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

Result	Value (kip, kip-ft)
Axial	6.9803
Shear X	-2.4584
Shear Z	0.3855
Moment X	0.9803
Moment Y (Twist)	0.7122
Moment Z	25.8442

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	0.0001	3.0461	-0.1293	-0.3424	0.1294	0.0411
ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R)	0.0001	3.6846	-0.1699	-0.4502	0.1701	0.0408
ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R)	0.0001	2.6109	-0.1108	-0.2933	0.1109	0.0344
ULS: 3. 1.2D + 1.6(S or Lr or R) + L	0.0002	6.0466	-0.3003	-0.7974	0.3004	0.0647
ULS: 5. 1.2D + E + L + 0.2S	0.0001	3.0404	-0.1344	-0.3560	0.1346	0.0366
ULS: 7. 0.9D + 1.0E	0.0000	1.9582	-0.0830	-0.2198	0.0832	0.0248
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only	-4.0963	10.7797	-0.6255	-1.5983	1.1926	41.0176
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only	-4.0963	10.7797	-0.6255	-1.5983	1.1926	41.0176
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only	3.5113	-2.3970	0.2176	0.5245	-0.7026	-34.0760
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only	2.9261	-1.3834	0.1549	0.3671	-0.5611	-43.0325
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only	-4.0963	9.7061	-0.5660	-1.4403	1.1332	40.9000
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only	-4.0963	9.7061	-0.5660	-1.4403	1.1332	40.9000
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only	3.5113	-3.4706	0.2764	0.6805	-0.7616	-33.9933
ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only	2.9261	-2.4570	0.2141	0.5239	-0.6208	-42.9136
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only	-2.0480	9.5941	-0.5280	-1.3711	0.8113	20.5123
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only	-2.0480	9.5941	-0.5280	-1.3711	0.8113	20.5123
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only	1.7558	3.0058	-0.1059	-0.3079	-0.1366	-17.2072
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only	1.4632	3.5126	-0.1378	-0.3881	-0.0648	-21.7522
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only	-2.0481	6.1585	-0.3379	-0.8653	0.6215	20.3061
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only	-2.0481	6.1585	-0.3379	-0.8653	0.6215	20.3061
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only	1.7557	-0.4299	0.0832	0.1947	-0.3258	-17.0918
ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only	1.4631	0.0769	0.0518	0.1159	-0.2550	-21.5779
ULS: 6. 0.9D + 1.0W_Wind downforce Case A only	-4.0964	9.0533	-0.5381	-1.3662	1.1054	40.8244
ULS: 6. 0.9D + 1.0W_Wind downforce Case B only	-4.0964	9.0533	-0.5381	-1.3662	1.1054	40.8244
ULS: 6. 0.9D + 1.0W_Wind uplift Case A only	3.5113	-4.1234	0.3040	0.7536	-0.7893	-33.9500
ULS: 6. 0.9D + 1.0W_Wind uplift Case B only	2.9260	-3.1098	0.2418	0.5973	-0.6487	-42.8481

ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	0.0001	2.1758	-0.0923	-0.2443	0.0924	0.0279
ULS: 2. D + L	0.0001	2.1758	-0.0923	-0.2443	0.0924	0.0279
ULS: 3. D + (S or Lr or R)	0.0001	4.3230	-0.2105	-0.5583	0.2108	0.0417
ULS: 3. D + (S or Lr or R)	0.0001	2.1758	-0.0923	-0.2443	0.0924	0.0279
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0001	3.7862	-0.1809	-0.4796	0.1812	0.0372
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0001	2.1758	-0.0923	-0.2443	0.0924	0.0279
ULS: 5b. D + 0.7E	0.0001	2.1758	-0.0923	-0.2443	0.0924	0.0279
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0001	3.7862	-0.1809	-0.4796	0.1812	0.0372
ULS: 8. 0.6D + 0.7E	0.0000	1.3055	-0.0553	-0.1464	0.0555	0.0158
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.4578	6.4328	-0.3649	-0.9308	0.7052	24.3663
ULS: 5a. D + 0.6W_Wind downforce Case B only	-2.4578	6.4328	-0.3649	-0.9308	0.7052	24.3663
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.1068	-1.4732	0.1403	0.3409	-0.4315	-20.4750
ULS: 5a. D + 0.6W_Wind uplift Case B only	1.7556	-0.8650	0.1028	0.2466	-0.3468	-25.8431
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.8433	6.9790	-0.3855	-0.9948	0.6408	18.3215
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.8433	6.9790	-0.3855	-0.9948	0.6408	18.3215
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.5801	1.0495	-0.0062	-0.0398	-0.2119	-15.4315
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.3168	1.5056	-0.0346	-0.1112	-0.1479	-19.4893
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.8433	5.3686	-0.2966	-0.7588	0.5519	18.2387
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	-1.8433	5.3686	-0.2966	-0.7588	0.5519	18.2387
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.5801	-0.5609	0.0823	0.1949	-0.3006	-15.3797
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	1.3168	-0.1048	0.0541	0.1240	-0.2370	-19.4128
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.4578	5.5625	-0.3278	-0.8325	0.6682	24.3024
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	-2.4578	5.5625	-0.3278	-0.8325	0.6682	24.3024
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.1068	-2.3435	0.1771	0.4384	-0.4684	-20.4443
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	1.7556	-1.7353	0.1397	0.3444	-0.3840	-25.7946

Worst Case Reactions (LRFD)

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

Result	Value (kip, kip-ft)
Axial	10.7797
Shear X	-4.0964
Shear Z	-0.6255
Moment X	-1.5983
Moment Y (Twist)	1.1926
Moment Z	43.0325

Worst Case Reactions (ASD)

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

Result	Value (kip, kip-ft)
Axial	6.9790
Shear X	-2.4578
Shear Z	-0.3855
Moment X	-0.9948
Moment Y (Twist)	0.7052
Moment Z	25.8431

Project Details

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

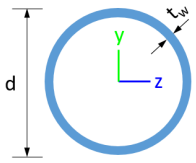
User Name: sales@mtsolar.us
Project Name: testing
Unit System: imperial

Design Input Information

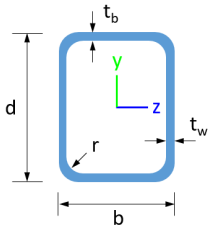
Design Factors			
Φ_t	Φ_c	Φ_b	Φ_v
0.9	0.9	0.9	0.9

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

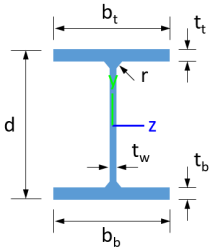
Section Dimensions



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					
9	8in Pipe Sch 40	8.63	0.32					



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



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

Section Properties								
ID	Name	A (in^2)	J (in^4)	I_{yp} (in^4)	I_{zp} (in^4)	I_w (in^6)	S_{yp} (in^3)	S_{zp} (in^3)
2	2in Pipe Sch 80	1.48	1.74	0.87	0.87	0.00	1.02	1.02
5	4in Pipe Sch 80	4.41	19.22	9.61	9.61	0.00	5.85	5.85
9	8in Pipe Sch 40	8.40	144.98	72.49	72.49	0.00	22.21	22.21
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_z L (ft)	K_y L (ft)	L_b (ft)	C_b	LST	LSC	LD
1	9	6.34	6.34	9.76	-	300	200	250
2	5	4.20	4.20	2.00	-	300	200	250
3	16	0.92	0.92	1.42	1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.19,1.12,1.18,1.18,1.16,1.17,1.17,1.17,1.17,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.17,1.17,1.17,1.17,1.17,1.11,1.16,1.18,1.18,1.16,1.17,1.17,1.17,1.17,1.17	300	200	250
4	16	2.44	2.44	3.75	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.66,1.70,1.67,1.67,1.66,1.83,1.67,1.67,1.70,1.68,1.67,1.67,1.64,1.70,1.67,1.67,1.66,1.55,1.69,1.69,1.68,1.69,1.68,1.69,1.69,1.68,1.69,1.67,1.67,1.65,1.72,1.67,1.67,1.55,1.68,1.67,1.67,1.65,1.71,1.67,1.67,1.66,1.29	300	200	250
5	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.68,1.58,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66,1.68,1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.60,1.65,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66	300	200	250
6	16	0.92	0.92	1.42	1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.19,1.38,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18,1.19,1.19,1.19,1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.13,1.17,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18	300	200	250
7	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.68,2.61,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.68,1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.61,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66	300	200	250
8	19	1.33	1.33	2.05	1.66,1.66,1.66,1.66,1.66,1.66,1.65,1.65,1.63,2.09,1.64,1.64,1.64,1.25,1.65,1.65,1.73,1.69,1.65,1.65,1.62,1.84,1.64,1.64,1.64,1.43,1.66,1.66,1.66,1.66,1.66,1.66,1.66,1.66,1.66,1.65,1.65,1.63,2.13,1.65,1.65,1.50,1.72,1.65,1.65,1.63,1.89,1.64,1.64,1.64,1.39	300	200	250
9	2	2.60	2.60	4.00	-	300	200	250
10	16	2.44	2.44	3.75	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.72,1.67,1.67,1.66,1.60,1.67,1.67,1.69,1.67,1.67,1.67,1.65,1.71,1.67,1.67,1.66,1.64,1.68,1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.68,1.67,1.67,1.66,1.81,1.67,1.67,1.58,1.68,1.67,1.67,1.65,1.71,1.67,1.67,1.66,1.63	300	200	250
11	19	1.33	1.33	2.05	1.68,1.68,1.68,1.68,1.68,1.68,1.66,1.66,1.64,1.67,1.66,1.66,1.65,1.67,1.67,1.67,1.75,1.59,1.66,1.66,1.64,1.67,1.66,1.66,1.65,1.67,1.68,1.68,1.68,1.68,1.68,1.68,1.68,1.68,1.68,1.66,1.66,1.65,1.67,1.67,1.67,1.51,1.67,1.66,1.66,1.64,1.67,1.66,1.66,1.65,1.67	300	200	250
12	5	1.30	1.30	2.00	-	300	200	250
13	19	4.88	4.00	7.50	1.08,1.08,1.08,1.08,1.08,1.08,1.09,1.09,1.09,1.13,1.09,1.09,1.09,1.13,1.08,1.08,1.07,1.64,1.09,1.09,1.09,1.14,1.09,1.09,1.09,1.12,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.09,1.09,1.09,1.13,1.08,1.08,1.14,1.20,1.09,1.09,1.09,1.14,1.09,1.09,1.09,1.13	300	200	250
14	19	4.88	4.00	7.50	1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.09,2.15,1.08,1.08,1.08,1.35,1.08,1.08,1.06,1.12,1.08,1.08,1.09,1.39,1.08,1.08,1.08,1.23,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.09,1.98,1.08,1.08,1.14,1.16,1.08,1.08,1.09,1.52,1.08,1.08,1.08,1.26	300	200	250
15	19	7.88	7.88	3.75	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	7.88	7.88	3.75	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	9	6.34	6.34	9.76	-	300	200	250
102	5	1.30	1.30	2.00	-	300	200	250
103	16	0.92	0.92	1.42	1.19,1.19,1.19,1.18,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.19,1.39,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18,1.19,1.19,1.19,1.19,1.19,1.19,1.19,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.13,1.17,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18	300	200	250

104	16	2.44	2.44	3.75	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.72,1.67,1.67,1.66,1.60,1.67,1.67,1.69,1.67,1.67,1.67,1.65,1.71,1.67,1.67,1.66,1.64,1.68,1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.68,1.67,1.67,1.66,1.81,1.67,1.67,1.58,1.68,1.67,1.67,1.65,1.71,1.67,1.67,1.66,1.63	300	200	250
105	16	1.52	1.52	2.33	1.67,1.67,1.67,1.67,1.67,1.67,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.68,2.63,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.67,1.67,1.67,1.67,1.67,1.67,1.67,1.67,1.67,1.66,1.66,1.67,1.67,1.61,1.65,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66	300	200	250
106	16	0.92	0.92	1.42	1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.17,1.19,1.12,1.18,1.18,1.16,1.17,1.17,1.17,1.17,1.17,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.17,1.17,1.17,1.17,1.17,1.17,1.11,1.16,1.18,1.18,1.16,1.17,1.17,1.17,1.17,1.17	300	200	250
107	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.68,1.58,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66,1.68,1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.60,1.65,1.67,1.67,1.65,1.66,1.67,1.67,1.66,1.66	300	200	250
108	19	7.88	7.88	3.75	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	1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.66,1.70,1.67,1.67,1.66,1.83,1.67,1.67,1.70,1.68,1.67,1.67,1.64,1.70,1.67,1.67,1.66,1.55,1.69,1.69,1.68,1.69,1.68,1.69,1.69,1.68,1.69,1.67,1.67,1.65,1.72,1.67,1.67,1.55,1.68,1.67,1.67,1.65,1.71,1.67,1.67,1.66,1.30	300	200	250
111	19	7.88	7.88	3.75	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	4.20	4.20	2.00	-	300	200	250
113	19	4.88	4.00	7.50	1.08,1.08,1.08,1.08,1.08,1.08,1.09,1.09,1.09,1.13,1.09,1.09,1.09,1.13,1.08,1.08,1.07,1.64,1.09,1.09,1.09,1.14,1.09,1.09,1.09,1.13,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.09,1.09,1.09,1.13,1.09,1.09,1.14,1.20,1.09,1.09,1.09,1.14,1.09,1.09,1.09,1.13	300	200	250
114	19	4.88	4.00	7.50	1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.09,2.15,1.08,1.08,1.09,1.35,1.08,1.08,1.06,1.12,1.08,1.08,1.09,1.39,1.08,1.08,1.09,1.23,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.08,1.09,1.97,1.08,1.08,1.14,1.16,1.08,1.08,1.09,1.52,1.08,1.08,1.09,1.26	300	200	250
115	19	12.95	12.95	12.95	1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.14,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.12,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13	300	200	250
116	19	12.95	12.95	12.95	1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.15,1.13,1.13,1.13,1.09,1.13,1.13,1.14,1.13,1.13,1.13,1.13,1.14,1.13,1.13,1.13,1.11,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.17,1.13,1.13,1.12,1.14,1.13,1.13,1.13,1.14,1.13,1.13,1.13,1.11	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	347.73	332.38	76.62	76.62	104.32	104.32
2	182.47	168.72	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	24.47	6.12	40.24	43.62
14	133.20	85.85	24.38	6.12	40.24	43.62
15	133.20	52.83	32.87	6.12	40.24	43.62
16	133.20	52.83	32.87	6.12	40.24	43.62
101	347.73	332.38	76.62	76.62	104.32	104.32
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	52.83	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	52.83	32.87	6.12	40.24	43.62
112	182.47	168.72	20.19	20.19	54.74	54.74
113	133.20	85.85	24.49	6.12	40.24	43.62
114	133.20	85.85	24.40	6.12	40.24	43.62
115	133.20	19.55	12.14	6.12	40.24	43.62
116	133.20	19.55	11.78	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	0.032	0.564	0.059	0.039	0.006	0.576	#32	0.130	Not Required	Pass
2	0.004	0.335	0.171	0.078	0.034	0.508	#13	0.171	Not Required	Pass
3	0.005	0.552	0.026	0.054	0.008	0.564	#13	0.045	Not Required	Pass
4	0.004	0.551	0.098	0.056	0.023	0.622	#13	0.080	Not Required	Pass
5	0.005	0.343	0.077	0.055	0.020	0.347	#13	0.074	Not Required	Pass
6	0.007	0.750	0.069	0.077	0.014	0.803	#13	0.045	Not Required	Pass
7	0.008	0.464	0.150	0.075	0.039	0.494	#13	0.074	Not Required	Pass
8	0.003	0.112	0.152	0.054	0.013	0.157	#24	0.095	Not Required	Pass
9	0.011	0.089	0.078	0.003	0.004	0.170	#13	0.204	Not Required	Pass
10	0.009	0.749	0.135	0.075	0.028	0.761	#13	0.080	Not Required	Pass
11	0.004	0.110	0.156	0.054	0.012	0.165	#21	0.095	Not Required	Pass
12	0.002	0.558	0.231	0.112	0.042	0.789	#13	0.053	Not Required	Pass
13	0.006	0.207	0.331	0.067	0.015	0.481	#21	0.286	Not Required	Pass
14	0.006	0.209	0.327	0.067	0.015	0.472	#21	0.190	Not Required	Pass
15	0.000	0.062	0.084	0.027	0.006	0.134	#21	Not Required	Not Required	Pass
16	0.000	0.062	0.084	0.027	0.006	0.134	#21	Not Required	Not Required	Pass
101	0.032	0.563	0.059	0.039	0.006	0.576	#32	0.130	Not Required	Pass
102	0.002	0.557	0.230	0.112	0.041	0.788	#13	0.053	Not Required	Pass
103	0.007	0.750	0.069	0.077	0.014	0.802	#13	0.045	Not Required	Pass
104	0.009	0.749	0.135	0.075	0.028	0.761	#13	0.080	Not Required	Pass
105	0.008	0.464	0.150	0.075	0.039	0.494	#13	0.074	Not Required	Pass
106	0.005	0.553	0.026	0.054	0.008	0.564	#13	0.045	Not Required	Pass
107	0.005	0.344	0.077	0.055	0.020	0.348	#13	0.074	Not Required	Pass
108	0.000	0.062	0.084	0.027	0.006	0.134	#21	Not Required	Not Required	Pass
109	0.011	0.089	0.078	0.003	0.004	0.169	#13	0.204	Not Required	Pass
110	0.004	0.552	0.098	0.056	0.023	0.622	#13	0.120	Not Required	Pass
111	0.000	0.062	0.084	0.027	0.006	0.134	#21	Not Required	Not Required	Pass
112	0.004	0.335	0.171	0.079	0.034	0.508	#13	0.171	Not Required	Pass
113	0.006	0.206	0.330	0.067	0.015	0.480	#21	0.190	Not Required	Pass
114	0.006	0.209	0.326	0.067	0.015	0.471	#21	0.286	Not Required	Pass
115	0.025	0.646	0.180	0.054	0.012	0.754	#13	0.925	Not Required	Pass
116	0.015	0.651	0.183	0.054	0.013	0.762	#13	0.925	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

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

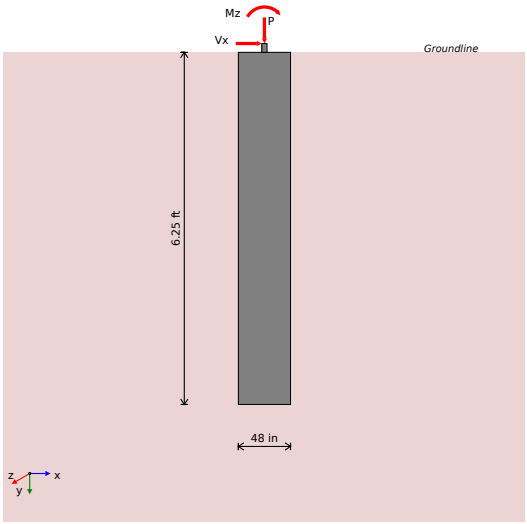
Input	Description	Value
f'_{ck}	Concrete compressive strength	2.5 ksi
f_{yk}	Yield strength of steel	60 ksi
d_b	Rebar diameter	#5 (0.625) in
cover	Concrete cover	3 in

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	6.979 kip	10.78 kip
Vx	-2.458 kip	-4.096 kip
Vz	-0.386 kip	-0.625 kip
Mx	-0.995 kip-ft	-1.598 kip-ft
Mz	25.84 kip-ft	43.03 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

$$H_o = \frac{V_x}{1.57 \times D} = \frac{-2.458}{1.57 \times 48} = -0.391\ \frac{kip}{ft}$$

Moment per section length

$$M_o = \frac{M_z + (V_x \times H)}{1.57 \times D} = \frac{25.84 + (-2.458 \times 0)}{1.57 \times 48} = 4.115 \frac{kip - ft}{ft}$$

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:

$$L_{e,x} = 5.783\ ft$$

Considering z-direction:

Lateral force per section length

$$H_o = \frac{V_z}{1.57 \times b} = \frac{-0.386}{1.57 \times 48} = -0.061 \frac{kip}{ft}$$

Moment per section length

$$M_o = \frac{M_x + (V_z \times H)}{1.57 \times b} = \frac{-0.995 + (-0.386 \times 0)}{1.57 \times 48} = -0.158 \frac{kip - ft}{ft}$$

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:

$$L_{e,z} = -1.816\ ft$$

Minimum embedded depth

Depth of pile required

$$L_{e,req} = MAX[L_{e,x}, L_{e,z}] = MAX[5.783, -1.816] = 5.783\ ft$$

Actual embedded length

$$L_e = L - h_2 - h_e = 6.25 - 0 - 0 = 6.25\ ft$$

Utilisation

$$Ratio = \frac{L_{e,req}}{L_e} = \frac{5.783}{6.25} = 0.925$$

UTILITY: 0.93

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:

$$q = \frac{P}{A} = \frac{6.979}{16} = 436.2\ psf$$

Utilisation

$$Ratio = \frac{q}{q_a} = \frac{436.2}{2000} = 0.218$$

UTILITY: 0.22

Lateral Soil Pressure (ASD)

Allowable lateral pressure	$R =$	150 psf/ft

Length to least lateral dimension ratio:

$$\frac{L}{MIN[b, D]} = \frac{6.25}{MIN[4, 4]} = 1.563$$

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

Considering x-direction:

Distance from resting surface to pivot point:

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

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

$$a = \frac{(4 \times 4.115 \times 6.25) + \left(3 \times 0.391 \times 6.25^2\right)}{(6 \times 4.115) + (4 \times 0.391 \times 6.25)} = 4.314\ ft$$

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

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

$$p = \frac{0.75 \times [(4 \times 4.115) + (3 \times -0.391 \times 6.25)]^2}{6.25^2 \times [(3 \times 4.115) + (2 \times -0.391 \times 6.25)]} = 0.214\ \frac{kip}{ft^2}$$

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

$$p_a = R \times \frac{a}{2} = 0.15 \times \frac{4.314}{2} = 0.324\ \frac{kip}{ft^2}$$

Utilisation - pressure at a depth of a/2

$$Ratio = \frac{p}{p_a} = \frac{0.214}{0.324} = 0.662$$

UTILITY: 0.66

Earth pressure against the pile at distance L_e:

$$s = \frac{6 \times [(2 \times M_o) + (H_o \times L_e)]}{L_e^2} = \frac{6 \times [(2 \times 4.115) + (-0.391 \times 6.25)]}{6.25^2} = 0.888\ \frac{kip}{ft^2}$$

Allowable lateral soil pressure at a depth of L_e:

$$p_s = R \times L_e = 0.15 \times 6.25 = 0.938\ \frac{kip}{ft^2}$$

Utilisation - pressure at a depth of L_e

$$Ratio = \frac{s}{p_s} = \frac{0.888}{0.938} = 0.948$$

UTILITY: 0.95

Considering z-direction:

Distance from resting surface to pivot point:

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

$$a = \frac{(4 \times 0.158 \times 6.25) + \left(3 \times 0.061 \times 6.25^2\right)}{(6 \times 0.158) + (4 \times 0.061 \times 6.25)} = 4.488\ ft$$

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

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

$$p = \frac{0.75 \times [(4 \times -0.158) + (3 \times -0.061 \times 6.25)]^2}{6.25^2 \times [(3 \times -0.158) + (2 \times -0.061 \times 6.25)]} = -0.049\ \frac{kip}{ft^2}$$

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

$$p_a = R \times \frac{a}{2} = 0.15 \times \frac{4.488}{2} = 0.337\ \frac{kip}{ft^2}$$

Utilisation - pressure at a depth of a/2

$$Ratio = \frac{p}{p_a} = \frac{-0.049}{0.337} = -0.146$$

UTILITY: 0.15

Earth pressure against the pile at distance L_e:

$$s = \frac{6 \times [(2 \times M_o) + (H_o \times L_e)]}{L_e^2} = \frac{6 \times [(2 \times -0.158) + (-0.061 \times 6.25)]}{6.25^2} = -0.108\ \frac{kip}{ft^2}$$

Allowable lateral soil pressure at a depth of L_e:

$$p_s = R \times L_e = 0.15 \times 6.25 = 0.938\ \frac{kip}{ft^2}$$

Utilisation - pressure at a depth of L_e

$$Ratio = \frac{s}{p_s} = \frac{-0.108}{0.938} = -0.115$$

UTILITY: 0.11

REFERENCES	CALCULATIONS	RESULTS

Shear force and bending moment (LRFD)

Considering x-direction:

Lateral force per section length

$$H_o = \frac{V_x}{1.57 \times D} = \frac{-4.096}{1.57 \times 48} = -0.652\ \frac{kip}{ft}$$

Moment per section length

$$M_o = \frac{M_z + (V_x \times H)}{1.57 \times D} = \frac{43.03 + (-4.096 \times 0)}{1.57 \times 48} = 6.852\ \frac{kip - ft}{ft}$$

Distance from resting surface to pivot point:

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

$$a = \frac{(4 \times 6.852 \times 6.25) + (3 \times 0.652 \times 6.25^2)}{(6 \times 6.852) + (4 \times 0.652 \times 6.25)} = 4.315\ ft$$

Max shear force located at depth a:

$$E = \frac{M_o}{H_o} = \frac{6.852}{-0.652} = 10.51\ ft$$

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

$$V_{max,x} = (-0.652 \times 48) \times [1 - [3 \times \left(\frac{4 \times 10.51}{6.25} + 3\right) \times \left(\frac{4.315}{6.25}\right)^2] + [4 \times \left(\frac{3 \times 10.51}{6.25} + 2\right) \times \left(\frac{4.315}{6.25}\right)^3]]$$

$$V_{max,x} = 9.481\ kip$$

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

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

$$M_{max,x} = (-0.652 \times 48 \times 6.25) \times [\left(\frac{10.51}{6.25} + \frac{4.315}{2 \times 6.25}\right) - [\left(\frac{4 \times 10.51}{6.25} + 3\right) \times \left(\frac{4.315}{2 \times 6.25}\right)^3] + [\left(\frac{3 \times 10.51}{6.25} + 2\right) \times \left(\frac{4.315}{2 \times 6.25}\right)^4]]$$

$$M_{max,x} = 28.15\ kip - ft$$

Considering z-direction:

Lateral force per section length

$$H_o = \frac{V_z}{1.57 \times b} = \frac{-0.625}{1.57 \times 48} = -0.1\ \frac{kip}{ft}$$

Moment per section length

$$M_o = \frac{M_x + (V_z \times H)}{1.57 \times b} = \frac{-1.598 + (-0.625 \times 0)}{1.57 \times 48} = -0.255\ \frac{kip - ft}{ft}$$

Distance from resting surface to pivot point:

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

$$a = \frac{(4 \times 0.255 \times 6.25) + (3 \times 0.1 \times 6.25^2)}{(6 \times 0.255) + (4 \times 0.1 \times 6.25)} = 4.49\ ft$$

Max shear force located at depth a:

$$E = \frac{M_o}{H_o} = \frac{-0.255}{-0.1} = 2.555\ ft$$

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

$$V_{max,z} = (-0.1 \times 48) \times [1 - [3 \times \left(\frac{4 \times 2.555}{6.25} + 3\right) \times \left(\frac{4.49}{6.25}\right)^{3}] + [4 \times \left(\frac{3 \times 2.555}{6.25} + 2\right) \times \left(\frac{4.49}{6.25}\right)^{4}]]$$

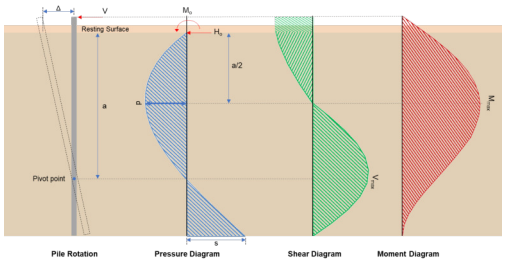
$$V_{max,z} = 0.554\ kip$$

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

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

$$M_{max,z} = (-0.1 \times 48 \times 6.25) \times [\left(\frac{2.555}{6.25} + \frac{4.49}{2 \times 6.25}\right) - [\left(\frac{4 \times 2.555}{6.25} + 3\right) \times \left(\frac{4.49}{2 \times 6.25}\right)^{3}] + [\left(\frac{3 \times 2.555}{6.25} + 2\right) \times \left(\frac{4.49}{2 \times 6.25}\right)^{4}]]$$

$$M_{max,z} = 1.511\ kip - ft$$



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:

$$A_{st,req} = \frac{P - (0.85 \times f'_{ck} \times A_g)}{f_{yk} - (0.85 \times f'_{ck})} = \frac{10.78 - (0.85 \times 2.5 \times 2304)}{60 - (0.85 \times 2.5)} = -84.41\ in^2$$

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:

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

Use: $n = 16$pcs at 1.5 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 ≤ 1.41 in: Use #3(0.375 in)

Maximum spacing of shear Reinforcements:

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

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

$$Ratio = \frac{P}{\phi P_N} = \frac{10.78}{2694} = 0.004$$

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	$V_{max,x} =$	9.481 kip
Maximum shear in the z-direction	$V_{max,z} =$	0.554 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:

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

$$V_{c,a} = \left(2 \times 1 \times \sqrt{2.5} + MIN[\frac{10.78}{6 \times 2304}, (0.05 \times 2.5)]\right) \times (48 \times 44.31) = 214.4\ kip$$

Governing shear strength of concrete:

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

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:

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

$$V_{max} = MAX[9.481, 0.554] = 9.481\ kip$$

Utilisation

$$Ratio = \frac{V_{max}}{\phi V_n} = \frac{9.481}{204.8} = 0.046$$

UTILITY: 0.05

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	$P =$	10.78 kip
Maximum moment in the x-direction	$M_{max,x} =$	28.15 kip-ft
Maximum moment in the z-direction	$M_{max,z} =$	1.511 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:

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

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

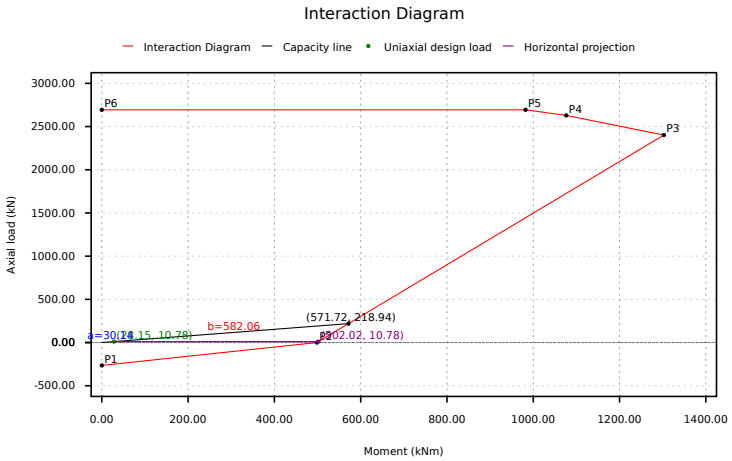
$$f_2 = E_s \times \varepsilon_2 \ (\varepsilon_2 < \varepsilon_{sy}),\ f_2 = \phi_s \times f_y \ (\varepsilon_2 \geq \varepsilon_{sy})$$

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

$$M_f = MAX[28.15, 1.511] = 28.15\ kip - ft$$



Segment	Signed Distance
P1 - P2	230.3
P2 - P3	449.3
P3 - P4	2590
P4 - P5	2752
P5 - P6	2683
Status	PASS: Point lies inside the curve

Utilisation

$$Ratio = \frac{a}{a+b} = \frac{30.14}{30.14 + 582.1} = 0.049$$

UTILITY: 0.05

Biaxial Bending Check

Maximum moment in the x-direction	$M_{max,x} =$ 28.15 kip-ft
Maximum moment in the z-direction	$M_{max,z} =$ 1.511 kip-ft
Nominal uniaxial moment strength about the x-axis	$M_{nox} =$ 502 kip-ft
Nominal uniaxial moment strength about the z-axis	$M_{noz} =$ 502 kip-ft
Interaction exponent	$\alpha =$ 1

Bresler (1960)	According to Bresler (method B): $$\left(\frac{M_{max,x}}{M_{nox}}\right)^{\alpha}+\left(\frac{M_{max,z}}{M_{noz}}\right)^{\alpha}=1.0$$ $$\left(\frac{28.15}{502}\right)^{1}+\left(\frac{1.511}{502}\right)^{1}=0.059$$	**UTILITY: 0.06**

REFERENCES	CALCULATIONS	RESULTS

Results Summary

Result Name	Results
PILE DETAILS	
Length of the pile	6.25 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	0.93
End-bearing capacity	0.22
p_a	0.66
p_s	0.95
Axial compression strength	0.00
Shear strength	0.05
Uniaxial bending strength	0.05
Biaxial bending strength	0.06