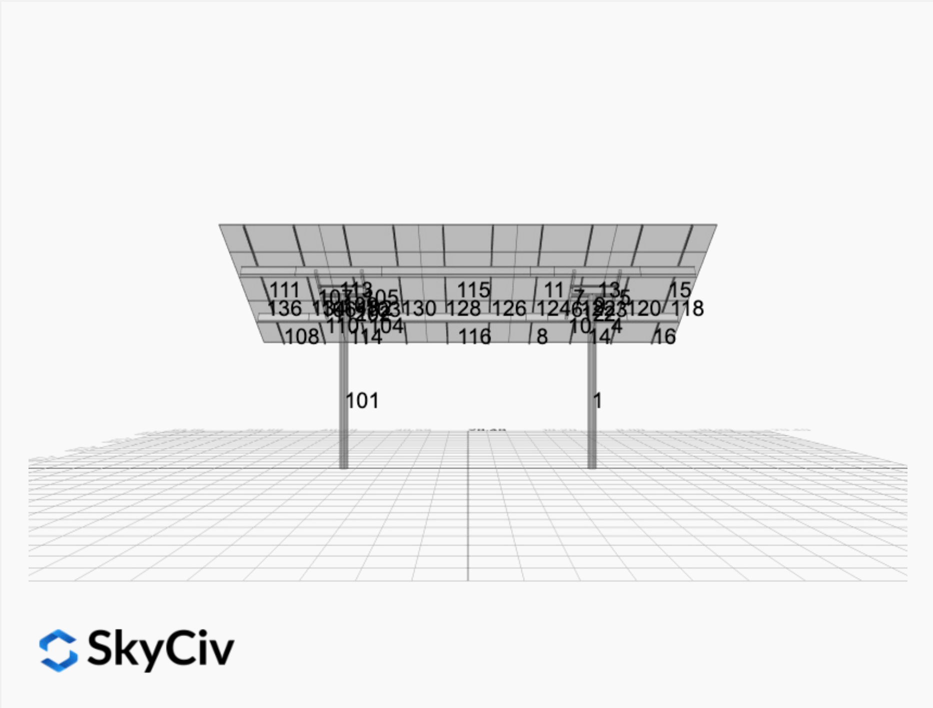
# Project Details

**Project Name:** FILTER POND 5x5 36inRound - V1Jb
**Location:** DuPage County 1 S, 649 Shaffner Rd, Wheaton, IL 60189, USA
**Unique ID:** 2P-22.5-8TOP-XD-57-L-5Hx5W-C3J2
**Dealer:** ______________________________

**Date:** Mon Nov 10 2025
**Number of Modules:** 25
**Number of Poles:** 2
**Date Sold:**
______________________________




| | |
|---|---|
| **Array Dimensions N/S** | 18.79 ft |
| **Array Dimensions E/W** | 40.79 ft |
| **Winter Tilt Angle (Degrees)** | 30 |
| **Front Edge Clearance** | 11 |

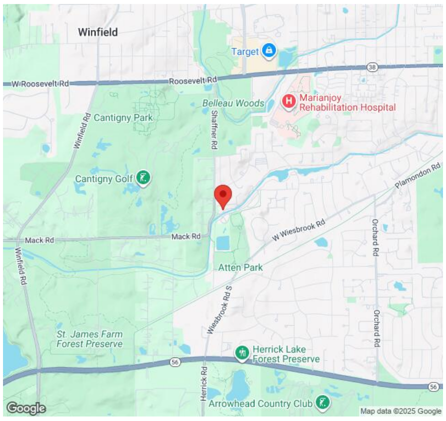
### MT Solar Bill of Materials (2P-22.5-8TOP-XD-57-L-5Hx5W-C3J2)

| Part | Short Description | BOM Qty |
|---|---|---|
| MTS-PC-8 | 8IN Pole Cap Assembly | 2 |
| MTS-HF-XD | H-Frame Assembly-XD | 2 |
| MTS-XD-Wing-57 | 57IN XD Wing | 4 |
| MTS-XD-Splice-90 | 90IN XD Splice | 4 |
| MTS-CLAMP-ANGLE-4PK | Angle Clamp | 5 |

### Rail Bill of Materials

| Part | Qty |
|---|---|
| Rails (226in Long) | 10x |
| Rail Attachment | 40x |
| Module Mid Clamp | 40x |
| Module End Clamp | 20x |
| Ground Lug | 5x |

# Site Details:




**Site Address:** DuPage County 1 S, 649 Shaffner Rd, Wheaton, IL 60189, USA

### Array Specifications

| | |
|---|---|
| **Duty Classification:** | XD |
| **Module Width:** | 44.60 in |
| **Module Length:** | 96.90 in |
| **Number of Rows:** | 5 |
| **Number of Columns:** | 5 |
| **Total Number of Modules:** | 25 |
| **Winter Tilt Angle:** | 30 |
| **Front Edge Clearance:** | 11 |
| **Total Array Height at Tilt:** | 20.40 ft |
| **Total Frame Length:** | 39.50 ft |
| **Module Info/Notes:** | 585w |
| **Array Dimensions N/S:** | 18.79 ft |
| **Array Dimensions E/W:** | 40.79 ft |
| **Rail Length:** | 225.50 in |
| **Rail Spacing:** | 4.08 ft |

### Support Specifications

| | |
|---|---|
| **Pole Size:** | 8in Pipe Sch 80 |
| **Pole Length above Grade:** | 15.70 ft |
| **Number of Poles:** | 2 |
| **Pole Spacing:** | 22.5 ft |

### Foundation Specifications

| | |
|---|---|
| **Foundation Type:** | round |
| **Foundation Dimensions:** | 36 in dia. |
| **Foundation Depth (below grade):** | 12.0 ft |
| **Foundation Volume:** | 84.82 $ft^3$ |

### Site Info

| | |
|---|---|
| **Risk Category:** | I |
| **Exposure:** | C |
| **Soil Classification:** | sand |
| **Site Location:** | DuPage County 1 S, 649 Shaffner Rd, Wheaton, IL 60189, USA |
| **Wind Speed:** | 101 mph |

| | |
|---|---|
| **Snow Load:** | 25 psf |

### Design Disclaimer

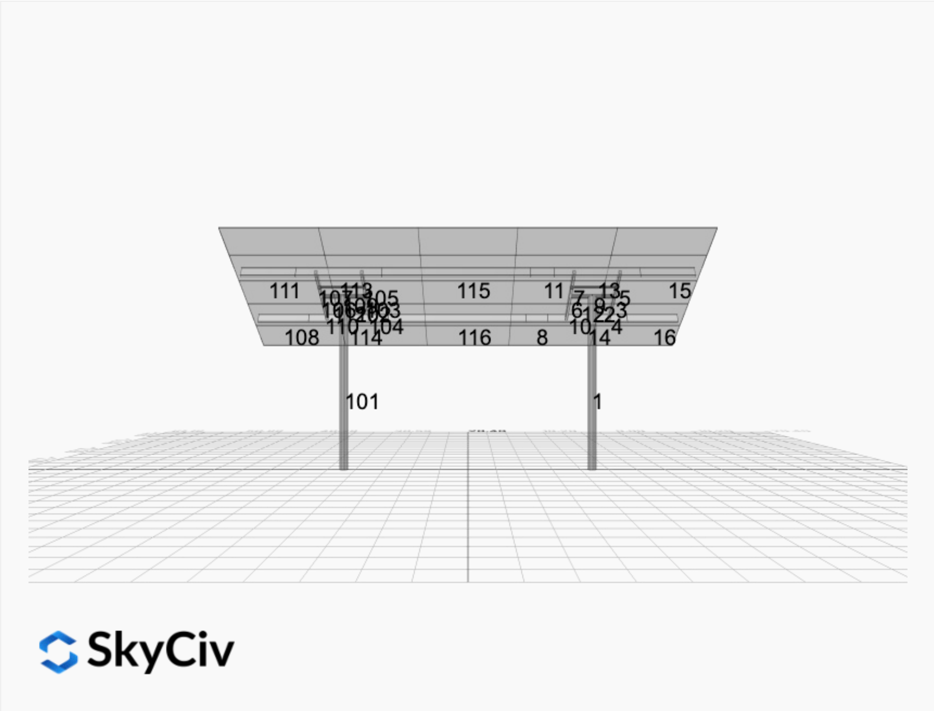
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

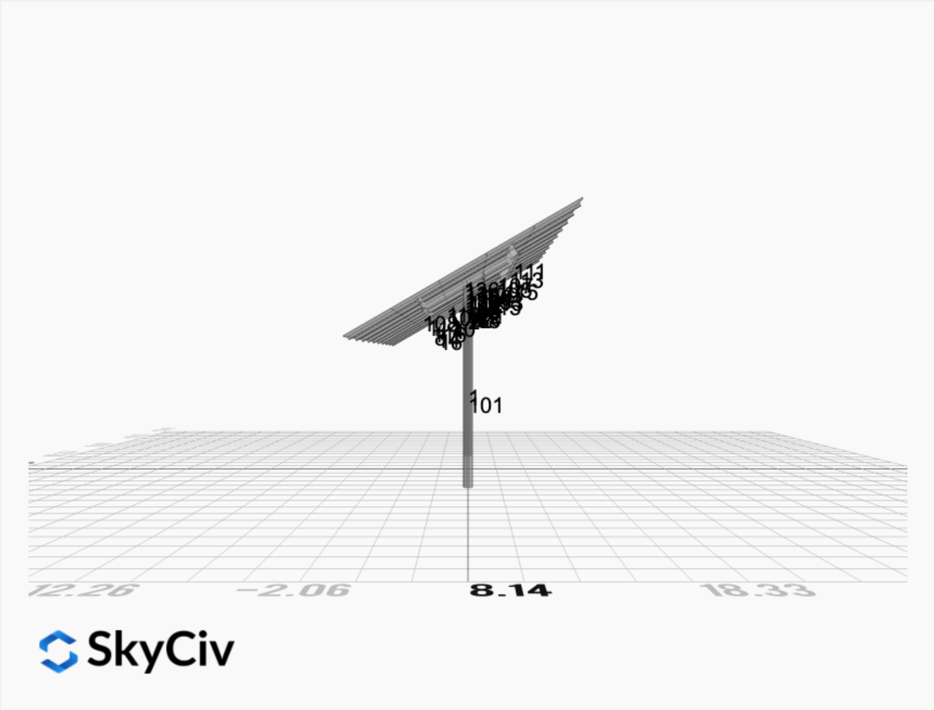
## AutoDesigner Input

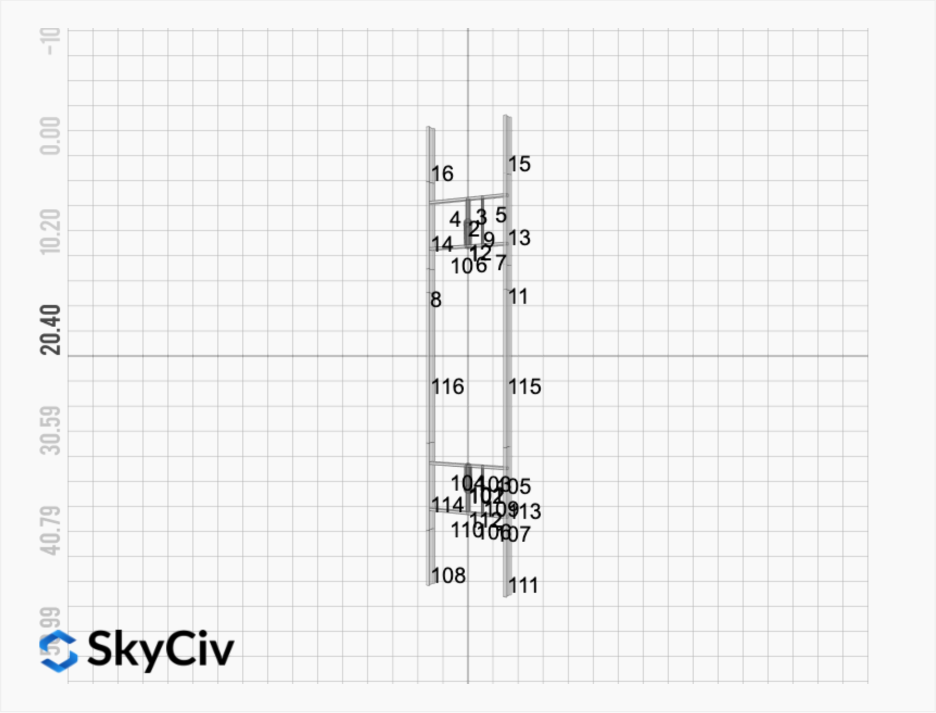

```
{"wind_speed_override":null,"snow_load_override":null,"direct_snow_load":false,"add_angle_brace":false,"product_type":"Beam","designer_name":"","designer_email":"","designer_phone":"","project_id":"FILTER POND 5x5 36inRound - V1Jb","site_address":"DuPage County 1 S, 649 Shaffner Rd, Wheaton, IL 60189, USA","module_info":"585w","module_width":44.6,"module_length":96.9,"number_rows":"5","number_columns":5,"pole_mount_section":"4_40","core_pipe_width":65,"core_pipe_section":"2_40","adjuster_section":"2_40","core_beam_height":65,"core_beam_section":"HSS3x2x1/8","main_pipe_section":"2_12GA","pole_spacing":"15","tilt_angle":30,"ground_clearance":11,"risk_category":"I","exposure_category":"C","frame_duty_override":"auto","pole_override":"auto","soil_type":"sand","customer_foundation_override":"48_Square","foundation_type":"Round","foundation_size":36,"check_rails":true}
```

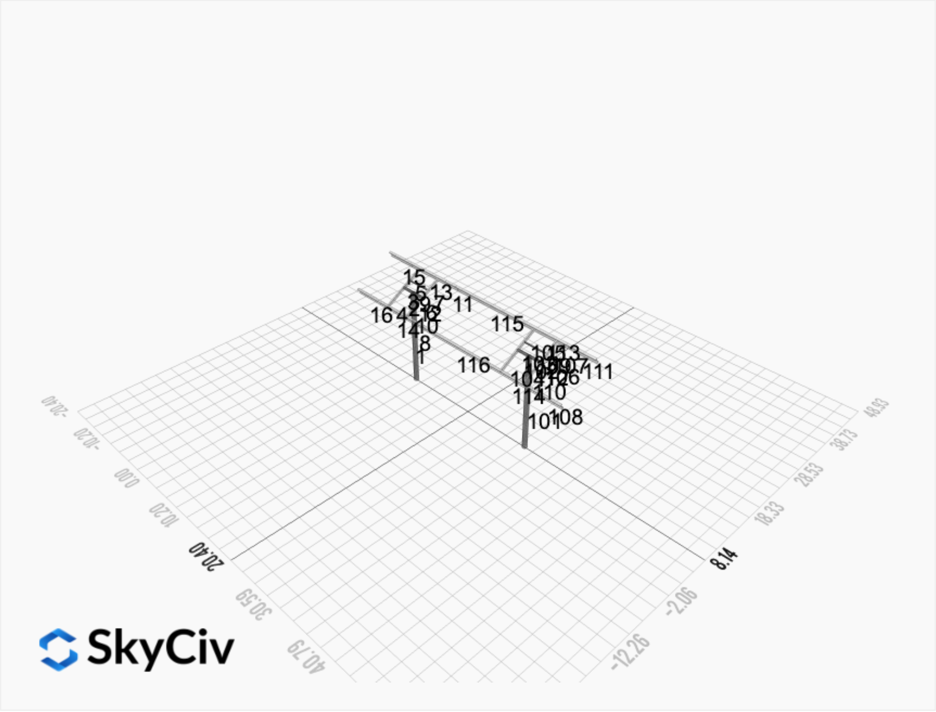

**Design Notes:**

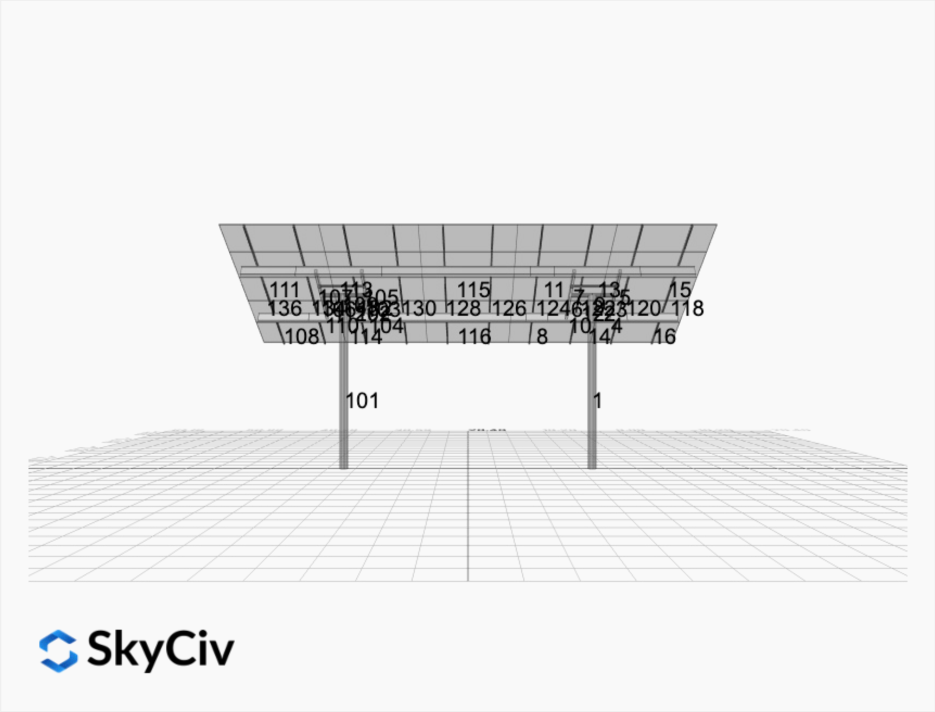
- Deflection checks are set to L/1 due to manufacturer structural design intent
- Foundation Soil Parameters used in this Autodesign are all estimates, proper geotechnical reports are required to confirm soil profiles
- Wind speeds, snow loads and other site specific results are based on ASCE 7-16
-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





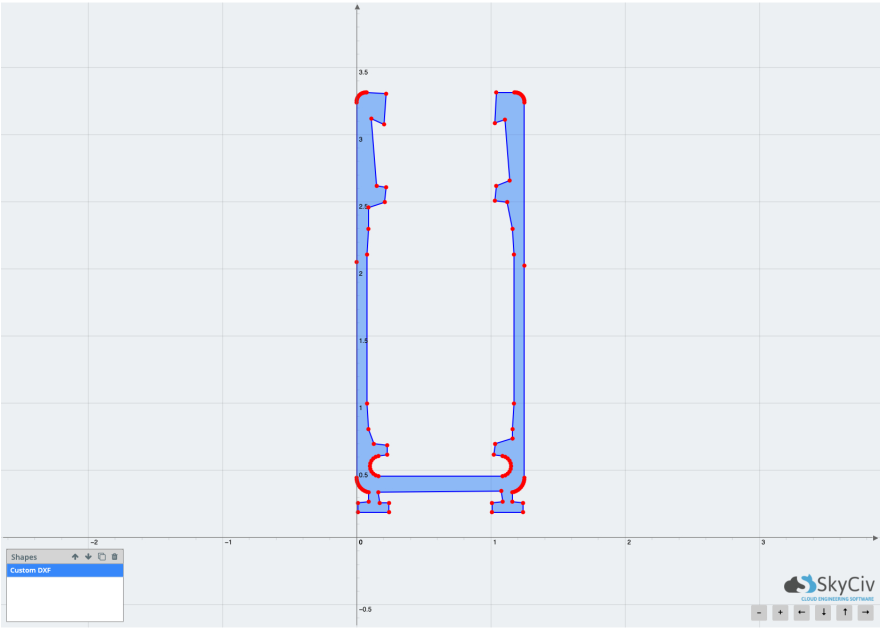




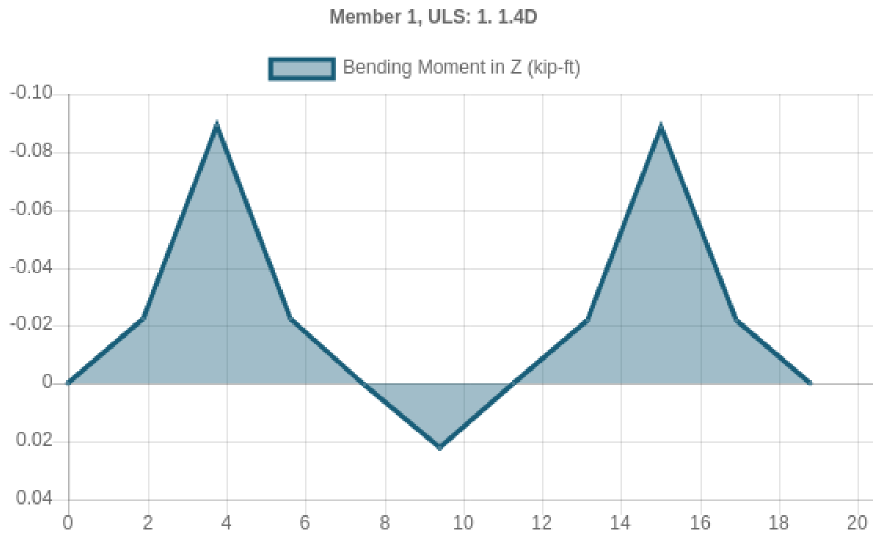
## Rail Design Check

**Rail Length:** 18.79 ft
**Additional Restraints Required:** 4ft Spread Clamps
**Tributary Width:** 4.08 ft
**Material:** Aluminium
**Density:** 169.00 lb/ft$^3$
**Elastic Modulus:** 10000.00 ksi
**Fy:** 34.50 ksi
**Fu:** 37.00 ksi

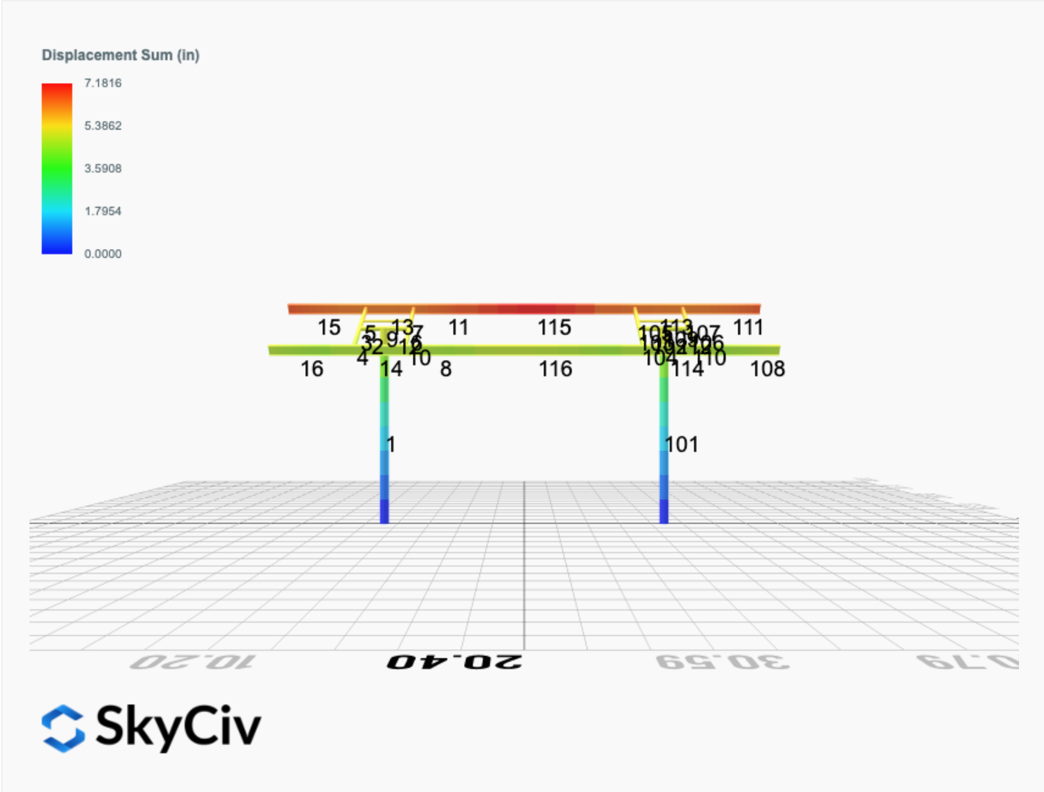
**Rail Distributed Loading:**
Note, gravity loading is resolved into member local X and Y axes.
**Snow (X):** 0.0388 kip/ft
**Snow (Y):** -0.0224 kip/ft
**Wind uplift Case A (Y):** 0.1157 kip/ft
**Wind uplift Case A (Y):** 0.1157 kip/ft
**Wind uplift Case B (Y):** 0.1606 kip/ft
**Wind uplift Case B (Y):** 0.1606 kip/ft
**Wind downforce Case A (Y):** -0.1349 kip/ft
**Wind downforce Case A (Y):** -0.1349 kip/ft
**Wind downforce Case B (Y):** -0.1349 kip/ft
**Wind downforce Case B (Y):** -0.1349 kip/ft
**Dead (Panel load) (X):** 0.0155 kip/ft
**Dead (Panel load) (Y):** -0.0090 kip/ft

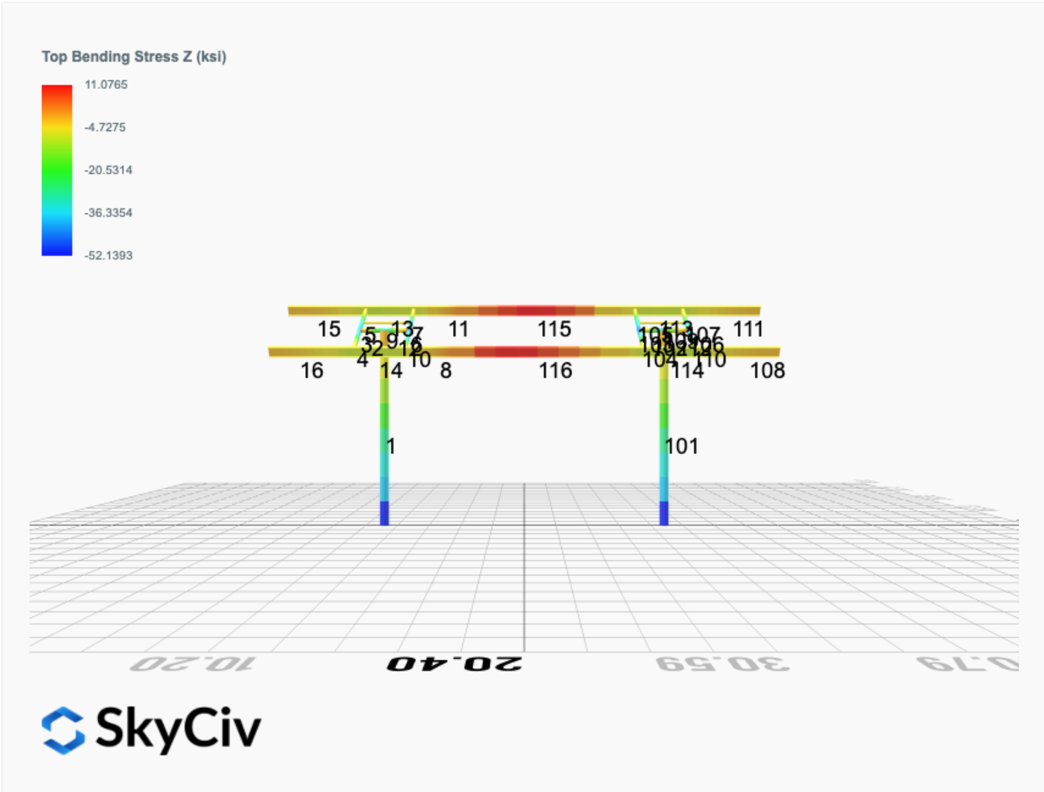


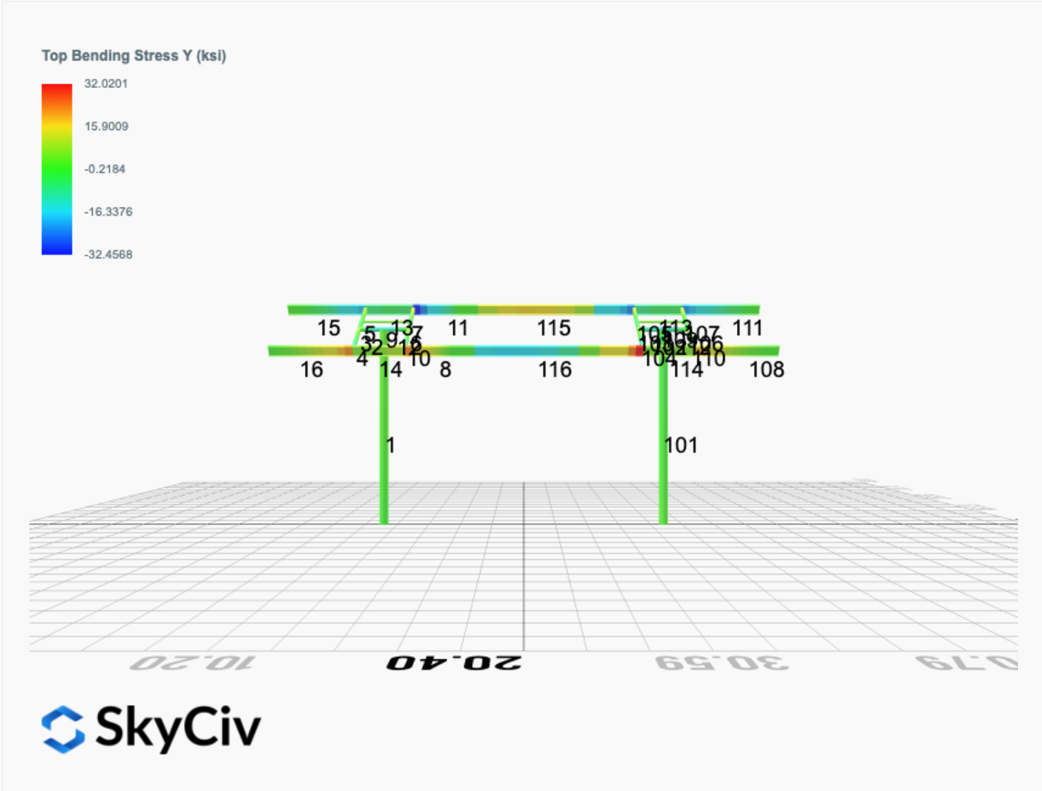

| Result Check | Max Limit | Max Value | Utility | Status |
|---|---|---|---|---|
| Custom Stress Limit | 34.50 | 24.14 | 0.700 | PASS |
| Material Yield | 34.50 | 24.14 | 0.700 | PASS |
| Material Strength | 37.00 | 24.14 | 0.652 | PASS |

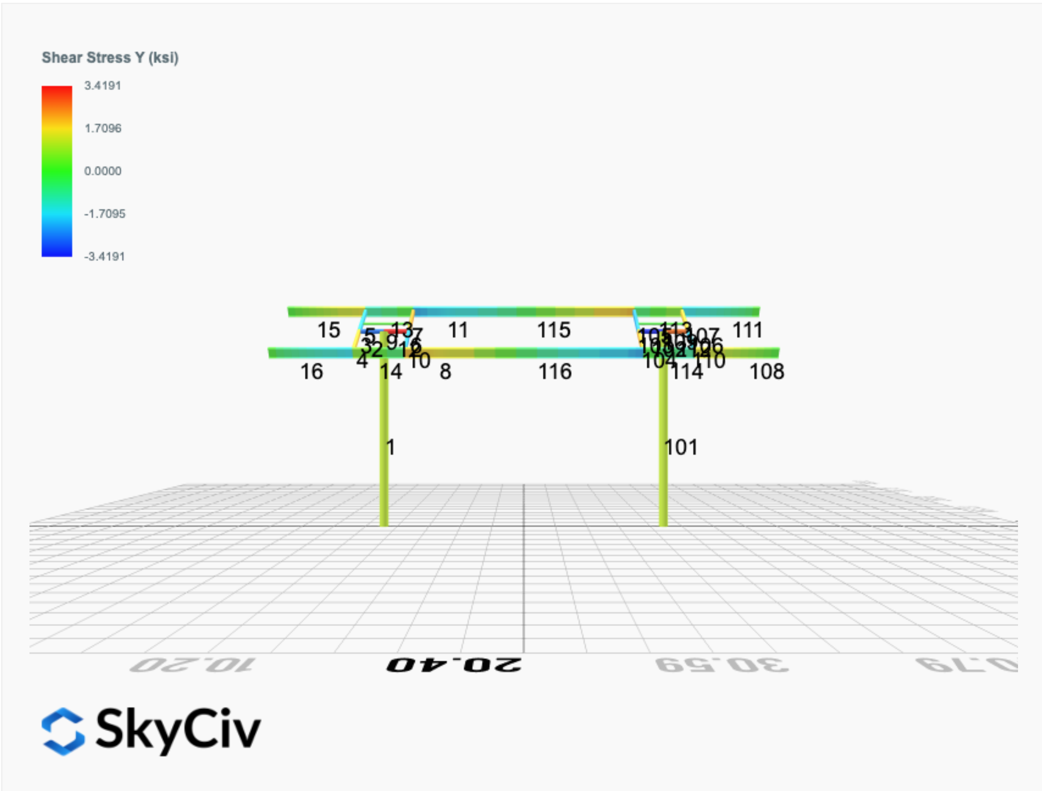


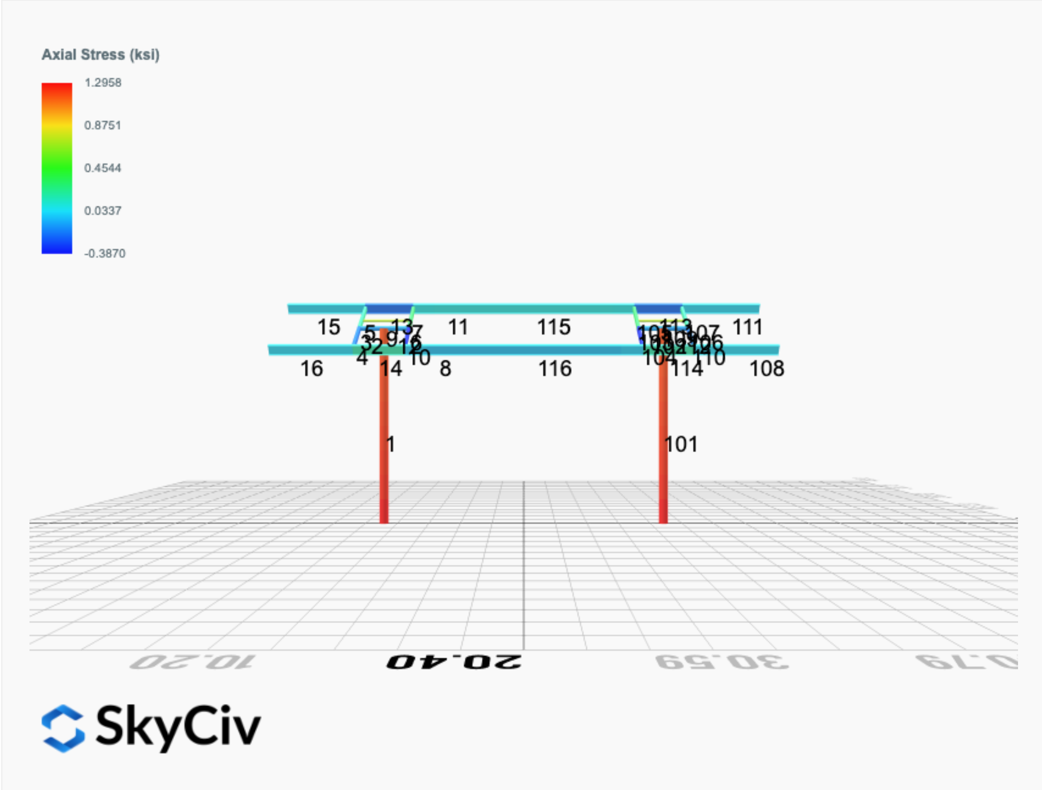
## FEM Results (Envelope Worst Case)




Top Bending Stress Y (ksi)
32.0201
15.9009
-0.2184
-16.3376
-32.4568
SkyCiv


Shear Stress Y (ksi)
3.4191
1.7096
0.0000
-1.7095
-3.4191
SkyCiv


Axial Stress (ksi)
1.2958
0.8751
0.4544
0.0337
-0.3870
15
11
115
111
16
14
8
116
114
108
1
101
10.20
20.40
30.59
SkyCiv

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

### LRFD Load Combination Results

| Name | Fx | Fy | Fz | Mx | My | Mz |
|---|---|---|---|---|---|---|
| ULS: 1. 1.4D | 0.0000 | 4.3558 | 0.0435 | 0.2176 | -0.0185 | 0.0489 |
| ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R) | 0.0000 | 5.5585 | 0.0637 | 0.3190 | -0.0274 | 0.0532 |
| ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R) | 0.0000 | 3.7335 | 0.0373 | 0.1864 | -0.0159 | 0.0407 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + L | 0.0000 | 9.5735 | 0.1220 | 0.6128 | -0.0526 | 0.1036 |
| ULS: 5. 1.2D + E + L + 0.2S | 0.0000 | 4.4635 | 0.0478 | 0.2394 | -0.0205 | 0.0449 |
| ULS: 7. 0.9D + 1.0E | 0.0000 | 2.8002 | 0.0279 | 0.1397 | -0.0119 | 0.0291 |
| ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only | -6.3391 | 16.5382 | 0.2367 | 1.1645 | -0.5228 | 106.5098 |
| ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only | -6.3391 | 16.5382 | 0.2367 | 1.1645 | -0.5228 | 106.5098 |
| ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only | 5.4335 | -3.8526 | -0.0839 | -0.3973 | 0.3970 | -84.0487 |
| ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only | 4.5280 | -2.2841 | -0.0597 | -0.2801 | 0.3276 | -92.7946 |
| ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only | -6.3391 | 14.7132 | 0.2104 | 1.0316 | -0.5120 | 105.6552 |
| ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only | -6.3391 | 14.7132 | 0.2104 | 1.0316 | -0.5120 | 105.6552 |
| ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only | 5.4335 | -5.6776 | -0.1104 | -0.5295 | 0.4091 | -83.4652 |
| ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only | 4.5280 | -4.1091 | -0.0865 | -0.4138 | 0.3404 | -92.0712 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only | -3.1695 | 15.0633 | 0.2083 | 1.0345 | -0.2994 | 53.0329 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only | -3.1695 | 15.0633 | 0.2083 | 1.0345 | -0.2994 | 53.0329 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only | 2.7168 | 4.8679 | 0.0483 | 0.2533 | 0.1590 | -43.4159 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only | 2.2640 | 5.6521 | 0.0607 | 0.3141 | 0.1233 | -47.9770 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only | -3.1696 | 9.2234 | 0.1237 | 0.6077 | -0.2639 | 51.6658 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only | -3.1696 | 9.2234 | 0.1237 | 0.6077 | -0.2639 | 51.6658 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only | 2.7168 | -0.9720 | -0.0367 | -0.1725 | 0.1967 | -42.4637 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only | 2.2640 | -0.1878 | -0.0246 | -0.1142 | 0.1622 | -46.7944 |
| ULS: 6. 0.9D + 1.0W_Wind downforce Case A only | -6.3391 | 13.7798 | 0.2011 | 0.9848 | -0.5083 | 105.2222 |
| ULS: 6. 0.9D + 1.0W_Wind downforce Case B only | -6.3391 | 13.7798 | 0.2011 | 0.9848 | -0.5083 | 105.2222 |
| ULS: 6. 0.9D + 1.0W_Wind uplift Case A only | 5.4335 | -6.6110 | -0.1197 | -0.5761 | 0.4133 | -83.1782 |
| ULS: 6. 0.9D + 1.0W_Wind uplift Case B only | 4.5280 | -5.0425 | -0.0960 | -0.4609 | 0.3448 | -91.7134 |

### ASD Load Combination Results

| Name | Fx | Fy | Fz | Mx | My | Mz |
|---|---|---|---|---|---|---|
| ULS: 1. D | 0.0000 | 3.1113 | 0.0310 | 0.1553 | -0.0132 | 0.0329 |
| ULS: 2. D + L | 0.0000 | 3.1113 | 0.0310 | 0.1553 | -0.0132 | 0.0329 |
| ULS: 3. D + (S or Lr or R) | 0.0000 | 6.7612 | 0.0839 | 0.4208 | -0.0362 | 0.0610 |
| ULS: 3. D + (S or Lr or R) | 0.0000 | 3.1113 | 0.0310 | 0.1553 | -0.0132 | 0.0329 |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R) | 0.0000 | 5.8487 | 0.0707 | 0.3542 | -0.0305 | 0.0516 |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R) | 0.0000 | 3.1113 | 0.0310 | 0.1553 | -0.0132 | 0.0329 |
| ULS: 5b. D + 0.7E | 0.0000 | 3.1113 | 0.0310 | 0.1553 | -0.0132 | 0.0329 |
| ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S | 0.0000 | 5.8487 | 0.0707 | 0.3542 | -0.0305 | 0.0516 |
| ULS: 8. 0.6D + 0.7E | 0.0000 | 1.8668 | 0.0186 | 0.0930 | -0.0080 | 0.0185 |
| ULS: 5a. D + 0.6W_Wind downforce Case A only | -3.8035 | 9.6991 | 0.1348 | 0.6610 | -0.3110 | 62.0989 |
| ULS: 5a. D + 0.6W_Wind downforce Case B only | -3.8035 | 9.6991 | 0.1348 | 0.6610 | -0.3110 | 62.0989 |
| ULS: 5a. D + 0.6W_Wind uplift Case A only | 3.2601 | -2.5354 | -0.0576 | -0.2752 | 0.2419 | -50.6653 |
| ULS: 5a. D + 0.6W_Wind uplift Case B only | 2.7168 | -1.5943 | -0.0433 | -0.2055 | 0.2006 | -55.8272 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -2.8526 | 10.7896 | 0.1484 | 0.7334 | -0.2533 | 46.8266 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | -2.8526 | 10.7896 | 0.1484 | 0.7334 | -0.2533 | 46.8266 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only | 2.4451 | 1.6137 | 0.0042 | 0.0309 | 0.1604 | -38.5987 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only | 2.0376 | 2.3196 | 0.0152 | 0.0843 | 0.1290 | -42.5723 |

| 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 | -2.8526 | 8.0521 | 0.1088 | 0.5342 | -0.2366 | 46.2728 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | -2.8526 | 8.0521 | 0.1088 | 0.5342 | -0.2366 | 46.2728 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only | 2.4451 | -1.1237 | -0.0355 | -0.1679 | 0.1781 | -38.1964 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only | 2.0376 | -0.4179 | -0.0247 | -0.1154 | 0.1471 | -42.0748 |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case A only | -3.8035 | 8.4546 | 0.1224 | 0.5987 | -0.3059 | 61.7639 |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case B only | -3.8035 | 8.4546 | 0.1224 | 0.5987 | -0.3059 | 61.7639 |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case A only | 3.2601 | -3.7799 | -0.0701 | -0.3373 | 0.2473 | -50.4344 |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case B only | 2.7168 | -2.8388 | -0.0558 | -0.2680 | 0.2062 | -55.5396 |

### Worst Case Reactions (LRFD)

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

| Result | Value (kip, kip-ft) |
|---|---|
| Axial | 16.5382 |
| Shear X | -6.3391 |
| Shear Z | 0.2367 |
| Moment X | 1.1645 |
| Moment Y (Twist) | 0.5228 |
| Moment Z | 106.5098 |

### Worst Case Reactions (ASD)

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

| Result | Value (kip, kip-ft) |
|---|---|
| Axial | 10.7896 |
| Shear X | -3.8035 |
| Shear Z | 0.1484 |
| Moment X | 0.7334 |
| Moment Y (Twist) | 0.3110 |
| Moment Z | 62.0989 |

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

### LRFD Load Combination Results

| Name | Fx | Fy | Fz | Mx | My | Mz |
|---|---|---|---|---|---|---|
| ULS: 1. 1.4D | -0.0000 | 4.3558 | -0.0435 | -0.2176 | 0.0186 | 0.0490 |
| ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R) | -0.0000 | 5.5585 | -0.0637 | -0.3190 | 0.0275 | 0.0533 |
| ULS: 2. 1.2D + 1.6L + 0.5(S or Lr or R) | -0.0000 | 3.7335 | -0.0373 | -0.1864 | 0.0159 | 0.0408 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + L | -0.0000 | 9.5735 | -0.1220 | -0.6129 | 0.0530 | 0.1042 |
| ULS: 5. 1.2D + E + L + 0.2S | -0.0000 | 4.4635 | -0.0478 | -0.2394 | 0.0206 | 0.0450 |
| ULS: 7. 0.9D + 1.0E | -0.0000 | 2.8002 | -0.0279 | -0.1397 | 0.0120 | 0.0292 |
| ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only | -6.3391 | 16.5382 | -0.2367 | -1.1649 | 0.5228 | 106.5115 |
| ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only | -6.3391 | 16.5382 | -0.2367 | -1.1649 | 0.5228 | 106.5115 |
| ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only | 5.4335 | -3.8526 | 0.0839 | 0.3976 | -0.3969 | -84.0497 |
| ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only | 4.5279 | -2.2841 | 0.0597 | 0.2807 | -0.3271 | -92.7961 |
| ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case A only | -6.3391 | 14.7132 | -0.2104 | -1.0319 | 0.5119 | 105.6566 |
| ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind downforce Case B only | -6.3391 | 14.7132 | -0.2104 | -1.0319 | 0.5119 | 105.6566 |
| ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case A only | 5.4335 | -5.6776 | 0.1104 | 0.5297 | -0.4090 | -83.4661 |
| ULS: 4. 1.2D + W + L + 0.5(S or Lr or R)_Wind uplift Case B only | 4.5279 | -4.1090 | 0.0865 | 0.4144 | -0.3399 | -92.0727 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only | -3.1696 | 15.0633 | -0.2083 | -1.0349 | 0.2999 | 53.0343 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only | -3.1696 | 15.0633 | -0.2083 | -1.0349 | 0.2999 | 53.0343 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only | 2.7167 | 4.8679 | -0.0483 | -0.2532 | -0.1586 | -43.4161 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only | 2.2639 | 5.6522 | -0.0607 | -0.3138 | -0.1228 | -47.9774 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case A only | -3.1696 | 9.2234 | -0.1237 | -0.6078 | 0.2639 | 51.6665 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind downforce Case B only | -3.1696 | 9.2234 | -0.1237 | -0.6078 | 0.2639 | 51.6665 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case A only | 2.7168 | -0.9720 | 0.0367 | 0.1727 | -0.1966 | -42.4642 |
| ULS: 3. 1.2D + 1.6(S or Lr or R) + 0.5W_Wind uplift Case B only | 2.2640 | -0.1878 | 0.0246 | 0.1145 | -0.1619 | -46.7951 |
| ULS: 6. 0.9D + 1.0W_Wind downforce Case A only | -6.3391 | 13.7798 | -0.2011 | -0.9850 | 0.5082 | 105.2232 |
| ULS: 6. 0.9D + 1.0W_Wind downforce Case B only | -6.3391 | 13.7798 | -0.2011 | -0.9850 | 0.5082 | 105.2232 |
| ULS: 6. 0.9D + 1.0W_Wind uplift Case A only | 5.4335 | -6.6110 | 0.1197 | 0.5762 | -0.4132 | -83.1789 |
| ULS: 6. 0.9D + 1.0W_Wind uplift Case B only | 4.5279 | -5.0424 | 0.0960 | 0.4614 | -0.3444 | -91.7144 |

### ASD Load Combination Results

| Name | Fx | Fy | Fz | Mx | My | Mz |
|---|---|---|---|---|---|---|
| ULS: 1. D | -0.0000 | 3.1113 | -0.0310 | -0.1552 | 0.0133 | 0.0329 |
| ULS: 2. D + L | -0.0000 | 3.1113 | -0.0310 | -0.1552 | 0.0133 | 0.0329 |
| ULS: 3. D + (S or Lr or R) | -0.0000 | 6.7612 | -0.0839 | -0.4208 | 0.0364 | 0.0612 |
| ULS: 3. D + (S or Lr or R) | -0.0000 | 3.1113 | -0.0310 | -0.1552 | 0.0133 | 0.0329 |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R) | -0.0000 | 5.8487 | -0.0707 | -0.3542 | 0.0307 | 0.0517 |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R) | -0.0000 | 3.1113 | -0.0310 | -0.1552 | 0.0133 | 0.0329 |
| ULS: 5b. D + 0.7E | -0.0000 | 3.1113 | -0.0310 | -0.1552 | 0.0133 | 0.0329 |
| ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S | -0.0000 | 5.8487 | -0.0707 | -0.3542 | 0.0307 | 0.0517 |
| ULS: 8. 0.6D + 0.7E | -0.0000 | 1.8668 | -0.0186 | -0.0930 | 0.0080 | 0.0185 |
| ULS: 5a. D + 0.6W_Wind downforce Case A only | -3.8035 | 9.6991 | -0.1348 | -0.6612 | 0.3110 | 62.0996 |
| ULS: 5a. D + 0.6W_Wind downforce Case B only | -3.8035 | 9.6991 | -0.1348 | -0.6612 | 0.3110 | 62.0996 |
| ULS: 5a. D + 0.6W_Wind uplift Case A only | 3.2601 | -2.5354 | 0.0576 | 0.2753 | -0.2418 | -50.6657 |
| ULS: 5a. D + 0.6W_Wind uplift Case B only | 2.7168 | -1.5943 | 0.0433 | 0.2058 | -0.2004 | -55.8279 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -2.8526 | 10.7896 | -0.1484 | -0.7336 | 0.2535 | 46.8274 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | -2.8526 | 10.7896 | -0.1484 | -0.7336 | 0.2535 | 46.8274 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only | 2.4451 | 1.6137 | -0.0042 | -0.0307 | -0.1603 | -38.5990 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only | 2.0376 | 2.3196 | -0.0152 | -0.0840 | -0.1287 | -42.5727 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -2.8526 | 8.0521 | -0.1088 | -0.5343 | 0.2365 | 46.2733 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | -2.8526 | 8.0521 | -0.1088 | -0.5343 | 0.2365 | 46.2733 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only | 2.4451 | -1.1237 | 0.0355 | 0.1680 | -0.1780 | -38.1967 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only | 2.0376 | -0.4179 | 0.0247 | 0.1157 | -0.1469 | -42.0753 |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case A only | -3.8035 | 8.4546 | -0.1224 | -0.5988 | 0.3059 | 61.7643 |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case B only | -3.8035 | 8.4546 | -0.1224 | -0.5988 | 0.3059 | 61.7643 |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case A only | 3.2601 | -3.7799 | 0.0701 | 0.3373 | -0.2473 | -50.4347 |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case B only | 2.7168 | -2.8388 | 0.0558 | 0.2682 | -0.2061 | -55.5401 |

### Worst Case Reactions (LRFD)

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

| Result | Value (kip, kip-ft) |
|---|---|
| Axial | 16.5382 |
| Shear X | -6.3391 |
| Shear Z | -0.2367 |
| Moment X | -1.1649 |
| Moment Y (Twist) | 0.5228 |
| Moment Z | 106.5115 |

### Worst Case Reactions (ASD)

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

| Result | Value (kip, kip-ft) |
|---|---|
| Axial | 10.7896 |
| Shear X | -3.8035 |
| Shear Z | -0.1484 |
| Moment X | -0.7336 |
| Moment Y (Twist) | 0.3110 |
| Moment Z | 62.0996 |

## Project Details

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

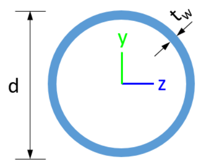
User Name: sales@mtsolar.us
Project Name: FILTER POND 5x5 36inRound - V1Jb
Unit System: imperial

## Design Input Information

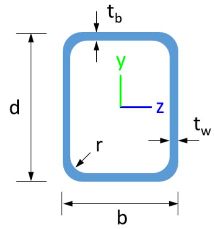
| Design Factors | | | |
|---|---|---|---|
| $\Phi_t$ | $\Phi_c$ | $\Phi_b$ | $\Phi_v$ |
| 0.9 | 0.9 | 0.9 | 0.9 |

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

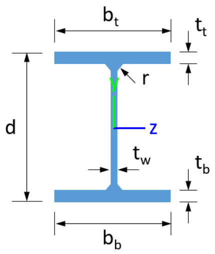
**Section Dimensions**




| ID | Name | d (in) | $t_w$ (in) | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3 | 2in Pipe Sch 120 | 2.38 | 0.25 | | | | | |
| 6 | 4in Pipe Sch 120 | 4.50 | 0.44 | | | | | |
| 10 | 8in Pipe Sch 80 | 8.63 | 0.50 | | | | | |




| ID | Name | d (in) | b (in) | $t_w$ (in) | $t_b$ (in) | r (in) | | |
|---|---|---|---|---|---|---|---|---|
| 17 | HSS5x3x1/4 | 5.00 | 3.00 | 0.23 | 0.23 | 0.23 | | |




| ID | Name | d (in) | $t_w$ (in) | $b_t$ (in) | $b_b$ (in) | $t_t$ (in) | $t_b$ (in) | r (in) |
|---|---|---|---|---|---|---|---|---|
| 20 | W10x12 | 9.87 | 0.19 | 3.96 | 3.96 | 0.21 | 0.21 | 0.30 |

| Section Properties | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ID | Name | A ($in^2$) | J ($in^4$) | $I_{yp}$ ($in^4$) | $I_{zp}$ ($in^4$) | $I_w$ ($in^6$) | $S_{yp}$ ($in^3$) | $S_{zp}$ ($in^3$) |
| 3 | 2in Pipe Sch 120 | 1.67 | 1.91 | 0.96 | 0.96 | 0.00 | 1.13 | 1.13 |
| 6 | 4in Pipe Sch 120 | 5.58 | 23.29 | 11.64 | 11.64 | 0.00 | 7.24 | 7.24 |
| 10 | 8in Pipe Sch 80 | 12.76 | 211.43 | 105.72 | 105.72 | 0.00 | 33.05 | 33.05 |
| 17 | HSS5x3x1/4 | 3.37 | 11.00 | 4.81 | 10.70 | 0.93 | 3.77 | 5.38 |
| 20 | W10x12 | 3.54 | 0.05 | 2.18 | 53.80 | 50.90 | 1.74 | 12.60 |

| Member Properties | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Member ID | Section ID | $K_z$ L (ft) | $K_y$ L (ft) | $L_b$ (ft) | $C_b$ | LST | LSC | LD |
| 1 | 10 | 10.20 | 10.20 | 15.70 | - | 300 | 200 | 250 |
| 2 | 6 | 1.30 | 1.30 | 2.00 | - | 300 | 200 | 250 |
| 3 | 17 | 0.92 | 0.92 | 1.42 | 1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.19,1.13,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.18,1.19,1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.19,1.18,1.18,1.17,1.17,1.18,1.18,1.15,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.18 | 300 | 200 | 250 |
| 4 | 17 | 2.44 | 2.44 | 3.75 | 1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.66,1.72,1.67,1.67,1.66,1.59,1.67,1.67,1.69,1.67,1.67,1.67,1.65,1.72,1.67,1.67,1.66,1.64,1.69,1.69,1.67,1.69,1.68,1.69,1.69,1.68,1.69,1.67,1.67,1.66,1.88,1.67,1.67,1.61,1.68,1.67,1.67,1.65,1.73,1.67,1.67,1.66,1.63 | 300 | 200 | 250 |
| 5 | 17 | 1.52 | 1.52 | 2.33 | 1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.68,1.60,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.68,1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.63,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66 | 300 | 200 | 250 |
| 6 | 17 | 0.92 | 0.92 | 1.42 | 1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.19,1.06,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18,1.19,1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.15,1.17,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18 | 300 | 200 | 250 |
| 7 | 17 | 1.52 | 1.52 | 2.33 | 1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.68,1.56,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.67,1.68,1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.63,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.67 | 300 | 200 | 250 |
| 8 | 20 | 1.33 | 1.33 | 2.05 | 2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.07,2.29,2.08,2.08,2.08,1.57,2.08,2.08,2.09,2.09,2.08,2.08,2.07,2.14,2.08,2.08,2.08,1.73,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,1.17,2.08,2.08,1.85,2.09,2.08,2.08,2.07,2.32,2.08,2.08,2.08,1.69 | 300 | 200 | 250 |
| 9 | 3 | 2.60 | 2.60 | 4.00 | - | 300 | 200 | 250 |
| 10 | 17 | 2.44 | 2.44 | 3.75 | 1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.74,1.67,1.67,1.66,1.62,1.67,1.67,1.69,1.67,1.67,1.67,1.65,1.73,1.67,1.67,1.66,1.65,1.68,1.68,1.67,1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.66,1.15,1.67,1.67,1.61,1.68,1.67,1.67,1.66,1.74,1.67,1.67,1.66,1.64 | 300 | 200 | 250 |
| 11 | 20 | 1.33 | 1.33 | 2.05 | 2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.10,1.86,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,1.85,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08,2.08 | 300 | 200 | 250 |
| 12 | 6 | 1.30 | 1.30 | 2.00 | - | 300 | 200 | 250 |
| 13 | 20 | 4.88 | 4.00 | 7.50 | 1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.10,1.11,1.09,1.09,1.09,1.11,1.09,1.09,1.08,1.50,1.09,1.09,1.10,1.11,1.09,1.09,1.09,1.11,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.10,1.11,1.09,1.09,1.12,1.14,1.09,1.09,1.10,1.11,1.09,1.09,1.09,1.11 | 300 | 200 | 250 |
| 14 | 20 | 4.88 | 4.00 | 7.50 | 1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,3.06,1.09,1.09,1.09,1.06,1.09,1.09,1.08,1.10,1.09,1.09,1.09,1.58,1.09,1.09,1.09,1.04,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.19,1.09,1.09,1.12,1.12,1.09,1.09,1.09,1.96,1.09,1.09,1.09,1.04 | 300 | 200 | 250 |
| 15 | 20 | 9.97 | 9.97 | 4.75 | 2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33 | 300 | 200 | 250 |
| 16 | 20 | 9.97 | 9.97 | 4.75 | 2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.32,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33 | 300 | 200 | 250 |
| 101 | 10 | 10.20 | 10.20 | 15.70 | - | 300 | 200 | 250 |
| 102 | 6 | 1.30 | 1.30 | 2.00 | - | 300 | 200 | 250 |
| 103 | 17 | 0.9 | 0.9 | 1.42 | 1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.18,1.19,1.06,1.18,1.18,1.17,1.18,1.18,1.18,1.18,1.18,1.19,1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.19,1.18,1.18,1.18,1.18,1.18,1.18,1.15,1.17,1.18,1.18,1.17,1.18,1.18,1.1 | 30 | 20 | 25 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 2 | 2 | 42 | 8,1.18,1.18 | 0 | 0 | 0 |
| 104 | 17 | 2.44 | 2.44 | 3.75 | 1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.74,1.67,1.67,1.66,1.62,1.67,1.67,1.69,1.67,1.67,1.67,1.65,1.73,1.67,1.67,1.66,1.65,1.68,1.68,1.67,1.68,1.68,1.68,1.68,1.68,1.68,1.67,1.67,1.66,1.15,1.67,1.67,1.61,1.68,1.67,1.67,1.66,1.74,1.67,1.67,1.66,1.64 | 300 | 200 | 250 |
| 105 | 17 | 1.52 | 1.52 | 2.33 | 1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.68,1.56,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.67,1.68,1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.63,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.67 | 300 | 200 | 250 |
| 106 | 17 | 0.92 | 0.92 | 1.42 | 1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.19,1.13,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.18,1.19,1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.19,1.18,1.18,1.17,1.17,1.18,1.18,1.15,1.17,1.18,1.18,1.17,1.17,1.18,1.18,1.17,1.18 | 300 | 200 | 250 |
| 107 | 17 | 1.52 | 1.52 | 2.33 | 1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.68,1.60,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66,1.68,1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.68,1.67,1.67,1.66,1.66,1.67,1.67,1.63,1.66,1.67,1.67,1.66,1.66,1.67,1.67,1.66,1.66 | 300 | 200 | 250 |
| 108 | 20 | 9.97 | 9.97 | 4.75 | 2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.32,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33 | 300 | 200 | 250 |
| 109 | 3 | 2.60 | 2.60 | 4.00 | - | 300 | 200 | 250 |
| 110 | 17 | 2.44 | 2.44 | 3.75 | 1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.67,1.66,1.72,1.67,1.67,1.66,1.59,1.67,1.67,1.69,1.67,1.67,1.67,1.65,1.72,1.67,1.67,1.66,1.64,1.69,1.69,1.67,1.69,1.68,1.69,1.69,1.68,1.69,1.67,1.67,1.66,1.87,1.67,1.67,1.61,1.68,1.67,1.67,1.65,1.73,1.67,1.67,1.66,1.63 | 300 | 200 | 250 |
| 111 | 20 | 9.97 | 9.97 | 4.75 | 2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33 | 300 | 200 | 250 |
| 112 | 6 | 1.30 | 1.30 | 2.00 | - | 300 | 200 | 250 |
| 113 | 20 | 4.88 | 4.00 | 7.50 | 1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.10,1.11,1.09,1.09,1.09,1.11,1.09,1.09,1.08,1.50,1.09,1.09,1.10,1.11,1.09,1.09,1.09,1.11,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.10,1.11,1.09,1.09,1.12,1.14,1.09,1.09,1.10,1.11,1.09,1.09,1.09,1.11 | 300 | 200 | 250 |
| 114 | 20 | 4.88 | 4.00 | 7.50 | 1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,3.08,1.09,1.09,1.09,1.06,1.09,1.09,1.08,1.10,1.09,1.09,1.09,1.58,1.09,1.09,1.09,1.04,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.19,1.09,1.09,1.12,1.12,1.09,1.09,1.09,1.95,1.09,1.09,1.09,1.04 | 300 | 200 | 250 |
| 115 | 20 | 8.42 | 8.42 | 12.95 | 1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.14,1.12,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.12,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13 | 300 | 200 | 250 |
| 116 | 20 | 8.42 | 8.42 | 12.95 | 1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.17,1.13,1.13,1.13,1.11,1.13,1.13,1.14,1.13,1.13,1.13,1.13,1.15,1.13,1.13,1.13,1.12,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,1.13,2.00,1.13,1.13,1.12,1.14,1.13,1.13,1.13,1.16,1.13,1.13,1.13,1.12 | 300 | 200 | 250 |

## Member Design Capacity

| Member ID | $\Phi_tP_n$ (kip) | $\Phi_cP_n$ (kip) | $\Phi_bM_{zn}$ (k-ft) | $\Phi_bM_{yn}$ (k-ft) | $\Phi_vV_{yn}$ (kip) | $\Phi_vV_{zn}$ (kip) |
|---|---|---|---|---|---|---|
| 1 | 528.38 | 467.81 | 114.02 | 114.02 | 158.51 | 158.51 |
| 2 | 230.93 | 229.13 | 24.98 | 24.98 | 69.28 | 69.28 |
| 3 | 151.65 | 150.70 | 20.17 | 14.14 | 54.12 | 28.95 |
| 4 | 151.65 | 145.15 | 20.17 | 14.14 | 54.12 | 28.95 |
| 5 | 151.65 | 149.10 | 20.17 | 14.14 | 54.12 | 28.95 |
| 6 | 151.65 | 150.70 | 20.17 | 14.14 | 54.12 | 28.95 |
| 7 | 151.65 | 149.10 | 20.17 | 14.14 | 54.12 | 28.95 |
| 8 | 159.30 | 140.46 | 46.90 | 6.46 | 56.26 | 44.91 |
| 9 | 69.10 | 61.62 | 3.91 | 3.91 | 20.73 | 20.73 |
| 10 | 151.65 | 145.15 | 20.17 | 14.14 | 54.12 | 28.95 |
| 11 | 159.30 | 140.46 | 46.90 | 6.46 | 56.26 | 44.91 |
| 12 | 230.93 | 229.13 | 24.98 | 24.98 | 69.28 | 69.28 |
| 13 | 159.30 | 97.43 | 32.96 | 6.46 | 56.26 | 44.91 |
| 14 | 159.30 | 97.43 | 31.72 | 6.46 | 56.26 | 44.91 |
| 15 | 159.30 | 34.37 | 46.90 | 6.46 | 56.26 | 44.91 |
| 16 | 159.30 | 34.37 | 46.90 | 6.46 | 56.26 | 44.91 |
| 101 | 528.38 | 467.81 | 114.02 | 114.02 | 158.51 | 158.51 |
| 102 | 230.93 | 229.13 | 24.98 | 24.98 | 69.28 | 69.28 |
| 103 | 151.65 | 150.70 | 20.17 | 14.14 | 54.12 | 28.95 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 104 | 151.65 | 145.15 | 20.17 | 14.14 | 54.12 | 28.95 |
| 105 | 151.65 | 149.10 | 20.17 | 14.14 | 54.12 | 28.95 |
| 106 | 151.65 | 150.70 | 20.17 | 14.14 | 54.12 | 28.95 |
| 107 | 151.65 | 149.10 | 20.17 | 14.14 | 54.12 | 28.95 |
| 108 | 159.30 | 34.37 | 46.90 | 6.46 | 56.26 | 44.91 |
| 109 | 69.10 | 61.62 | 3.91 | 3.91 | 20.73 | 20.73 |
| 110 | 151.65 | 145.15 | 20.17 | 14.14 | 54.12 | 28.95 |
| 111 | 159.30 | 34.37 | 46.90 | 6.46 | 56.26 | 44.91 |
| 112 | 230.93 | 229.13 | 24.98 | 24.98 | 69.28 | 69.28 |
| 113 | 159.30 | 97.43 | 32.97 | 6.46 | 56.26 | 44.91 |
| 114 | 159.30 | 97.43 | 31.69 | 6.46 | 56.26 | 44.91 |
| 115 | 159.30 | 48.27 | 14.92 | 6.46 | 56.26 | 44.91 |
| 116 | 159.30 | 48.27 | 14.73 | 6.46 | 56.26 | 44.91 |

## Design Ratio

| Member ID | P | $M_z$ | $M_y$ | $V_y$ | $V_z$ | $(P,M_z,M_y)$ | Worst LC | KL/r | δ | Status |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.035 | 0.934 | 0.022 | 0.040 | 0.001 | 0.962 | #13 | 0.213 | Not Required | Warn |
| 2 | 0.004 | 0.488 | 0.236 | 0.106 | 0.045 | 0.725 | #13 | 0.036 | Not Required | Pass |
| 3 | 0.006 | 0.734 | 0.036 | 0.072 | 0.005 | 0.744 | #13 | 0.046 | Not Required | Pass |
| 4 | 0.006 | 0.731 | 0.132 | 0.073 | 0.028 | 0.787 | #13 | 0.082 | Not Required | Pass |
| 5 | 0.006 | 0.456 | 0.129 | 0.073 | 0.034 | 0.473 | #13 | 0.076 | Not Required | Pass |
| 6 | 0.008 | 0.820 | 0.054 | 0.082 | 0.006 | 0.854 | #13 | 0.046 | Not Required | Pass |
| 7 | 0.008 | 0.509 | 0.173 | 0.081 | 0.045 | 0.534 | #13 | 0.076 | Not Required | Pass |
| 8 | 0.002 | 0.084 | 0.213 | 0.056 | 0.018 | 0.242 | #21 | 0.102 | Not Required | Pass |
| 9 | 0.018 | 0.088 | 0.066 | 0.002 | 0.002 | 0.157 | #13 | 0.206 | Not Required | Pass |
| 10 | 0.009 | 0.817 | 0.166 | 0.081 | 0.035 | 0.860 | #13 | 0.082 | Not Required | Pass |
| 11 | 0.002 | 0.083 | 0.218 | 0.056 | 0.018 | 0.249 | #21 | 0.102 | Not Required | Pass |
| 12 | 0.004 | 0.589 | 0.257 | 0.121 | 0.047 | 0.847 | #13 | 0.036 | Not Required | Pass |
| 13 | 0.006 | 0.292 | 0.461 | 0.069 | 0.022 | 0.656 | #21 | 0.306 | Not Required | Pass |
| 14 | 0.008 | 0.296 | 0.455 | 0.069 | 0.022 | 0.648 | #21 | 0.204 | Not Required | Pass |
| 15 | 0.000 | 0.100 | 0.186 | 0.035 | 0.011 | 0.269 | #21 | Not Required | Not Required | Pass |
| 16 | 0.000 | 0.100 | 0.186 | 0.035 | 0.011 | 0.269 | #21 | Not Required | Not Required | Pass |
| 101 | 0.035 | 0.934 | 0.022 | 0.040 | 0.001 | 0.962 | #13 | 0.213 | Not Required | Warn |
| 102 | 0.004 | 0.589 | 0.257 | 0.121 | 0.047 | 0.847 | #13 | 0.036 | Not Required | Pass |
| 103 | 0.008 | 0.820 | 0.054 | 0.082 | 0.006 | 0.854 | #13 | 0.046 | Not Required | Pass |
| 104 | 0.009 | 0.817 | 0.166 | 0.081 | 0.035 | 0.860 | #13 | 0.082 | Not Required | Pass |
| 105 | 0.008 | 0.509 | 0.173 | 0.081 | 0.045 | 0.534 | #13 | 0.076 | Not Required | Pass |
| 106 | 0.006 | 0.734 | 0.036 | 0.072 | 0.005 | 0.744 | #13 | 0.046 | Not Required | Pass |
| 107 | 0.006 | 0.456 | 0.129 | 0.073 | 0.034 | 0.473 | #13 | 0.076 | Not Required | Pass |
| 108 | 0.000 | 0.100 | 0.186 | 0.035 | 0.011 | 0.269 | #21 | Not Required | Not Required | Pass |
| 109 | 0.018 | 0.088 | 0.066 | 0.002 | 0.002 | 0.157 | #13 | 0.206 | Not Required | Pass |
| 110 | 0.006 | 0.731 | 0.132 | 0.073 | 0.028 | 0.787 | #13 | 0.082 | Not Required | Pass |
| 111 | 0.000 | 0.100 | 0.186 | 0.035 | 0.011 | 0.269 | #21 | Not Required | Not Required | Pass |
| 112 | 0.004 | 0.488 | 0.236 | 0.106 | 0.045 | 0.725 | #13 | 0.036 | Not Required | Pass |
| 113 | 0.006 | 0.292 | 0.461 | 0.069 | 0.022 | 0.656 | #21 | 0.204 | Not Required | Pass |
| 114 | 0.008 | 0.296 | 0.455 | 0.069 | 0.022 | 0.648 | #21 | 0.306 | Not Required | Pass |
| 115 | 0.007 | 0.667 | 0.248 | 0.056 | 0.018 | 0.800 | #21 | 0.644 | Not Required | Pass |
| 116 | 0.002 | 0.670 | 0.248 | 0.056 | 0.018 | 0.801 | #13 | 0.644 | 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/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 | Round |
| D | Section diameter | 36 in |

## Material Properties

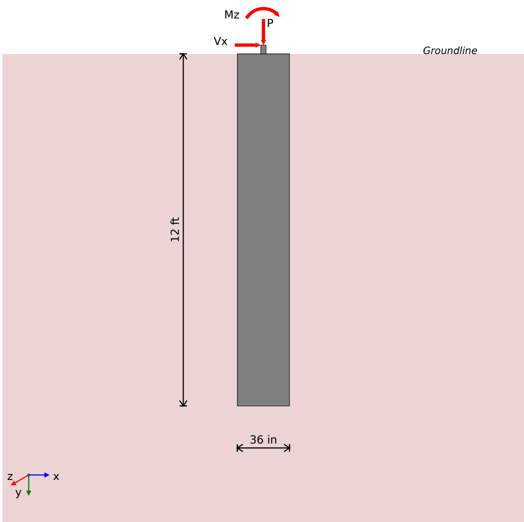
| Input | Description | Value |
|---|---|---|
| $f'_{ck}$ | Concrete compressive strength | 2.5 ksi |
| $f_{yk}$ | Yield strength of steel | 60 ksi |
| $d_b$ | Rebar diameter | #5 (0.625) in |
| cover | Concrete cover | 3 in |

## 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 | 10.79 kip | 16.54 kip |
| Vx | -3.803 kip | -6.339 kip |
| Vz | -0.148 kip | -0.237 kip |
| Mx | -0.734 kip-ft | -1.165 kip-ft |
| Mz | 62.1 kip-ft | 106.5 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

$$H_o = \frac{V_x}{D} = \frac{-3.803}{36} = -1.268\ \frac{kip}{ft}$$

Moment per section length

$$M_o = \frac{M_z + (V_x \times H)}{} = \frac{62.1 + (-3.803 \times 0)}{} = 20.7\ \frac{kip - ft}{}$$

$$M_o = \frac{\dots}{D} = \frac{\dots}{36} = \dots \frac{\dots}{ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$$L_{e,x} = 10.91\ ft$$

**Considering z-direction:**

Lateral force per section length

$$H_o = \frac{V_z}{D} = \frac{-0.148}{36} = -0.049\ \frac{kip}{ft}$$

Moment per section length

$$M_o = \frac{M_x + (V_z \times H)}{D} = \frac{-0.734 + (-0.148 \times 0)}{36} = -0.245\ \frac{kip - ft}{ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$$L_{e,z} = -2.641\ ft$$

**Minimum embedded depth**

Depth of pile required

$$L_{e,req} = MAX[L_{e,x}, L_{e,z}] = MAX[10.91, -2.641] = 10.91\ ft$$

Actual embedded length

$$L_e = L - h_2 - h_e = 12 - 0 - 0 = 12\ ft$$

Utilisation

$$Ratio = \frac{L_{e,req}}{L_e} = \frac{10.91}{12} = 0.909$$

**UTILITY: 0.91**

| REFERENCES | CALCULATIONS | RESULTS |
|---|---|---|

## End-bearing Capacity (ASD)

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

Cross-sectional area:

$$A = \frac{\pi \times D^2}{4} = \frac{\pi \times 36^2}{4} = 7.069\ ft^2$$

End-bearing pressure:

$$q = \frac{P}{A} = \frac{10.79}{7.069} = 1526\ psf$$

Utilisation

$$Ratio = \frac{q}{q_a} = \frac{1526}{2000} = 0.763$$

**UTILITY: 0.76**

## Lateral Soil Pressure (ASD)

| | | |
|---|---|---|
| Allowable lateral pressure | $R =$ | 150 psf/ft |

Length to least lateral dimension ratio:

$$\frac{L}{D} = \frac{12}{3} = 4$$

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

**Considering x-direction:**

Distance from resting surface to pivot point:

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

$$a = \frac{(4 \times 20.7 \times 12) + \left(3 \times 1.268 \times 12^2\right)}{(6 \times 20.7) + (4 \times 1.268 \times 12)} = 8.329\ ft$$

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

$$p = \frac{1.178 \times [(4 \times M_o) + (3 \times H_o \times L_e)]^2}{L_e^2 \times [(3 \times M_o) + (2 \times H_o \times L_e)]}$$

$$p = \frac{1.178 \times [(4 \times 20.7) + (3 \times -1.268 \times 12)]^2}{12^2 \times [(3 \times 20.7) + (2 \times -1.268 \times 12)]} = 0.357\ \frac{kip}{ft^2}$$

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

$$p_a = R \times \frac{a}{2} = 0.15 \times \frac{8.329}{2} = 0.625\ \frac{kip}{ft^2}$$

Utilisation - pressure at a depth of a/2

$$Ratio = \frac{p}{p_a} = \frac{0.357}{0.625} = 0.571$$

UTILITY: 0.57

Earth pressure against the pile at distance $L_e$:

$$s = \frac{9.425 \times [(2 \times M_o) + (H_o \times L_e)]}{L_e^2} = \frac{9.425 \times [(2 \times 20.7) + (-1.268 \times 12)]}{12^2} = 1.714\ \frac{kip}{ft^2}$$

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

$$p_s = R \times L_e = 0.15 \times 12 = 1.8\ \frac{kip}{ft^2}$$

Utilisation - pressure at a depth of $L_e$

$$Ratio = \frac{s}{p_s} = \frac{1.714}{1.8} = 0.952$$

UTILITY: 0.95

**Considering z-direction:**

Distance from resting surface to pivot point:

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

$$a = \frac{(4 \times 0.245 \times 12) + \left(3 \times 0.049 \times 12^2\right)}{(6 \times 0.245) + (4 \times 0.049 \times 12)} = 8.618\ ft$$

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

$$p = \frac{1.178 \times [(4 \times M_o) + (3 \times H_o \times L_e)]^2}{L_e^2 \times [(3 \times M_o) + (2 \times H_o \times L_e)]}$$

$$p = \frac{1.178 \times [(4 \times -0.245) + (3 \times -0.049 \times 12)]^2}{12^2 \times [(3 \times -0.245) + (2 \times -0.049 \times 12)]} = -0.032\ \frac{kip}{ft^2}$$

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

$$p_a = R \times \frac{a}{2} = 0.15 \times \frac{8.618}{2} = 0.646\ \frac{kip}{ft^2}$$

Utilisation - pressure at a depth of a/2

$$Ratio = \frac{p}{p_a} = \frac{-0.032}{0.646} = -0.05$$

UTILITY: 0.05

Earth pressure against the pile at distance $L_e$:

$$s = \frac{9.425 \times [(2 \times M_o) + (H_o \times L_e)]}{L_e^2} = \frac{9.425 \times [(2 \times -0.245) + (-0.049 \times 12)]}{12^2} = -0.071\ \frac{kip}{ft^2}$$

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

$$p_s = R \times L_e = 0.15 \times 12 = 1.8\ \frac{kip}{ft^2}$$

Utilisation - pressure at a depth of $L_e$

$$Ratio = \frac{s}{p_s} = \frac{-0.071}{1.8} = -0.039$$

UTILITY: 0.04

| REFERENCES | CALCULATIONS | RESULTS |
|---|---|---|

## Shear force and bending moment (LRFD)

**Considering x-direction:**

Lateral force per section length

$$H_o = \frac{V_x}{D} = \frac{-6.339}{36} = -2.113\ \frac{kip}{ft}$$

Moment per section length

$$M_o = \frac{M_z + (V_x \times H)}{D} = \frac{106.5 + (-6.339 \times 0)}{36} = 35.5\ \frac{kip - ft}{ft}$$

Distance from resting surface to pivot point:

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

$$a = \frac{(4 \times 35.5 \times 12) + \left(3 \times 2.113 \times 12^2\right)}{(6 \times 35.5) + (4 \times 2.113 \times 12)} = 8.323\ ft$$

Max shear force located at depth a:

$$E = \frac{M_o}{H_o} = \frac{35.5}{-2.113} = 16.8\ ft$$

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

$$V_{max,x} = (-2.113 \times 36) \times [1 - [3 \times \left(\frac{4 \times 16.8}{12} + 3\right) \times \left(\frac{8.323}{12}\right)^2] + [4 \times \left(\frac{3 \times 16.8}{12} + 2\right) \times \left(\frac{8.323}{12}\right)^3]]$$

$$V_{max,x} = 19.89\ kip$$

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

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

$$M_{max,x} = (-2.113 \times 36 \times 12) \times [\left(\frac{16.8}{12} + \frac{8.323}{2 \times 12}\right) - [\left(\frac{4 \times 16.8}{12} + 3\right) \times \left(\frac{8.323}{2 \times 12}\right)^3] + [\left(\frac{3 \times 16.8}{12} + 2\right) \times \left(\frac{8.323}{2 \times 12}\right)^4]]$$

$$M_{max,x} = 112.4\ kip - ft$$

**Considering z-direction:**

Lateral force per section length

$$H_o = \frac{V_z}{D} = \frac{-0.237}{36} = -0.079\ \frac{kip}{ft}$$

Moment per section length

$$M_o = \frac{M_x + (V_z \times H)}{D} = \frac{-1.165 + (-0.237 \times 0)}{36} = -0.388\ \frac{kip - ft}{ft}$$

Distance from resting surface to pivot point:

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

$$a = \frac{(4 \times 0.388 \times 12) + \left(3 \times 0.079 \times 12^2\right)}{(6 \times 0.388) + (4 \times 0.079 \times 12)} = 8.619\ ft$$

Max shear force located at depth a:

$$E = \frac{M_o}{H_o} = \frac{-0.388}{-0.079} = 4.922\ ft$$

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

$$V_{max,z} = (-0.079 \times 36) \times [1 - [3 \times \left(\frac{4 \times 4.922}{\ } + 3\right) \times \left(\frac{8.619}{\ }\right)^2] + [4 \times \left(\frac{3 \times 4.922}{\ } + 2\right) \times \left(\frac{8.619}{\ }\right)^3]]$$

$$V_{max,z} = (-0.079 \times 36) \times [1 - [3 \times \left(\frac{\quad}{12} + 3\right) \times \left(\frac{\quad}{12}\right)] + [4 \times \left(\frac{\quad}{12} + 2\right) \times \left(\frac{\quad}{12}\right)]]$$

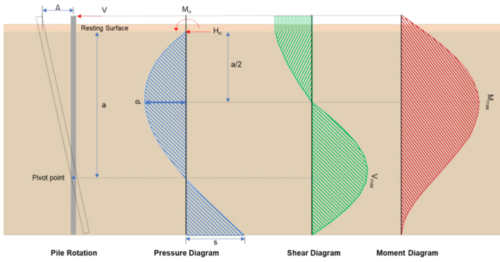
$$V_{max,z} = 0.33\ kip$$

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

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

$$M_{max,z} = (-0.079 \times 36 \times 12) \times [\left(\frac{4.922}{12} + \frac{8.619}{2 \times 12}\right) - [\left(\frac{4 \times 4.922}{12} + 3\right) \times \left(\frac{8.619}{2 \times 12}\right)^3] + [\left(\frac{3 \times 4.922}{12} + 2\right) \times \left(\frac{8.619}{2 \times 12}\right)^4]]$$

$$M_{max,z} = 1.727\ kip - ft$$




## Minimum Reinforcement Check (LRFD)

Gross area of concrete:

$$A_g = \frac{\pi \times D^2}{4} = \frac{\pi \times 36^2}{4} = 1018\ in^2$$

**Main Reinforcement**

22.4.2.2 Required reinforcement:

$$A_{st,req} = \frac{P - (0.85 \times f'_{ck} \times A_g)}{f_{yk} - (0.85 \times f'_{ck})} = \frac{16.54 - (0.85 \times 2.5 \times 1018)}{60 - (0.85 \times 2.5)} = -37.09\ in^2$$

10.6.1.1 Maximum reinforcement:

$$A_{st,max} = 0.08 \times A_g = 0.08 \times 1018 = 81.43 in^2$$

7.6.1.1 Minimum reinforcement:

$$A_{st,min} = 0.0018 \times A_g = 0.0018 \times 1018 = 1.832 in^2$$

Governing minimum reinforcement area:

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

$$A_{min} = 1.832\ in^2$$

Minimum number of reinforcements:

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

$$n_{min} = \frac{A_{min}}{A_{bar}} = \frac{1.832}{0.307} = 6$$

25.2.3 Minimum spacing:

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

$$\text{Use: } n = 6 \text{pcs at } 1.5 \text{ in minimum spacing}$$

Total reinforcement area:

$$A_{st} = 6 \times 0.307 = 1.841\ in^2$$

**Shear Reinforcement**

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

Maximum spacing of shear Reinforcements:

$$s = MIN[16 \times d_b, 48 \times d_{b,ties}, D] = MIN[(16 \times 0.625), (48 \times 0.375), 36] = 10\ in$$

| Detailing Summary | |
|---|---|
| Main reinforcement | #5 (0.625 in) - 6pcs at 1.5 in min. spacing |

| | |
|---|---|
| Main reinforcement | #5 (0.625 in) - 6pcs 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:

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

$$\phi P_N = 0.65 \times 0.85 \times [(0.85 \times 2.5 \times [1018 - 1.841]) + (60 \times 1.841)] = 1254\ kip$$

Utilisation

$$Ratio = \frac{P}{\phi P_N} = \frac{16.54}{1254} = 0.013$$

**UTILITY: 0.01**

## Shear Strength LRFD)

| | | |
|---|---|---|
| Effective shear width | $b_w =$ | 36 in |
| Effective shear depth | $d =$ | 28.8 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 | $V_{max,x} =$ | 19.89 kip |
| Maximum shear in the z-direction | $V_{max,z} =$ | 0.33 kip |

22.5.5.1.1 Max shear strength of concrete:

$$V_{c,max} = 5 \times \lambda \times \sqrt{f'_{ck}} \times b_w \times d = 5 \times 1 \times \sqrt{2.5} \times 36 \times 28.8 = 259.2\ kip$$

*Table 22.5.5.1* Shear strength of concrete:

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

$$V_{c,a} = \left(2 \times 1 \times \sqrt{2.5} + MIN[\frac{16.54}{6 \times 1018}, (0.05 \times 2.5)]\right) \times (36 \times 28.8) = 106.5\ kip$$

Governing shear strength of concrete:

$$V_c = MIN[V_{c,max}, V_{c,a}] = MIN[259.2, 106.5] = 106.5\ kip$$

22.5.1.2 Shear strength of steel (a):

$$V_{s,a} = 8 \times \sqrt{f'_{ck}} \times b_w \times d = 8 \times \sqrt{2.5} \times 36 \times 28.8 = 414.7\ kip$$

22.5.8.5.3 Shear strength of steel (b):

$$V_{s,b} = \frac{A_v \times f_{yk} \times d}{s} = \frac{0.221 \times 60 \times 28.8}{10} = 38.17\ kip$$

Governing shear strength of steel:

$$V_s = MIN[V_{s,a}, V_{s,b}] = MIN[414.7, 38.17] = 38.17\ kip$$

22.5.1.1 Allowable shear strength:

$$\phi V_n = \phi \times (V_c + V_s) = 0.75 \times (106.5 + 38.17) = 108.5\ kip$$

$$V_{max} = MAX[19.89, 0.33] = 19.89\ kip$$

Utilisation

$$Ratio = \frac{V_{max}}{\phi V_n} = \frac{19.89}{108.5} = 0.183$$

**UTILITY: 0.18**

## 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 | $b =$ | 36 in |
| Distance to the compression rebar | $d_s =$ | 3.688 in |
| Distance to the tension rebar | $d =$ | 28.8 in |
| Total bar area | $A_s =$ | 1.841 $in^2$ |
| Maximum applied axial load | $P =$ | 16.54 kip |
| Maximum moment in the x-direction | $M_{max,x} =$ | 112.4 kip-ft |
| Maximum moment in the z-direction | $M_{max,z} =$ | 1.727 kip-ft |

Maximum moment in the z-direction $M_{max,z} =$ 1.727 kip-ft

Compressive force due to concrete:

$$\beta_1 = 0.85$$

$$C_{rc} = \beta_1 \times f_c' \times A_c$$

$$A_c = \frac{h^2}{8} \times (\theta - sin\theta)$$

$$\theta = \text{Central angle of the compressive area in radians}$$

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:

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

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

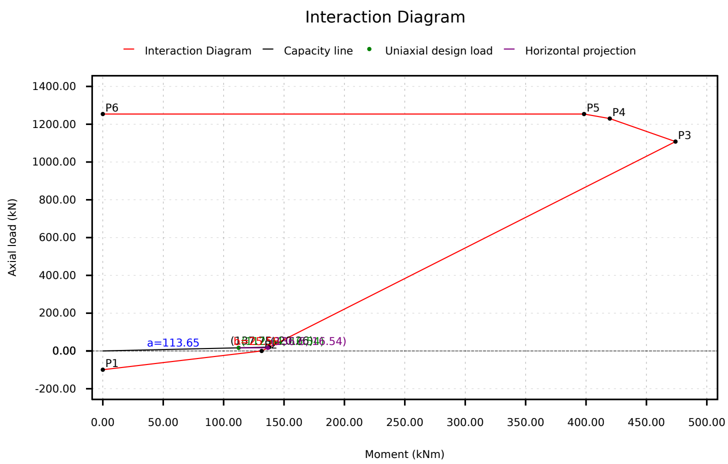
$$f_2 = E_s \times \varepsilon_2 \ (\varepsilon_2 < \varepsilon_{sy}),\ f_2 = \phi_s \times f_y \ (\varepsilon_2 \geq \varepsilon_{sy})$$

## Interaction Diagram Summary

| Point | Case | $M_r$ | $P_r$ |
|---|---|---|---|
| P1 | Pure Tension | 0 | -99.4 |
| P2 | Pure Bending | 131.5 | 0 |
| P3 | Balanced Failure | 474.1 | 1108 |
| P4 | Decompression | 419.7 | 1230 |
| P5 | Compression Limit | 398.3 | 1254 |
| P6 | Pure Compression | 0 | 1254 |

## Uniaxial Bending Check

$$M_f = \sqrt{M_{max,x}^2 + M_{max,z}^2} = \sqrt{112.4^2 + 1.727^2} = 112.4\ kip - ft$$




| Segment | Signed Distance |
|---|---|
| P1 - P2 | 24.68 |
| P2 - P3 | 23.08 |
| P3 - P4 | 775.3 |
| P4 - P5 | 1036 |
| P5 - P6 | 1237 |
| Status | PASS: Point lies inside the curve |

Utilisation

$$Ratio = \frac{a}{a+b} = \frac{113.7}{113.7 + 25.58} = 0.816$$

UTILITY: 0.82



SkyCiv

### Biaxial Bending Check

| | | |
|---|---|---|
| Maximum moment in the x-direction | $M_{max,x} =$ | 112.4 kip-ft |
| Maximum moment in the z-direction | $M_{max,z} =$ | 1.727 kip-ft |
| Nominal uniaxial moment strength about the x-axis | $M_{nox} =$ | 136.6 kip-ft |
| Nominal uniaxial moment strength about the z-axis | $M_{noz} =$ | 136.6 kip-ft |
| Interaction exponent | $\alpha =$ | 1 |

*Bresler (1960)*

According to Bresler (method B):

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

$$\left(\frac{112.4}{136.6}\right)^{1} + \left(\frac{1.727}{136.6}\right)^{1} = 0.836$$

**UTILITY: 0.84**

| REFERENCES | CALCULATIONS | RESULTS |
|---|---|---|

### Results Summary

| Result Name | Results |
|---|---|
| PILE DETAILS | |
| Length of the pile | 12.00 ft |
| Dimension | 36Ø in |
| Main bar reinforcement | #5-6pcs at 1.5 in min. |
| Shear reinforcement | #3 at 10 in max. |
| UTILISATIONS | |
| Required depth | 0.91 |
| End-bearing capacity | 0.76 |
| $p_a$ | 0.57 |
| $p_s$ | 0.95 |
| Axial compression strength | 0.01 |
| Shear strength | 0.18 |
| Uniaxial bending strength | 0.82 |
| Biaxial bending strength | 0.84 |