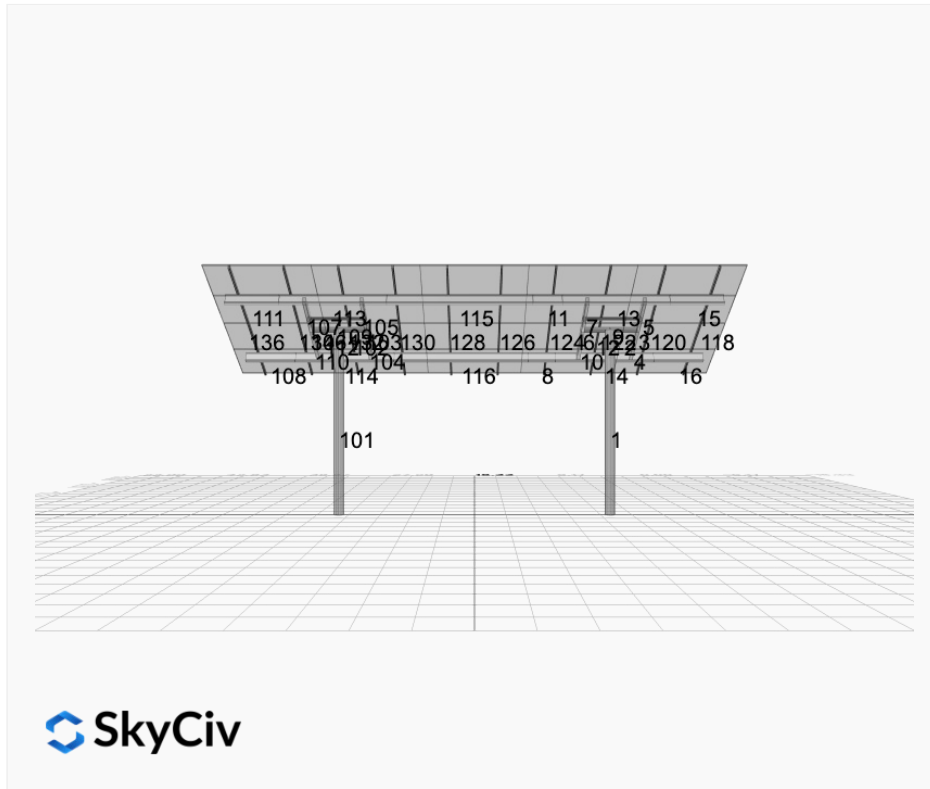


Project Name: W-12340 Pilot Peak - V1Jb **Date:** Thu Sep 04 2025
Location: 8XV4+QQ Mina, NV, USA **Number of Modules:** 20
Unique ID: 2P-19.75-8TOP-HD-45-L-4Hx5W-BKB7 **Number of Poles:** 2
Dealer: _____ **Date Sold:** _____



| | |
|-----------------------------|----------|
| Array Dimensions N/S | 13.83 ft |
| Array Dimensions E/W | 36.67 ft |
| Winter Tilt Angle | 30 |
| Front Edge Clearance | 10 ft |

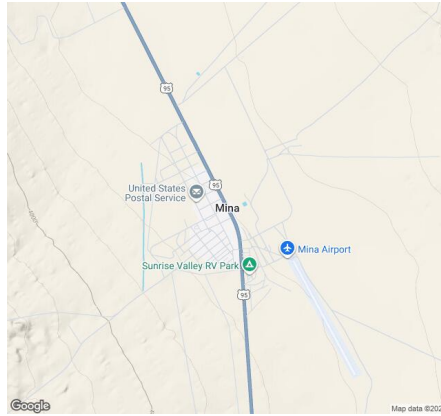
MT Solar Bill of Materials (2P-19.75-8TOP-HD-45-L-4Hx5W-BKB7)

| 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 | 2 |
| MTS-HD-Splice-57 | 57IN HD Splice | 2 |
| MTS-CLAMP-HOOK-4PK | Hook Clamp | 5 |

Rail Bill of Materials

| Part | Qty |
|------------------|-----|
| Rails (166in) | 10 |
| Rail Attachment | 20 |
| Module Mid Clamp | 30 |
| Module End Clamp | 20 |
| Ground Lug | 5 |

Site Details:



Site Address: 8XV4+QQ Mina, NV, USA

Array Specification

| | |
|------------------------------------|-----------|
| Duty Classification: | HD |
| Module Width: | 41.00 in |
| Module Length: | 87.00in |
| Number of Rows: | 4 |
| Number of Columns: | 5 |
| Total Number of Modules: | 20 |
| Winter Tilt Angle: | 30 |
| Front Edge Clearance: | 10 |
| Total Array Height at Tilt: | 16.92 ft |
| Total Frame Length: | 34.75 ft |
| Module Info/Notes: | |
| Array Dimensions N/S: | 13.83 ft |
| Array Dimensions E/W: | 36.67 ft |
| Rail Length: | 166.00 in |
| Rail Spacing: | 3.67 ft |

Support Specifications

| | |
|---------------------------------|-----------------|
| Pole Size: | 8in Pipe Sch 40 |
| Pole Length above Grade: | 13.46 ft |
| Number of Poles: | 2 |
| Pole Spacing: | 19.75 ft |

Foundation Specifications

| | |
|--|------------------------------------|
| Foundation Type: | Square |
| Foundation Dimensions: | 48 x 48 in |
| Foundation Depth (below grade): | Pile 1: 7.25 ft Pile 2: 7.25 ft |
| Foundation Volume: | 8.593 y ³ |

Site Info

| | |
|-----------------------------|-----------------------|
| Risk Category: | I |
| Exposure: | C |
| Soil Classification: | sand |
| Site Location: | 8XV4+QQ Mina, NV, USA |
| Wind Speed: | 115 mph |
| Snow Load: | 45 psf |

Design Disclaimer

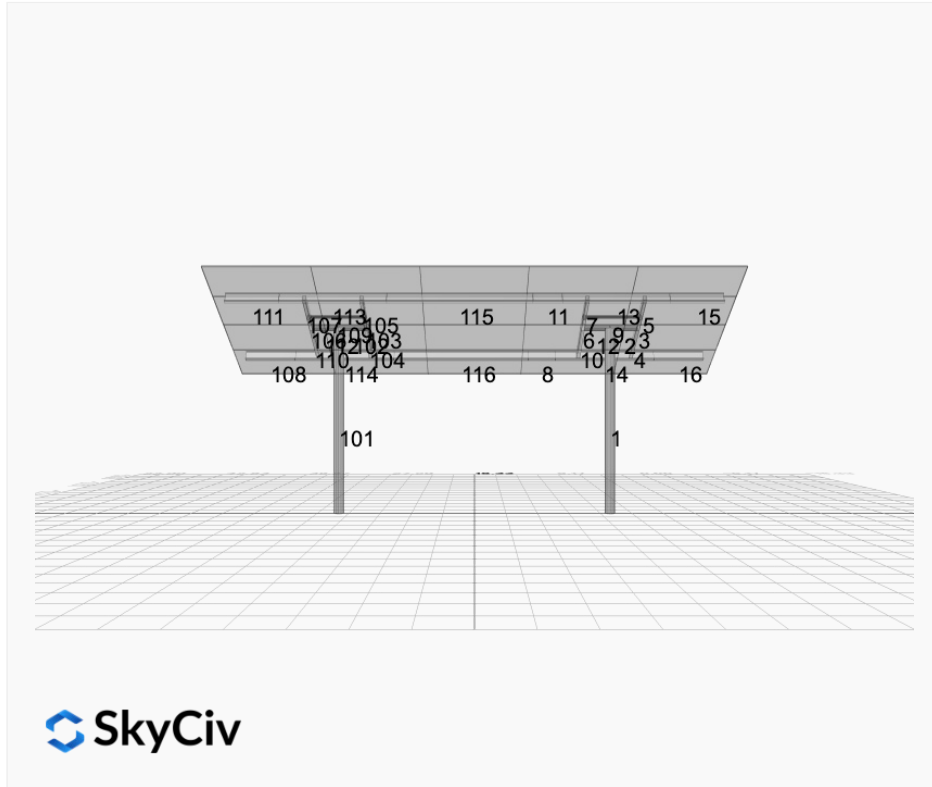
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

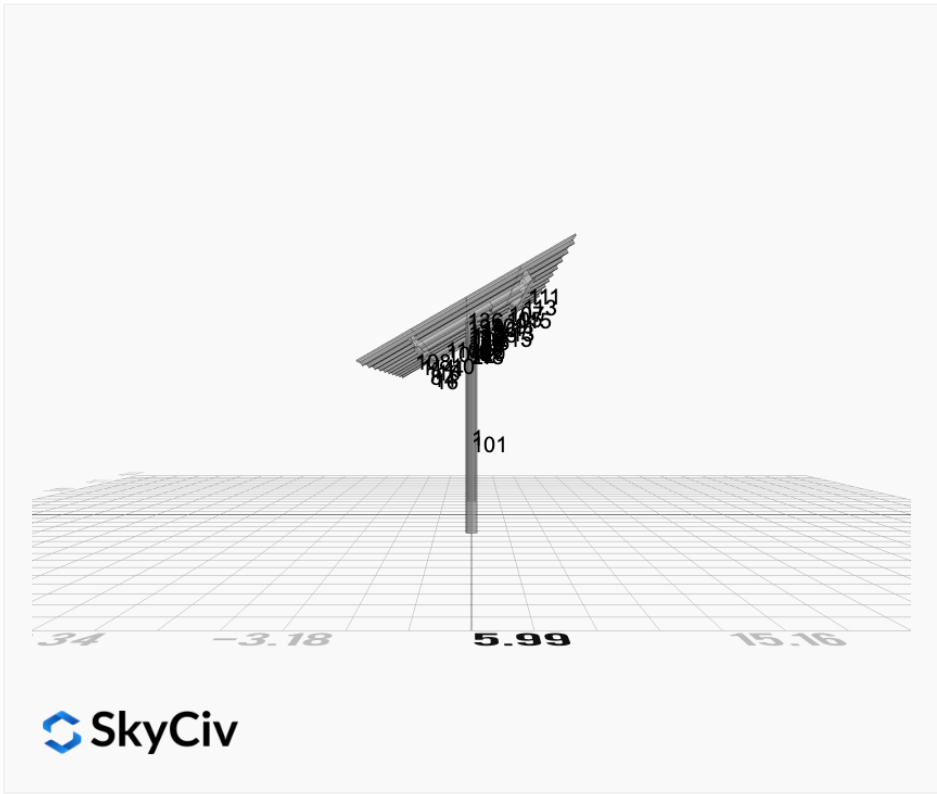
AutoDesigner Input

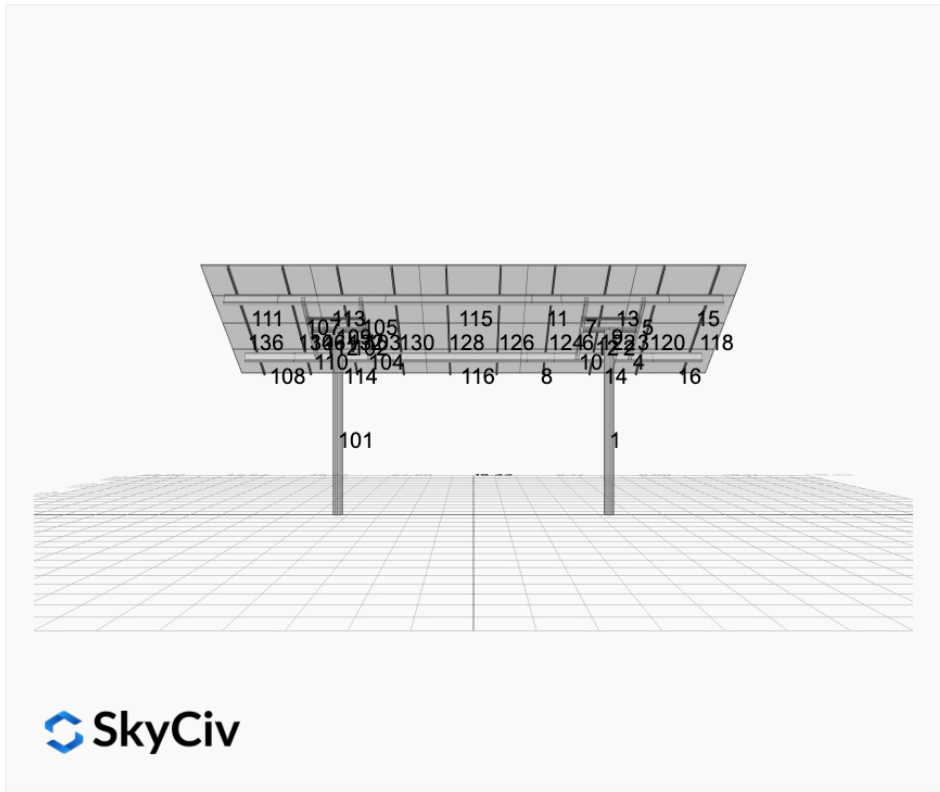
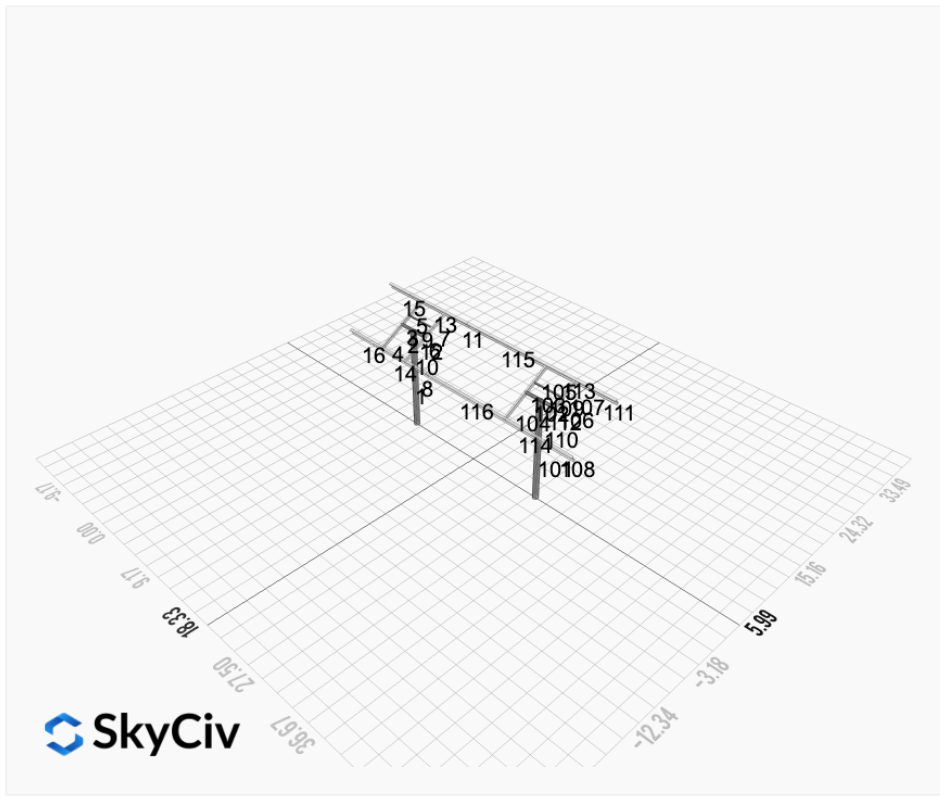
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Design Notes:

- AISC Deflection checks are set to L/1 due to structure 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 2016
- Steel frame design checks are based on AISC 360 2016 (LRFD)

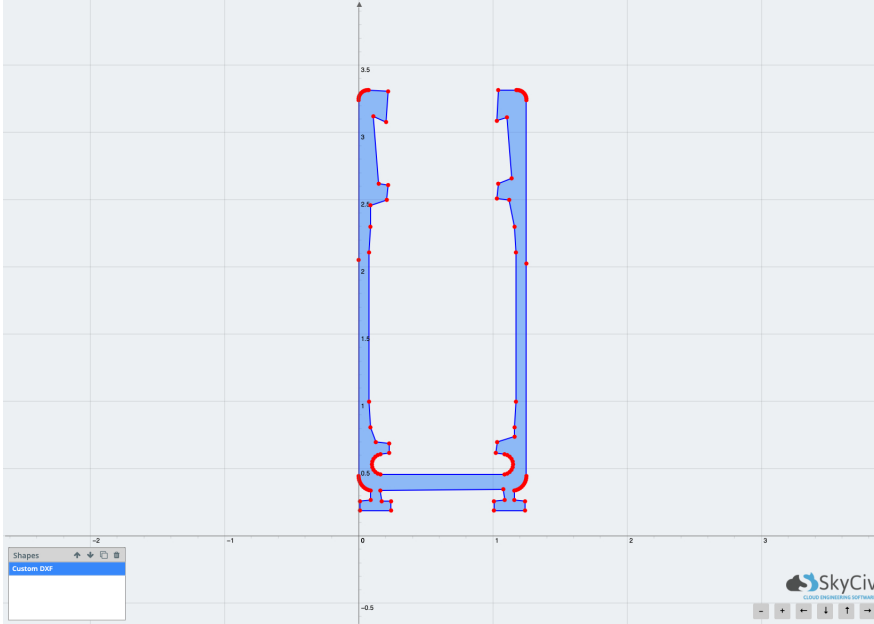






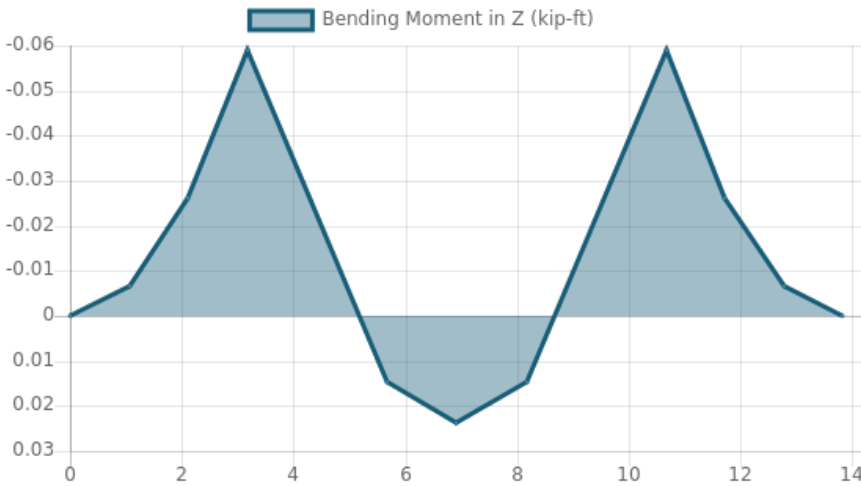
Rail Design Check

Rail Length: 13.833333333333334 ft
Additional Restraints Required: None
Tributary Width: 3.6666666666666665 ft
Material: Aluminium
Density: 169 lb/ft³
Elasticity Modulus: 10000 ksi
Fy: 34.5 ksi
Fu: 37 ksi
Snow (X): 0.0629 kip/ft
Snow (Y): -0.0363 kip/ft
Wind uplift Case A: 0.1110 kip/ft
Wind uplift Case A: 0.1110 kip/ft
Wind uplift Case B (X): 0.0000 kip/ft
Wind uplift Case B (Y): 0.1542 kip/ft

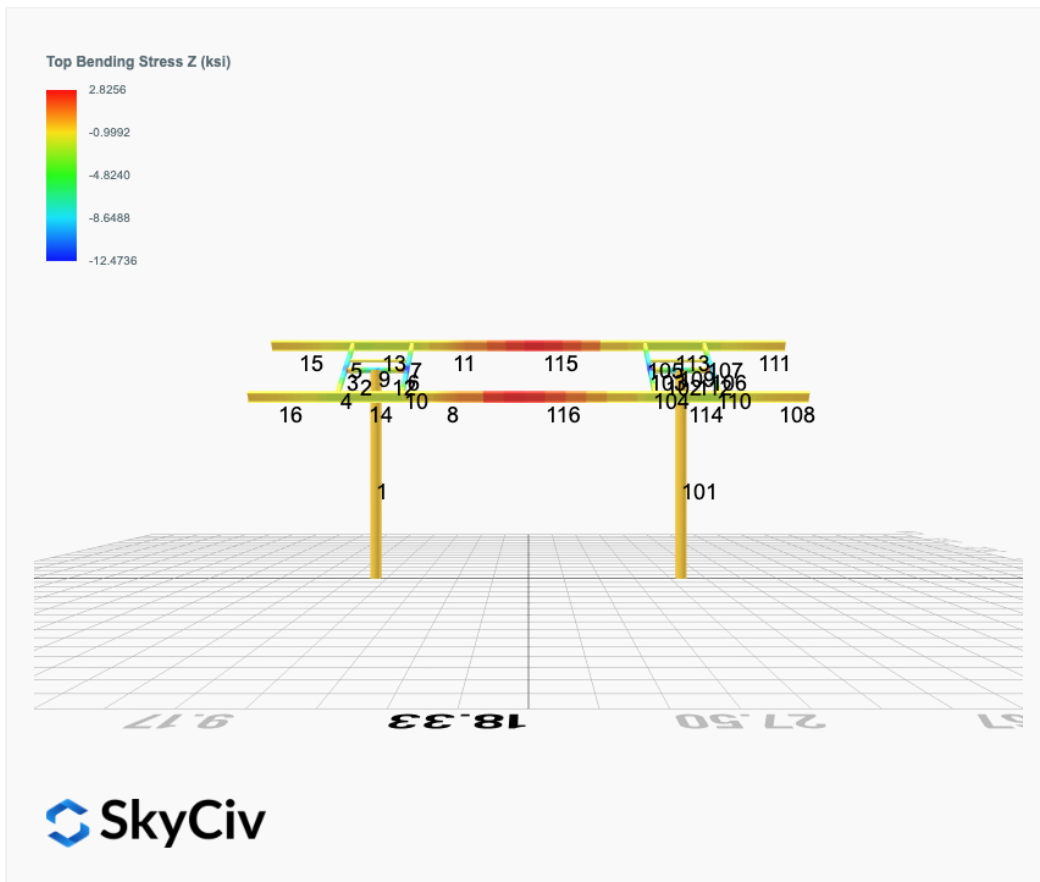
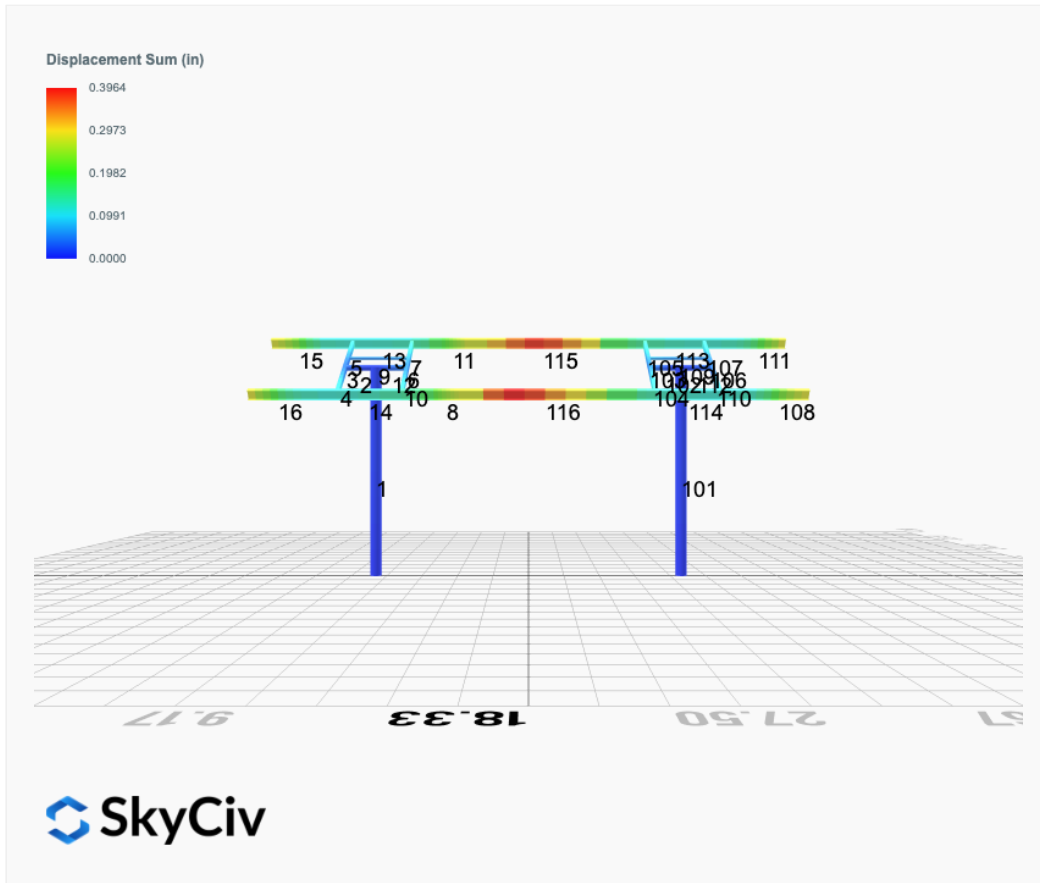


| Result Check | Max Limit | Max Value | Utility | Status |
|---------------------|-----------|-------------|---------|--------|
| Custom Stress Limit | 34.5 | 17.28107634 | 0.501 | PASS |
| Material Yield | 34.5 | 17.28107634 | 0.501 | PASS |
| Material Strength | 37 | 17.28107634 | 0.467 | PASS |

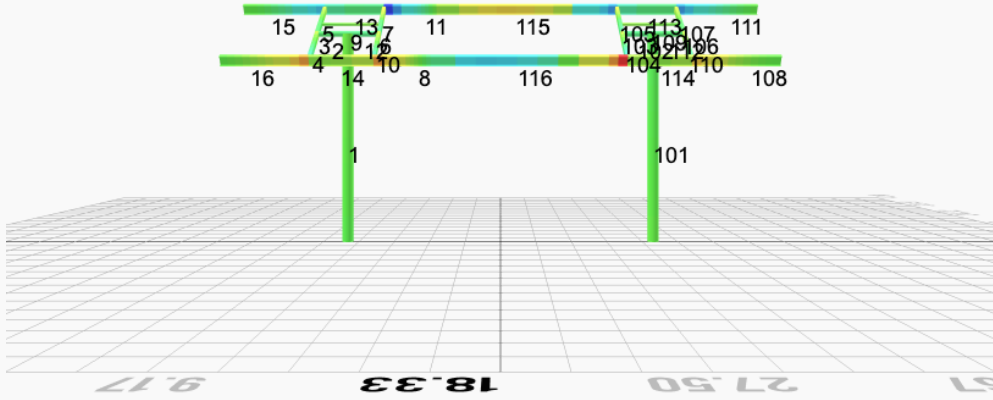
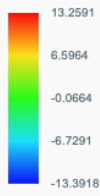
Member 1, ULS: 1. 1.4D



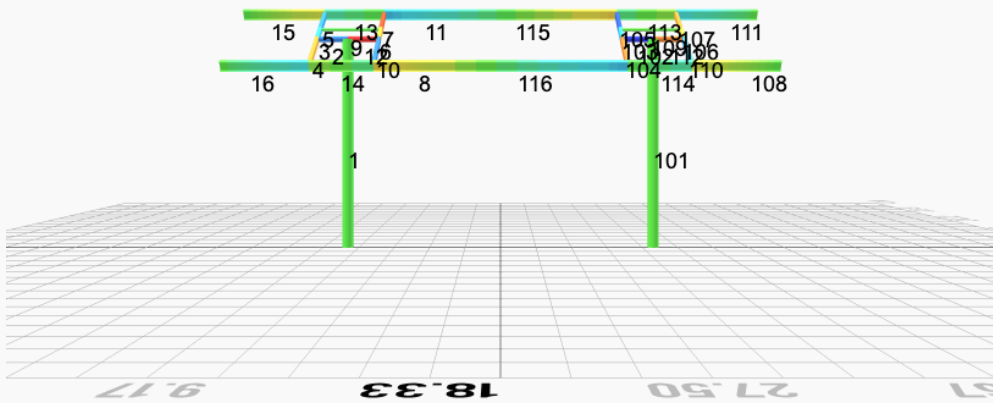
FEM Results (Envelope Worst Case for each member)



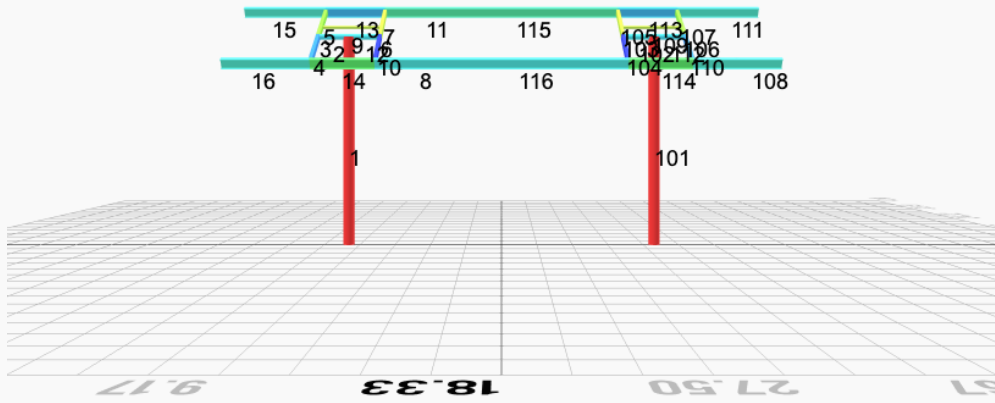
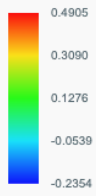
Top Bending Stress Y (ksi)



Shear Stress Y (ksi)



Axial Stress (ksi)



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

ASD Load Combination Results

| Name | Fx | Fy | Fz | Mx | My | Mz |
|---|---------|---------|---------|---------|---------|----------|
| ULS: 1. D | 0.0000 | 2.1109 | 0.0249 | 0.1049 | -0.0116 | 0.0265 |
| ULS: 2. D + L | 0.0000 | 2.1109 | 0.0249 | 0.1049 | -0.0116 | 0.0265 |
| ULS: 3. D + (S or Lr or R) | 0.0000 | 6.2310 | 0.0931 | 0.3930 | -0.0442 | 0.0460 |
| ULS: 3. D + (S or Lr or R) | 0.0000 | 2.1109 | 0.0249 | 0.1049 | -0.0116 | 0.0265 |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R) | 0.0000 | 5.2009 | 0.0761 | 0.3210 | -0.0361 | 0.0411 |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R) | 0.0000 | 2.1109 | 0.0249 | 0.1049 | -0.0116 | 0.0265 |
| ULS: 5b. D + 0.7E | 0.0000 | 2.1109 | 0.0249 | 0.1049 | -0.0116 | 0.0265 |
| ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S | 0.0000 | 5.2009 | 0.0761 | 0.3210 | -0.0361 | 0.0411 |
| ULS: 8. 0.6D + 0.7E | 0.0000 | 1.2665 | 0.0149 | 0.0629 | -0.0070 | 0.0159 |
| ULS: 5a. D + 0.6W_Wind downforce Case A only | -2.6883 | 6.7671 | 0.1103 | 0.4543 | -0.2217 | 37.4137 |
| ULS: 5a. D + 0.6W_Wind downforce Case B only | -2.6883 | 6.7671 | 0.1103 | 0.4543 | -0.2217 | 37.4137 |
| ULS: 5a. D + 0.6W_Wind uplift Case A only | 2.3042 | -1.8801 | -0.0480 | -0.1916 | 0.1682 | -30.1585 |
| ULS: 5a. D + 0.6W_Wind uplift Case B only | 1.9202 | -1.2150 | -0.0364 | -0.1446 | 0.1397 | -34.5193 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -2.0162 | 8.6931 | 0.1401 | 0.5830 | -0.1937 | 28.0815 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | -2.0162 | 8.6931 | 0.1401 | 0.5830 | -0.1937 | 28.0815 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only | 1.7282 | 2.2077 | 0.0214 | 0.0986 | 0.0988 | -22.5977 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only | 1.4401 | 2.7065 | 0.0301 | 0.1338 | 0.0774 | -25.8683 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -2.0162 | 5.6030 | 0.0890 | 0.3670 | -0.1692 | 28.0669 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | -2.0162 | 5.6030 | 0.0890 | 0.3670 | -0.1692 | 28.0669 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only | 1.7282 | -0.8824 | -0.0297 | -0.1175 | 0.1233 | -22.6122 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only | 1.4401 | -0.3835 | -0.0211 | -0.0823 | 0.1018 | -25.8829 |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case A only | -2.6883 | 5.9227 | 0.1004 | 0.4124 | -0.2171 | 37.4031 |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case B only | -2.6883 | 5.9227 | 0.1004 | 0.4124 | -0.2171 | 37.4031 |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case A only | 2.3042 | -2.7245 | -0.0579 | -0.2335 | 0.1729 | -30.1691 |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case B only | 1.9202 | -2.0593 | -0.0463 | -0.1866 | 0.1443 | -34.5299 |

Worst Case Reactions LRFD

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

| Result | Value (kip, kip-ft) |
|------------------|---------------------|
| Axial | 13.0053 |
| Shear X | -4.4804 |
| Shear Z | 0.2105 |
| Moment X | 0.8819 |
| Moment Y (Twist) | 0.3797 |
| Moment Z | 63.6819 |

Worst Case Reactions ASD

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

| Result | Value (kip, kip-ft) |
|------------------|---------------------|
| Axial | 8.6931 |
| Shear X | -2.6883 |
| Shear Z | 0.1401 |
| Moment X | 0.5830 |
| Moment Y (Twist) | 0.2217 |
| Moment Z | 37.4137 |

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

ASD Load Combination Results

| Name | Fx | Fy | Fz | Mx | My | Mz |
|--|---------|--------|---------|---------|--------|--------|
| ULS: 1. D | -0.0000 | 2.1109 | -0.0249 | -0.1049 | 0.0116 | 0.0265 |
| ULS: 2. D + L | -0.0000 | 2.1109 | -0.0249 | -0.1049 | 0.0116 | 0.0265 |
| ULS: 3. D + (S or Lr or R) | -0.0000 | 6.2310 | -0.0931 | -0.3930 | 0.0443 | 0.0460 |
| ULS: 3. D + (S or Lr or R) | -0.0000 | 2.1109 | -0.0249 | -0.1049 | 0.0116 | 0.0265 |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R) | -0.0000 | 5.2009 | -0.0761 | -0.3210 | 0.0361 | 0.0412 |

| Name | Fx | Fy | Fz | Mx | My | Mz |
|---|---------|---------|---------|---------|---------|----------|
| ULS: 4. D + 0.75L + 0.75(S or Lr or R) | -0.0000 | 2.1109 | -0.0249 | -0.1049 | 0.0116 | 0.0265 |
| ULS: 5b. D + 0.7E | -0.0000 | 2.1109 | -0.0249 | -0.1049 | 0.0116 | 0.0265 |
| ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S | -0.0000 | 5.2009 | -0.0761 | -0.3210 | 0.0361 | 0.0412 |
| ULS: 8. 0.6D + 0.7E | -0.0000 | 1.2665 | -0.0149 | -0.0629 | 0.0070 | 0.0159 |
| ULS: 5a. D + 0.6W_Wind downforce Case A only | -2.6883 | 6.7671 | -0.1103 | -0.4543 | 0.2218 | 37.4137 |
| ULS: 5a. D + 0.6W_Wind downforce Case B only | -2.6883 | 6.7671 | -0.1103 | -0.4543 | 0.2218 | 37.4137 |
| ULS: 5a. D + 0.6W_Wind uplift Case A only | 2.3042 | -1.8801 | 0.0480 | 0.1916 | -0.1682 | -30.1585 |
| ULS: 5a. D + 0.6W_Wind uplift Case B only | 1.9202 | -1.2150 | 0.0364 | 0.1446 | -0.1397 | -34.5193 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -2.0162 | 8.6931 | -0.1401 | -0.5831 | 0.1937 | 28.0815 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | -2.0162 | 8.6931 | -0.1401 | -0.5831 | 0.1937 | 28.0815 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only | 1.7282 | 2.2077 | -0.0214 | -0.0987 | -0.0988 | -22.5976 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only | 1.4401 | 2.7065 | -0.0301 | -0.1339 | -0.0773 | -25.8682 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -2.0162 | 5.6030 | -0.0890 | -0.3670 | 0.1692 | 28.0669 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | -2.0162 | 5.6030 | -0.0890 | -0.3670 | 0.1692 | 28.0669 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only | 1.7282 | -0.8824 | 0.0297 | 0.1175 | -0.1233 | -22.6122 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only | 1.4401 | -0.3835 | 0.0211 | 0.0823 | -0.1018 | -25.8828 |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case A only | -2.6883 | 5.9227 | -0.1004 | -0.4124 | 0.2171 | 37.4031 |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case B only | -2.6883 | 5.9227 | -0.1004 | -0.4124 | 0.2171 | 37.4031 |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case A only | 2.3042 | -2.7245 | 0.0579 | 0.2335 | -0.1729 | -30.1691 |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case B only | 1.9202 | -2.0593 | 0.0463 | 0.1866 | -0.1443 | -34.5299 |

Worst Case Reactions LRFD

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

| Result | Value (kip, kip-ft) |
|------------------|---------------------|
| Axial | 13.0053 |
| Shear X | -4.4804 |
| Shear Z | -0.2105 |
| Moment X | -0.8819 |
| Moment Y (Twist) | 0.3797 |
| Moment Z | 63.6828 |

Worst Case Reactions ASD

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

| Result | Value (kip, kip-ft) |
|------------------|---------------------|
| Axial | 8.6931 |
| Shear X | -2.6883 |
| Shear Z | -0.1401 |
| Moment X | -0.5831 |
| Moment Y (Twist) | 0.2218 |
| Moment Z | 37.4137 |

Project Details

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

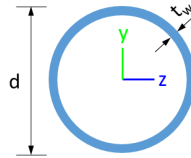


Design Input Information

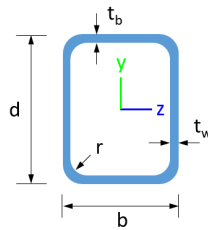
| Design Factors | | | |
|----------------|----------|----------|----------|
| Φ_t | Φ_c | Φ_b | Φ_v |
| 0.9 | 0.9 | 0.9 | 0.9 |

| Design Materials | | | |
|------------------|---------|-------------|-------------|
| ID | E (ksi) | F_y (ksi) | F_u (ksi) |
| 1 | 29000 | 50 | 65 |

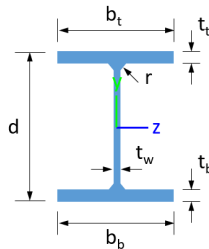
Section Dimensions



| 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) |
|----|------|----------------------|----------------------|-----------------------------|-----------------------------|--------------------------|-----------------------------|-----------------------------|
|----|------|----------------------|----------------------|-----------------------------|-----------------------------|--------------------------|-----------------------------|-----------------------------|

| | | | | | | | | |
|-----|----|------|------|-------|--|-----|-----|---|
| 113 | 19 | 4.88 | 4.00 | 7.50 | 1.11,1.11,1.11,1.12,1.11,1.11,1.12,1.12,1.12,1.14,1.12,1.12,1.12,1.14,1.12,1.12,1.11,1.07,1.12,1.12,1.12,1.14,1.12,1.12,1.12,1.14 | 300 | 200 | 1 |
| 114 | 19 | 4.88 | 4.00 | 7.50 | 1.11,1.11,1.11,1.11,1.11,1.11,1.12,1.12,1.12,1.63,1.12,1.12,1.12,1.07,1.11,1.11,1.11,1.12,1.11,1.11,1.12,1.81,1.12,1.12,1.12,1.05 | 300 | 200 | 1 |
| 115 | 19 | 6.63 | 6.63 | 10.20 | 1.12,1.12 | 300 | 200 | 1 |
| 116 | 19 | 6.63 | 6.63 | 10.20 | 1.12,1.12,1.12,1.12,1.12,1.12,1.12,1.12,1.12,1.12,1.14,1.12,1.12,1.12,1.10,1.12,1.12,1.12,1.12,1.12,1.12,1.12,1.12,1.12,1.12,1.12,1.14,1.12,1.12,1.12,1.11 | 300 | 200 | 1 |

Member Design Capacity

| Member ID | $\Phi_t P_n$ (kip) | $\Phi_c P_n$ (kip) | $\Phi_b M_{zn}$ (k-ft) | $\Phi_b M_{yn}$ (k-ft) | $\Phi_v V_{zn}$ (kip) | $\Phi_v V_{zn}$ (kip) |
|-----------|--------------------|--------------------|------------------------|------------------------|-----------------------|-----------------------|
| 1 | 377.97 | 142.37 | 83.29 | 83.29 | 113.39 | 113.39 |
| 2 | 198.33 | 182.14 | 21.95 | 21.95 | 59.50 | 59.50 |
| 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 | 66.48 | 58.89 | 3.82 | 3.82 | 19.94 | 19.94 |
| 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 | 198.33 | 196.72 | 21.95 | 21.95 | 59.50 | 59.50 |
| 13 | 133.20 | 85.85 | 24.51 | 6.12 | 40.24 | 43.62 |
| 14 | 133.20 | 85.85 | 23.99 | 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 | 377.97 | 142.37 | 83.29 | 83.29 | 113.39 | 113.39 |
| 102 | 198.33 | 196.72 | 21.95 | 21.95 | 59.50 | 59.50 |
| 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 | 66.48 | 58.89 | 3.82 | 3.82 | 19.94 | 19.94 |
| 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 | 198.33 | 182.14 | 21.95 | 21.95 | 59.50 | 59.50 |
| 113 | 133.20 | 85.85 | 24.52 | 6.12 | 40.24 | 43.62 |
| 114 | 133.20 | 85.85 | 23.97 | 6.12 | 40.24 | 43.62 |
| 115 | 133.20 | 69.16 | 17.35 | 6.12 | 40.24 | 43.62 |
| 116 | 133.20 | 69.16 | 17.00 | 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 | 0.091 | 0.765 | 0.023 | 0.040 | 0.002 | 0.818 | #13 | 0.577 | Not Required | Pass |
| 2 | 0.003 | 0.433 | 0.195 | 0.097 | 0.037 | 0.618 | #13 | 0.114 | Not Required | Pass |
| 3 | 0.008 | 0.700 | 0.039 | 0.070 | 0.002 | 0.716 | #13 | 0.045 | Not Required | Pass |
| 4 | 0.008 | 0.697 | 0.130 | 0.070 | 0.028 | 0.761 | #21 | 0.080 | Not Required | Pass |

| | | | | | | | | | | |
|-----|-------|-------|-------|-------|-------|-------|-----|--------------|--------------|------|
| 5 | 0.008 | 0.434 | 0.124 | 0.070 | 0.031 | 0.447 | #13 | 0.074 | Not Required | Pass |
| 6 | 0.010 | 0.783 | 0.078 | 0.079 | 0.015 | 0.833 | #21 | 0.045 | Not Required | Pass |
| 7 | 0.011 | 0.485 | 0.174 | 0.078 | 0.044 | 0.512 | #21 | 0.074 | Not Required | Pass |
| 8 | 0.002 | 0.105 | 0.149 | 0.054 | 0.017 | 0.158 | #21 | 0.095 | Not Required | Pass |
| 9 | 0.011 | 0.075 | 0.067 | 0.001 | 0.002 | 0.137 | #21 | 0.204 | Not Required | Pass |
| 10 | 0.011 | 0.779 | 0.164 | 0.078 | 0.035 | 0.851 | #21 | 0.080 | Not Required | Pass |
| 11 | 0.003 | 0.104 | 0.153 | 0.054 | 0.017 | 0.163 | #21 | 0.095 | Not Required | Pass |
| 12 | 0.002 | 0.522 | 0.212 | 0.113 | 0.039 | 0.722 | #13 | 0.053 | Not Required | Pass |
| 13 | 0.005 | 0.234 | 0.396 | 0.069 | 0.022 | 0.571 | #21 | 0.286 | Not Required | Pass |
| 14 | 0.008 | 0.238 | 0.391 | 0.069 | 0.022 | 0.563 | #21 | 0.190 | Not Required | Pass |
| 15 | 0.000 | 0.076 | 0.139 | 0.033 | 0.010 | 0.211 | #21 | Not Required | Not Required | Pass |
| 16 | 0.000 | 0.076 | 0.139 | 0.033 | 0.010 | 0.211 | #21 | Not Required | Not Required | Pass |
| 101 | 0.091 | 0.765 | 0.023 | 0.040 | 0.002 | 0.818 | #13 | 0.577 | Not Required | Pass |
| 102 | 0.002 | 0.522 | 0.212 | 0.113 | 0.039 | 0.722 | #13 | 0.053 | Not Required | Pass |
| 103 | 0.010 | 0.783 | 0.078 | 0.079 | 0.015 | 0.833 | #21 | 0.045 | Not Required | Pass |
| 104 | 0.011 | 0.779 | 0.164 | 0.078 | 0.035 | 0.851 | #21 | 0.080 | Not Required | Pass |
| 105 | 0.011 | 0.485 | 0.174 | 0.078 | 0.044 | 0.512 | #21 | 0.074 | Not Required | Pass |
| 106 | 0.008 | 0.700 | 0.039 | 0.070 | 0.002 | 0.717 | #13 | 0.045 | Not Required | Pass |
| 107 | 0.008 | 0.434 | 0.124 | 0.070 | 0.031 | 0.447 | #13 | 0.074 | Not Required | Pass |
| 108 | 0.000 | 0.076 | 0.139 | 0.033 | 0.010 | 0.211 | #21 | Not Required | Not Required | Pass |
| 109 | 0.011 | 0.075 | 0.067 | 0.001 | 0.002 | 0.137 | #21 | 0.204 | Not Required | Pass |
| 110 | 0.008 | 0.697 | 0.130 | 0.070 | 0.028 | 0.761 | #21 | 0.080 | Not Required | Pass |
| 111 | 0.000 | 0.076 | 0.139 | 0.033 | 0.010 | 0.211 | #21 | Not Required | Not Required | Pass |
| 112 | 0.003 | 0.433 | 0.195 | 0.097 | 0.037 | 0.618 | #13 | 0.114 | Not Required | Pass |
| 113 | 0.005 | 0.234 | 0.396 | 0.069 | 0.022 | 0.571 | #21 | 0.190 | Not Required | Pass |
| 114 | 0.008 | 0.238 | 0.391 | 0.069 | 0.022 | 0.563 | #21 | 0.286 | Not Required | Pass |
| 115 | 0.004 | 0.367 | 0.220 | 0.054 | 0.017 | 0.570 | #21 | 0.473 | Not Required | Pass |
| 116 | 0.002 | 0.369 | 0.221 | 0.054 | 0.017 | 0.572 | #21 | 0.473 | Not Required | Pass |

Definitions

| | |
|----------|---|
| Φ_t | Safety factor for tensile |
| Φ_c | Safety factor for compression |
| Φ_b | Safety factor for flexure |
| Φ_v | Safety factor for shear |
| E | Modulus of elasticity |
| F_y | Specified minimum yield stress |
| F_u | Specified minimum tensile strength |
| A | Cross-sectional area |
| J | Torsional constant |
| I_{yp} | Moment of inertia about the Y axes |
| I_{zp} | Moment of inertia about the Z axes |
| I_w | Warping constant |
| S_{yp} | Plastic section modulus about the Y axis |
| S_{zp} | Plastic section modulus about the Z axis |
| KL | Effective length |
| C_b | Buckling modification factor (from all load combinations) |
| L_b | Length between braced points |
| LST | Limited slenderness for tension |
| LSC | Limited slenderness for compression |
| LD | Limited deflection |
| P_n | Nominal axial strength (tension/compression) |
| M_n | Nominal flexural strength (about Z/Y axis) |
| V_n | Nominal shear strength (along Z/Y axis) |
| P | Design ratio in case of axial force |
| M_z | Design ratio in case of bending about Z axis |
| M_y | Design ratio in case of bending about Y axis |
| V_y | Design ratio in case of shear along Y axis |
| V_z | Design ratio in case of shear along Z axis |

| | |
|-------------------------------------|--|
| (P,M _z ,M _y) | Design ratio in case of axial force and bending action |
| KL/r | Design ratio in case of section slenderness |
| δ | Design ratio in case of member deflection |
| OK | Capacity is provided |
| NG | Capacity is not provided |

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

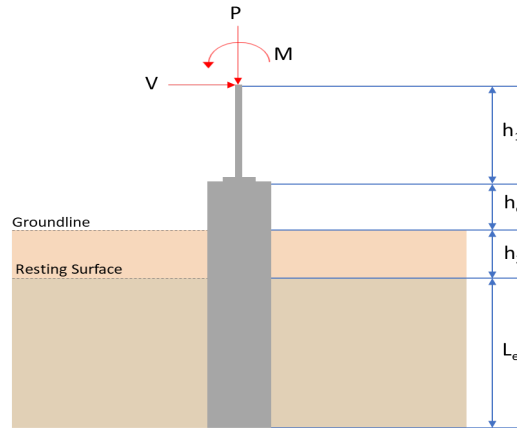
SkyCiv Foundation Design

Pile Foundation

Design Information :

Design code : IBC 2021 (International Building Code)
Unit System : Imperial

Pile Input



Geometry

Pile shape: rectangular

$b = 48$ in - Pile width

$D = 48$ in - Pile depth

$L = 7.25$ ft - Total pile length

$h_1 = 0$ ft - Lateral load height from the top of the pile,

$h_2 = 0$ ft - Depth to resisting surface

$h_e = 0$ ft - Length of pile above the ground

Tabulation of Soil Parameters

| Layer | Label | Allowable Bearing Pressure (q_a) (psf) | Allowable Lateral Pressure (R) (psf/ft) |
|-------|---|--|---|
| 1 | Sand, silty sand, clayey sand, silty gravel & clayey gravel | 2000.000 | 150.000 |

Tabulation of Loads

| Load Component | ASD | LRFD |
|----------------|--------|--------|
| P (kip) | 8.693 | 13.005 |
| V_x (kip) | -2.688 | -4.480 |
| V_z (kip) | 0.140 | 0.210 |
| M_x (kipft) | 0.583 | 0.882 |
| M_z (kipft) | 37.414 | 63.682 |

Material Properties

$f'_{ck} = 2.5$ ksi - Concrete strength.

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

$$H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})$$

$$H = 0 \text{ ft}$$

Considering x-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-2.688 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.42803 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(37.414 \text{ kipft}) + ((-2.688 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 5.9576 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$L_{e,x} = 6.7235 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.14 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.022293 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.583 \text{ kipft}) + ((0.14 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.092834 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$L_{e,z} = 2.1786 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = \text{MAX}[(6.7235 \text{ ft}), (2.1786 \text{ ft})]$$

$$L_{e,req} = 6.724 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (7.25 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$$

$$L_e = 7.25 \text{ ft}$$

Ratio - Embedded depth

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

$$\text{Ratio} = \frac{(6.724 \text{ ft})}{(7.25 \text{ ft})}$$

$$\text{Ratio} = 0.92745$$

Status: **PASS**
Ratio: **0.930**

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = b D$$

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

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

q - End-bearing pressure

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

$$q = \frac{(8.693 \text{ kip})}{(16 \text{ ft}^2)}$$

$$q = 0.54331 \text{ kip/ft}^2$$

Check bearing capacity ratio:

Ratio - Capacity

$$\text{Ratio} = \frac{q}{q_a}$$

$$\text{Ratio} = \frac{(0.54331 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$\text{Ratio} = 0.27166$$

Status: **PASS**
Ratio: **0.270**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

$$L/D = \frac{L}{D}$$

$$L/D = \frac{(7.25 \text{ ft})}{(48 \text{ in})}$$

$$L/D = 1.8125$$

Since $L/D \leq 10$,

Pile is short.

Considering x-direction:

$H_o = -0.42803 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 5.9576 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.9576 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.42803 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (5.9576 \text{ kipft/ft})) + (4 \times (-0.42803 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 4.9891 \text{ ft}$$

p - Earth pressure against the pile at distance $a/2$ from resting surface,

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

$$p = \frac{0.75 \times [(4 \times (5.9576 \text{ kipft/ft})) + (3 \times (-0.42803 \text{ kip/ft}) \times (7.25 \text{ ft}))]^2}{(7.25 \text{ ft})^2 \times [(3 \times (5.9576 \text{ kipft/ft})) + (2 \times (-0.42803 \text{ kip/ft}) \times (7.25 \text{ ft}))]}$$

$$p = 0.25789 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

$$s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$$

$$s = \frac{6 \times [(2 \times (5.9576 \text{ kipft/ft})) + ((-0.42803 \text{ kip/ft}) \times (7.25 \text{ ft}))]}{(7.25 \text{ ft})^2}$$

$$s = 1.0059 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

p_a - Allowable lateral soil pressure at depth $a/2$,

$$p_a = R \frac{a}{2}$$

$$p_a = (150 \text{ psf/ft}) \times \frac{(4.9891 \text{ ft})}{2}$$

$$p_a = 0.37418 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

$$Ratio = \frac{p}{p_a}$$

$$Ratio = \frac{(0.25789 \text{ kip/ft}^2)}{(0.37418 \text{ kip/ft}^2)}$$

$$Ratio = 0.68922$$

p_s - Allowable lateral soil pressure at depth L_e ,

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (7.25 \text{ ft})$$

$$p_s = 1.0875 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

$$Ratio = \frac{s}{p_s}$$

$$Ratio = \frac{(1.0059 \text{ kip/ft}^2)}{(1.0875 \text{ kip/ft}^2)}$$

$$Ratio = 0.92497$$

Status: **PASS**
Ratio: **0.690**

Status: **PASS**
Ratio: **0.920**

Considering z-direction:

$H_o = 0.022293 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 0.092834 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.092834 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (0.022293 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (0.092834 \text{ kipft/ft})) + (4 \times (0.022293 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 5.1579 \text{ ft}$$

p - Earth pressure against the pile at distance $a/2$ from resting surface,

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

$$p = \frac{0.75 \times [(4 \times (0.092834 \text{ kipft/ft})) + (3 \times (0.022293 \text{ kip/ft}) \times (7.25 \text{ ft}))]^2}{(7.25 \text{ ft})^2 \times [(3 \times (0.092834 \text{ kipft/ft})) + (2 \times (0.022293 \text{ kip/ft}) \times (7.25 \text{ ft}))]}$$

$$p = 0.017383 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

$$s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$$

$$s = \frac{6 \times [(2 \times (0.092834 \text{ kipft/ft})) + ((0.022293 \text{ kip/ft}) \times (7.25 \text{ ft}))]}{(7.25 \text{ ft})^2}$$

$$s = 0.039643 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

p_a - Allowable lateral soil pressure at depth $a/2$,

$$p_a = R \frac{a}{2}$$

$$p_a = (150 \text{ psf/ft}) \times \frac{(5.1579 \text{ ft})}{2}$$

$$p_a = 0.38684 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

$$Ratio = \frac{p}{p_a}$$

$$Ratio = \frac{(0.017383 \text{ kip/ft}^2)}{(0.38684 \text{ kip/ft}^2)}$$

$$Ratio = 0.044936$$

p_s - Allowable lateral soil pressure at depth L_e ,

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (7.25 \text{ ft})$$

$$p_s = 1.0875 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

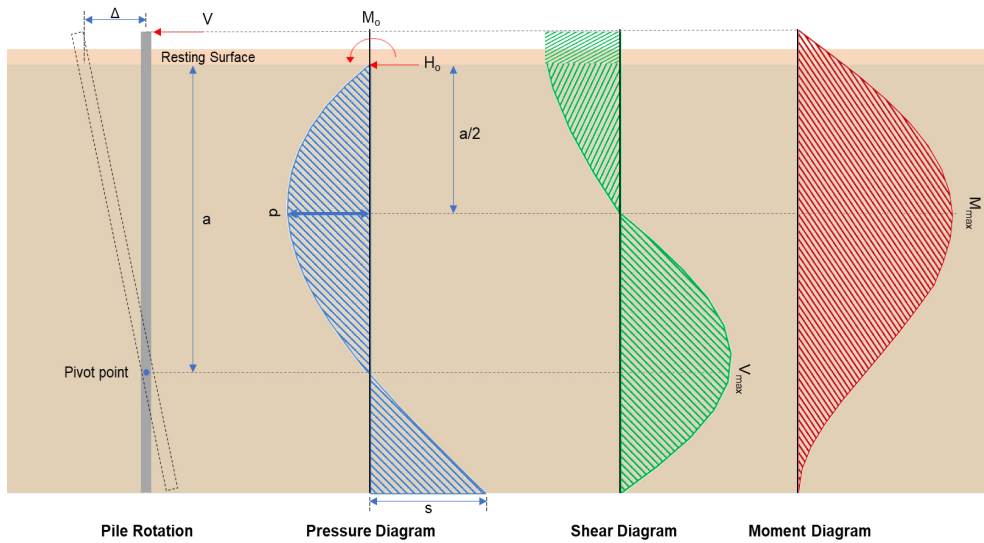
$$Ratio = \frac{s}{p_s}$$

$$Ratio = \frac{(0.039643 \text{ kip/ft}^2)}{(1.0875 \text{ kip/ft}^2)}$$

$$Ratio = 0.036454$$

Status: **PASS**
Ratio: **0.040**

Status: **PASS**
Ratio: **0.040**



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-4.48 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.71338 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(63.682 \text{ kipft}) + ((-4.48 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 10.14 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(10.14 \text{ kipft/ft})}{(-0.71338 \text{ kip/ft})}$$

$$E = 14.215 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (10.14 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.71338 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (10.14 \text{ kipft/ft})) + (4 \times (-0.71338 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = \frac{(-0.71338 \text{ kip/ft}) \times (48 \text{ in})}{(6 \times (10.14 \text{ kipft/ft})) + (4 \times (-0.71338 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 4.9866 \text{ ft}$$

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

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

$$V_{max} = ((-0.71338 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (14.215 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left(\frac{(4.9866 \text{ ft})}{(7.25 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (14.215 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left(\frac{(4.9866 \text{ ft})}{(7.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 11.783 \text{ kip}$$

M_{max} - Max bending moment located at depth $a/2$,

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

$$M_{max} = ((-0.71338 \text{ kip/ft}) \times (48 \text{ in}) \times (7.25 \text{ ft})) \times \left[\left(\frac{(14.215 \text{ ft})}{(7.25 \text{ ft})} + \frac{(4.9866 \text{ ft})}{2 \times (7.25 \text{ ft})} \right) - \left[\left(\frac{4 \times (14.215 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left(\frac{(4.9866 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (14.215 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left(\frac{(4.9866 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 40.834 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(0.21 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = 0.033439 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.882 \text{ kipft}) + ((0.21 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.14045 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.14045 \text{ kipft/ft})}{(0.033439 \text{ kip/ft})}$$

$$E = 4.2 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.14045 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (0.033439 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (0.14045 \text{ kipft/ft})) + (4 \times (0.033439 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 5.1566 \text{ ft}$$

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

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

$$V_{max} = ((0.033439 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (4.2 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left(\frac{(5.1566 \text{ ft})}{(7.25 \text{ ft})} \right)^2 \right] \right. \\ \left. + \left[4 \times \left(\frac{3 \times (4.2 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left(\frac{(5.1566 \text{ ft})}{(7.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.22604 \text{ kip}$$

M_{max} - Max bending moment located at depth $a/2$,

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

$$M_{max} = ((0.033439 \text{ kip/ft}) \times (48 \text{ in}) \times (7.25 \text{ ft})) \times \left[\left(\frac{(4.2 \text{ ft})}{(7.25 \text{ ft})} + \frac{(5.1566 \text{ ft})}{2 \times (7.25 \text{ ft})} \right) \right. \\ \left. - \left[\left(\frac{4 \times (4.2 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left(\frac{(5.1566 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (4.2 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left(\frac{(5.1566 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.73271 \text{ kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

$f'_{ck} = 2.5 \text{ ksi}$ - Concrete strength,

$f_{yk} = 60 \text{ ksi}$ - Longitudinal reinforcement strength,

$\phi = 0.65$ - Reduction factor for axial strength,

$\alpha = 0.8$ - Alpha factor for axial strength,

$A_g = 2304 \text{ in}^2$ - Gross area of concrete,

Longitudinal reinforcement:

Required reinforcement due to axial load, $A_{st,required}$

$A_{st,required}$

$$A_{st,required} = \text{Min} \left[\frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$$

$$A_{st,required} = \text{Min} \left[\frac{\frac{(13.005 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$$

$$A_{st,required} = -84.164 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

$$A_{min} = \text{Max} [A_{st,required}, (0.0018 A_g)]$$

$$A_{min} = \text{Max} [(-84.164 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$$

$$A_{min} = 4.1472 \text{ in}^2$$

n_{rebar} - Required number of reinforcement,

$$n_{rebar} = \frac{A_{min}}{A_{rebar}}$$

$$n_{rebar} = \frac{(4.1472 \text{ in}^2)}{(0.3068 \text{ in}^2)}$$

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

$$A_{st} = n_{rebar} \frac{\pi d_{bar}^2}{4}$$

$$A_{st} = (14) \times \frac{\pi \times (0.625 \text{ in})^2}{4}$$

$$A_{st} = 4.2951 \text{ in}^2$$

Ratio - Capacity

$$\text{Ratio} = \frac{A_{min}}{A_{st}}$$

$$\text{Ratio} = \frac{(4.1472 \text{ in}^2)}{(4.2951 \text{ in}^2)}$$

Table 22.4.2.1

22.4.2.2, 10.6.1.1

| | | |
|---|---|--|
| <p>25.2.3</p> <p>25.7.2.2</p> <p>25.7.2.1</p> | <p style="text-align: center;">$Ratio = 0.96556$</p> <p>$s_{rebar} = Max[1.5, (1.5 d_{bar})]$</p> <p>$s_{rebar} = Max[1.5, (1.5 \times (0.625 \text{ in}))]$</p> <p>$s_{rebar} = 1.5 \text{ in}$</p> <p>Ties:</p> <p>Since longitudinal reinforcement is \leq No. 10ø: Use #3(0.375 in)</p> <p>$s_{ties} = Min[(16 d_{bar}), (48 d_{ties}), Min(D, b)]$</p> <p>$s_{ties} = Min[(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), Min((48 \text{ in}), (48 \text{ in}))]$</p> <p>$s_{ties} = 10 \text{ in}$</p> <p>Summary:</p> <p style="text-align: center;">Main reinforcement: 14 - #5 (0.625 in) Ties: #3(0.375 in) - 10 in</p> | <p>Status: PASS Ratio: 0.970</p> |
| <p>22.4.2.2</p> | <p>Axial Compression Strength (ACI 318-19, LRFD)</p> <p>ϕP_N - Allowable axial compressive strength</p> <p style="text-align: center;">$\phi P_N = \phi 0.80 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_y A_{st})]$</p> <p style="text-align: center;">$\phi P_N = (0.65) \times 0.80 \times [(0.85 \times (2.5 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2))]$</p> <p style="text-align: center;">$\phi P_N = 2675.2 \text{ kip}$</p> <p>Ratio - Capacity</p> <p style="text-align: center;">$Ratio = \frac{P}{\phi P_N}$</p> <p style="text-align: center;">$Ratio = \frac{(13.005 \text{ kip})}{(2675.2 \text{ kip})}$</p> <p style="text-align: center;">$Ratio = 0.0048614$</p> | <p>Status: PASS Ratio: 0.000</p> |
| <p>22.5.2.2</p> <p>22.5.5.1.3</p> <p>22.5.5.1.1</p> | <p>Shear Strength (ACI 318-19, LRFD)</p> <p>Parameters:</p> <p>$b_w = 48 \text{ in}$ - Effective width, d - Effective depth</p> <p style="text-align: center;">$d = 0.80 D$</p> <p style="text-align: center;">$d = 0.80 \times (48 \text{ in})$</p> <p style="text-align: center;">$d = 38.4 \text{ in}$</p> <p>λ_s - size effect modification factor</p> <p style="text-align: center;">$\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$</p> <p style="text-align: center;">$\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]$</p> <p style="text-align: center;">$\lambda_s = 0.64282$</p> <p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$,</p> <p>$V_{c,max}$ - Max shear strength of concrete</p> <p style="text-align: center;">$V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$</p> <p style="text-align: center;">$V_{c,max} = 5 \times (0.64282) \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$</p> | |

$$V_{c,max} = 296.21 \text{ kip}$$

22.5.5.1.1(a) The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 13.005 \text{ kip} \rightarrow 13005 \text{ lbf}$,
 $V_{c,a}$ - Shear strength of concrete (a)

$$V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck} + \frac{P}{6 A_g}} \right] b_w d$$

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi}) + \frac{(13005 \text{ lbf})}{6 \times (2304 \text{ in}^2)}} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 120.22 \text{ kip}$$

22.5.5.1.2 The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$,
 $V_{c,b}$ - Shear strength of concrete (b)

$$V_{c,b} = \left[2 \lambda_s \sqrt{f'_{ck} + (0.05 f'_{ck})} \right] b_w d$$

$$V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi}) + (0.05 \times (2500 \text{ psi}))} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,b} = 348.89 \text{ kip}$$

V_c - Governing shear strength of concrete

$$V_c = \text{Min}[V_{c,max}, V_{c,a}, V_{c,b}]$$

$$V_c = \text{Min}[(296.21 \text{ kip}), (120.22 \text{ kip}), (348.89 \text{ kip})]$$

$$V_c = 120.22 \text{ kip}$$

22.5.5.1.2 The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$,
 $V_{s,a}$ - Shear strength of steel (a)

$$V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$$

$$V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{s,a} = 737.28 \text{ kip}$$

A_v - Ties rebar area,

$$A_v = \frac{\pi d_{ties}^2}{4}$$

$$A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$$

$$A_v = 0.11045 \text{ in}^2$$

22.5.8.5.3 $V_{s,b}$ - Shear strength of steel (b)

$$V_{s,b} = \frac{2 A_v f_{yw} d}{s_{ties}}$$

$$V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$$

$$V_{s,b} = 50.894 \text{ kip}$$

V_s - Governing shear strength of steel

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

$$V_s = \text{MIN}[(737.28 \text{ kip}), (50.894 \text{ kip})]$$

$$V_s = 50.894 \text{ kip}$$

22.5.1.1 ϕV_n - Allowable shear strength

$$\phi V_n = \phi (V_c + V_s)$$

$$\phi V_n = (0.65) \times ((120.22 \text{ kip}) + (50.894 \text{ kip}))$$

$$\phi V_n = 111.22 \text{ kip}$$

Considering x-direction:

$V_{max} = 11.783 \text{ kip}$ - Maximum shear force in the x-direction,

Ratio - Capacity

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

$$Ratio = \frac{(11.783 \text{ kip})}{(111.22 \text{ kip})}$$

$$Ratio = 0.10594$$

Considering z-direction:

$V_{max} = 0.22604 \text{ kip}$ - Maximum shear force in the z-direction,

$Ratio$ - Capacity

$$Ratio = \frac{V_{max}}{\phi V_n}$$

$$Ratio = \frac{(0.22604 \text{ kip})}{(111.22 \text{ kip})}$$

$$Ratio = 0.0020323$$

Status: **PASS**
Ratio: **0.110**

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

Flexural Strength (ACI 318-19, LRFD)

S_m - Section modulus

$$S_m = \frac{b D^2}{6}$$

$$S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$$

$$S_m = 18432 \text{ in}^3$$

$\lambda = 1$ - Concrete modification factor (Normal concrete),

Allowable flexural strength:

M_n shall be the lesser of:

$\phi M_{n,1}$

$$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$$

$$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 \text{ ksi})} \times 18432.001 \text{ in}^3$$

$$\phi M_{n,1} = 249.600 \text{ kipft}$$

14.5.2.1b

$\phi M_{n,2}$

$$\phi M_{n,2} = \phi \times 0.85 \times f'_{ck} \times S_m$$

$$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (18432 \text{ in}^3)$$

$$\phi M_{n,2} = 2121.6 \text{ kipft}$$

Therefore,

ϕM_n - Allowable flexural strength,

$$\phi M_n = \text{MIN}[\phi M_{n,1}, \phi M_{n,2}]$$

$$\phi M_n = \text{MIN}[(249.6 \text{ kipft}), (2121.6 \text{ kipft})]$$

$$\phi M_n = 249.6 \text{ kipft}$$

Considering x-direction:

$M_{max} = 40.834 \text{ kipft}$ - Maximum moment in the x-direction,

$Ratio$ - Capacity

$$Ratio = \frac{M_{max}}{\phi M_n}$$

$$Ratio = \frac{(40.834 \text{ kipft})}{(249.6 \text{ kipft})}$$

$$Ratio = 0.1636$$

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

Considering z-direction:

$M_{max} = 0.73271 \text{ kipft}$ - Maximum moment in the z-direction,

$Ratio$ - Capacity

$$Ratio = \frac{M_{max}}{\phi M_n}$$

$$\text{Ratio} = \frac{(0.73271 \text{ kipft})}{(249.6 \text{ kipft})}$$

$$\text{Ratio} = 0.0029356$$

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

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

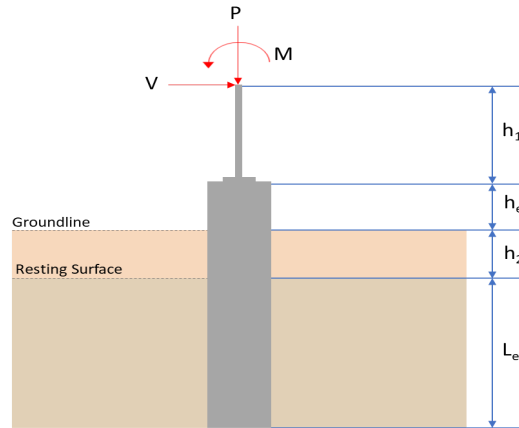
SkyCiv Foundation Design

Pile Foundation

Design Information :

Design code : IBC 2021 (International Building Code)
Unit System : Imperial

Pile Input



Geometry

Pile shape: rectangular

$b = 48$ in - Pile width

$D = 48$ in - Pile depth

$L = 7.25$ ft - Total pile length

$h_1 = 0$ ft - Lateral load height from the top of the pile,

$h_2 = 0$ ft - Depth to resisting surface

$h_e = 0$ ft - Length of pile above the ground

Tabulation of Soil Parameters

| Layer | Label | Allowable Bearing Pressure (q_a) (psf) | Allowable Lateral Pressure (R) (psf/ft) |
|-------|---|--|---|
| 1 | Sand, silty sand, clayey sand, silty gravel & clayey gravel | 2000.000 | 150.000 |

Tabulation of Loads

| Load Component | ASD | LRFD |
|----------------|--------|--------|
| P (kip) | 8.693 | 13.005 |
| V_x (kip) | -2.688 | -4.480 |
| V_z (kip) | -0.140 | -0.210 |
| M_x (kipft) | -0.583 | -0.882 |
| M_z (kipft) | 37.414 | 63.683 |

Material Properties

$f'_{ck} = 2.5$ ksi - Concrete strength.

Required depth to resist lateral loads (ASD)

H - Point of application of the lateral load

$$H = h_1 + h_2 + h_e$$

$$H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})$$

$$H = 0 \text{ ft}$$

Considering x-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-2.688 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.42803 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(37.414 \text{ kipft}) + ((-2.688 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 5.9576 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$L_{e,x} = 6.7235 \text{ ft}$ - Required depth in x-direction,

Considering z-direction:

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.14 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.022293 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.583 \text{ kipft}) + ((-0.14 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.092834 \text{ kipft/ft}$$

Required depth of embedment in earth:

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

Solving the cubic equation:

$L_{e,z} = 1.7237 \text{ ft}$ - Required depth in z-direction,

Minimum embedded depth required:

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

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

$$L_{e,req} = \text{MAX}[(6.7235 \text{ ft}), (1.7237 \text{ ft})]$$

$$L_{e,req} = 6.724 \text{ ft}$$

L_e - Actual embedded length of pile,

$$L_e = L - h_e - h_2$$

$$L_e = (7.25 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$$

$$L_e = 7.25 \text{ ft}$$

Ratio - Embedded depth

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

$$\text{Ratio} = \frac{(6.724 \text{ ft})}{(7.25 \text{ ft})}$$

$$\text{Ratio} = 0.92745$$

Status: **PASS**
Ratio: **0.930**

End-bearing Capacity (ASD)

A - Pile cross-section area

$$A = b D$$

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

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

q - End-bearing pressure

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

$$q = \frac{(8.693 \text{ kip})}{(16 \text{ ft}^2)}$$

$$q = 0.54331 \text{ kip/ft}^2$$

Check bearing capacity ratio:

Ratio - Capacity

$$\text{Ratio} = \frac{q}{q_a}$$

$$\text{Ratio} = \frac{(0.54331 \text{ kip/ft}^2)}{(2000 \text{ psf})}$$

$$\text{Ratio} = 0.27166$$

Status: **PASS**
Ratio: **0.270**

Czerniak

Lateral Soil Pressure (ASD):

L/D - Length to least lateral dimension ratio,

$$L/D = \frac{L}{D}$$

$$L/D = \frac{(7.25 \text{ ft})}{(48 \text{ in})}$$

$$L/D = 1.8125$$

Since $L/D \leq 10$,

Pile is short.

Considering x-direction:

$H_o = -0.42803 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 5.9576 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.9576 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.42803 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (5.9576 \text{ kipft/ft})) + (4 \times (-0.42803 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 4.9891 \text{ ft}$$

p - Earth pressure against the pile at distance $a/2$ from resting surface,

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

$$p = \frac{0.75 \times [(4 \times (5.9576 \text{ kipft/ft})) + (3 \times (-0.42803 \text{ kip/ft}) \times (7.25 \text{ ft}))]^2}{(7.25 \text{ ft})^2 \times [(3 \times (5.9576 \text{ kipft/ft})) + (2 \times (-0.42803 \text{ kip/ft}) \times (7.25 \text{ ft}))]}$$

$$p = 0.25789 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

$$s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$$

$$s = \frac{6 \times [(2 \times (5.9576 \text{ kipft/ft})) + ((-0.42803 \text{ kip/ft}) \times (7.25 \text{ ft}))]}{(7.25 \text{ ft})^2}$$

$$s = 1.0059 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

p_a - Allowable lateral soil pressure at depth $a/2$,

$$p_a = R \frac{a}{2}$$

$$p_a = (150 \text{ psf/ft}) \times \frac{(4.9891 \text{ ft})}{2}$$

$$p_a = 0.37418 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

$$\text{Ratio} = \frac{p}{p_a}$$

$$\text{Ratio} = \frac{(0.25789 \text{ kip/ft}^2)}{(0.37418 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.68922$$

p_s - Allowable lateral soil pressure at depth L_e ,

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (7.25 \text{ ft})$$

$$p_s = 1.0875 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

$$\text{Ratio} = \frac{s}{p_s}$$

$$\text{Ratio} = \frac{(1.0059 \text{ kip/ft}^2)}{(1.0875 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.92497$$

Status: **PASS**
Ratio: **0.690**

Status: **PASS**
Ratio: **0.920**

Considering z-direction:

$H_o = -0.022293 \text{ kip/ft}$ - Lateral force per length of pile,

$M_o = 0.092834 \text{ kipft/ft}$ - Overturning moment per length of pile,

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.092834 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.022293 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (0.092834 \text{ kipft/ft})) + (4 \times (-0.022293 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 5.1579 \text{ ft}$$

p - Earth pressure against the pile at distance $a/2$ from resting surface,

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

$$p = \frac{0.75 \times [(4 \times (0.092834 \text{ kipft/ft})) + (3 \times (-0.022293 \text{ kip/ft}) \times (7.25 \text{ ft}))]^2}{(7.25 \text{ ft})^2 \times [(3 \times (0.092834 \text{ kipft/ft})) + (2 \times (-0.022293 \text{ kip/ft}) \times (7.25 \text{ ft}))]}$$

$$p = -0.0041105 \text{ kip/ft}^2$$

s - Earth pressure against the pile at distance L_e ,

$$s = \frac{6 [(2 M_o) + (H_o L_e)]}{L_e^2}$$

$$s = \frac{6 \times [(2 \times (0.092834 \text{ kipft/ft})) + ((-0.022293 \text{ kip/ft}) \times (7.25 \text{ ft}))]}{(7.25 \text{ ft})^2}$$

$$s = 0.0027447 \text{ kip/ft}^2$$

Check lateral soil pressure capacity:

p_a - Allowable lateral soil pressure at depth $a/2$,

$$p_a = R \frac{a}{2}$$

$$p_a = (150 \text{ psf/ft}) \times \frac{(5.1579 \text{ ft})}{2}$$

$$p_a = 0.38684 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

$$\text{Ratio} = \frac{p}{p_a}$$

$$\text{Ratio} = \frac{(-0.0041105 \text{ kip/ft}^2)}{(0.38684 \text{ kip/ft}^2)}$$

$$Ratio = -0.010626$$

p_s - Allowable lateral soil pressure at depth L_e ,

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (7.25 \text{ ft})$$

$$p_s = 1.0875 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

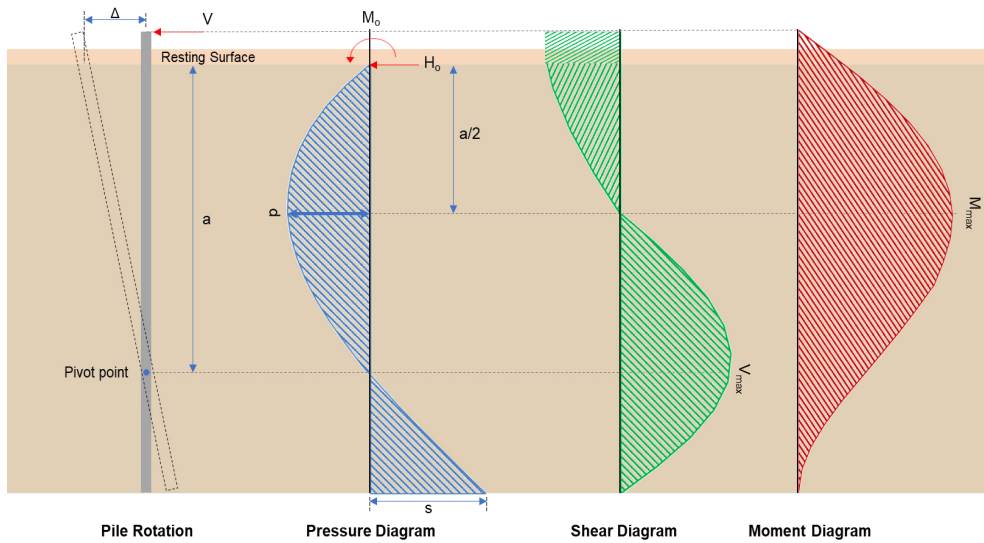
$$Ratio = \frac{s}{p_s}$$

$$Ratio = \frac{(0.0027447 \text{ kip/ft}^2)}{(1.0875 \text{ kip/ft}^2)}$$

$$Ratio = 0.0025238$$

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

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



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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-4.48 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.71338 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(63.683 \text{ kipft}) + ((-4.48 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 10.141 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(10.141 \text{ kipft/ft})}{(-0.71338 \text{ kip/ft})}$$

$$E = 14.215 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (10.141 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.71338 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (10.141 \text{ kipft/ft})) + (4 \times (-0.71338 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = \frac{(-0.71338 \text{ kip/ft}) \times (48 \text{ in})}{(6 \times (10.141 \text{ kipft/ft})) + (4 \times (-0.71338 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 4.9866 \text{ ft}$$

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

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

$$V_{max} = ((-0.71338 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (14.215 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left(\frac{(4.9866 \text{ ft})}{(7.25 \text{ ft})} \right)^2 \right] + \left[4 \times \left(\frac{3 \times (14.215 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left(\frac{(4.9866 \text{ ft})}{(7.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 11.784 \text{ kip}$$

M_{max} - Max bending moment located at depth a/2,

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

$$M_{max} = ((-0.71338 \text{ kip/ft}) \times (48 \text{ in}) \times (7.25 \text{ ft})) \times \left[\left(\frac{(14.215 \text{ ft})}{(7.25 \text{ ft})} + \frac{(4.9866 \text{ ft})}{2 \times (7.25 \text{ ft})} \right) - \left[\left(\frac{4 \times (14.215 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left(\frac{(4.9866 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (14.215 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left(\frac{(4.9866 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 40.834 \text{ kipft}$$

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

H_o - Lateral force per length of pile,

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

$$H_o = \frac{(-0.21 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.033439 \text{ kip/ft}$$

M_o - Moment per length of pile,

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

$$M_o = \frac{(0.882 \text{ kipft}) + ((-0.21 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 0.14045 \text{ kipft/ft}$$

E - Distance from lateral load to resisting surface,

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

$$E = \frac{(0.14045 \text{ kipft/ft})}{(-0.033439 \text{ kip/ft})}$$

$$E = 4.2 \text{ ft}$$

a - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (0.14045 \text{ kipft/ft}) \times (7.25 \text{ ft})) + (3 \times (-0.033439 \text{ kip/ft}) \times (7.25 \text{ ft})^2)}{(6 \times (0.14045 \text{ kipft/ft})) + (4 \times (-0.033439 \text{ kip/ft}) \times (7.25 \text{ ft}))}$$

$$a = 5.1566 \text{ ft}$$

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

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

$$V_{max} = ((-0.033439 \text{ kip/ft}) \times (48 \text{ in})) \times \left[1 - \left[3 \times \left(\frac{4 \times (4.2 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left(\frac{(5.1566 \text{ ft})}{(7.25 \text{ ft})} \right)^2 \right] \right. \\ \left. + \left[4 \times \left(\frac{3 \times (4.2 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left(\frac{(5.1566 \text{ ft})}{(7.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 0.22604 \text{ kip}$$

M_{max} - Max bending moment located at depth $a/2$,

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

$$M_{max} = ((-0.033439 \text{ kip/ft}) \times (48 \text{ in}) \times (7.25 \text{ ft})) \times \left[\left(\frac{(4.2 \text{ ft})}{(7.25 \text{ ft})} + \frac{(5.1566 \text{ ft})}{2 \times (7.25 \text{ ft})} \right) \right. \\ \left. - \left[\left(\frac{4 \times (4.2 \text{ ft})}{(7.25 \text{ ft})} + 3 \right) \times \left(\frac{(5.1566 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^3 \right] + \left[\left(\frac{3 \times (4.2 \text{ ft})}{(7.25 \text{ ft})} + 2 \right) \times \left(\frac{(5.1566 \text{ ft})}{2 \times (7.25 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 0.73271 \text{ kipft}$$

Minimum Reinforcement Check (LRFD)

Parameters:

$f'_{ck} = 2.5 \text{ ksi}$ - Concrete strength,

$f_{yk} = 60 \text{ ksi}$ - Longitudinal reinforcement strength,

$\phi = 0.65$ - Reduction factor for axial strength,

$\alpha = 0.8$ - Alpha factor for axial strength,

$A_g = 2304 \text{ in}^2$ - Gross area of concrete,

Longitudinal reinforcement:

Required reinforcement due to axial load, $A_{st,required}$

$A_{st,required}$

$$A_{st,required} = \text{Min} \left[\frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$$

$$A_{st,required} = \text{Min} \left[\frac{\frac{(13.005 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$$

$$A_{st,required} = -84.164 \text{ in}^2$$

A_{min} - Governing minimum reinforcement area,

$$A_{min} = \text{Max} [A_{st,required}, (0.0018 A_g)]$$

$$A_{min} = \text{Max} [(-84.164 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$$

$$A_{min} = 4.1472 \text{ in}^2$$

n_{rebar} - Required number of reinforcement,

$$n_{rebar} = \frac{A_{min}}{A_{rebar}}$$

$$n_{rebar} = \frac{(4.1472 \text{ in}^2)}{(0.3068 \text{ in}^2)}$$

$$n_{rebar} = 14$$

A_{st} - Actual total reinforcement area,

$$A_{st} = n_{rebar} \frac{\pi d_{bar}^2}{4}$$

$$A_{st} = (14) \times \frac{\pi \times (0.625 \text{ in})^2}{4}$$

$$A_{st} = 4.2951 \text{ in}^2$$

Ratio - Capacity

$$\text{Ratio} = \frac{A_{min}}{A_{st}}$$

$$\text{Ratio} = \frac{(4.1472 \text{ in}^2)}{(4.2951 \text{ in}^2)}$$

Table 22.4.2.1

22.4.2.2, 10.6.1.1

| | | |
|---|---|--|
| <p>25.2.3</p> <p>25.7.2.2</p> <p>25.7.2.1</p> | <p style="text-align: center;">$Ratio = 0.96556$</p> <p>$s_{rebar} = Max[1.5, (1.5 d_{bar})]$</p> <p>$s_{rebar} = Max[1.5, (1.5 \times (0.625 \text{ in}))]$</p> <p>$s_{rebar} = 1.5 \text{ in}$</p> <p>Ties:</p> <p>Since longitudinal reinforcement is \leq No. 10ø: Use #3(0.375 in)</p> <p>$s_{ties} = Min[(16 d_{bar}), (48 d_{ties}), Min(D, b)]$</p> <p>$s_{ties} = Min[(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), Min((48 \text{ in}), (48 \text{ in}))]$</p> <p>$s_{ties} = 10 \text{ in}$</p> <p>Summary:</p> <p style="text-align: center;">Main reinforcement: 14 - #5 (0.625 in) Ties: #3(0.375 in) - 10 in</p> | <p>Status: PASS Ratio: 0.970</p> |
| <p>22.4.2.2</p> | <p>Axial Compression Strength (ACI 318-19, LRFD)</p> <p>ϕP_N - Allowable axial compressive strength</p> <p style="text-align: center;">$\phi P_N = \phi 0.80 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_y k A_{st})]$</p> <p style="text-align: center;">$\phi P_N = (0.65) \times 0.80 \times [(0.85 \times (2.5 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2))]$</p> <p style="text-align: center;">$\phi P_N = 2675.2 \text{ kip}$</p> <p>Ratio - Capacity</p> <p style="text-align: center;">$Ratio = \frac{P}{\phi P_N}$</p> <p style="text-align: center;">$Ratio = \frac{(13.005 \text{ kip})}{(2675.2 \text{ kip})}$</p> <p style="text-align: center;">$Ratio = 0.0048614$</p> | <p>Status: PASS Ratio: 0.000</p> |
| <p>22.5.2.2</p> <p>22.5.5.1.3</p> <p>22.5.5.1.1</p> | <p>Shear Strength (ACI 318-19, LRFD)</p> <p>Parameters:</p> <p>$b_w = 48 \text{ in}$ - Effective width, d - Effective depth</p> <p style="text-align: center;">$d = 0.80 D$</p> <p style="text-align: center;">$d = 0.80 \times (48 \text{ in})$</p> <p style="text-align: center;">$d = 38.4 \text{ in}$</p> <p>λ_s - size effect modification factor</p> <p style="text-align: center;">$\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$</p> <p style="text-align: center;">$\lambda_s = MIN \left[\sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]$</p> <p style="text-align: center;">$\lambda_s = 0.64282$</p> <p>The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$,</p> <p>$V_{c,max}$ - Max shear strength of concrete</p> <p style="text-align: center;">$V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$</p> <p style="text-align: center;">$V_{c,max} = 5 \times (0.64282) \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$</p> | |

$$V_{c,max} = 296.21 \text{ kip}$$

22.5.5.1.1(a) The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$, $P = 13.005 \text{ kip} \rightarrow 13005 \text{ lbf}$,
 $V_{c,a}$ - Shear strength of concrete (a)

$$V_{c,a} = \left[2 \lambda_s \sqrt{f'_{ck} + \frac{P}{6 A_g}} \right] b_w d$$

$$V_{c,a} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi}) + \frac{(13005 \text{ lbf})}{6 \times (2304 \text{ in}^2)}} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 120.22 \text{ kip}$$

22.5.5.1.2 The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$,
 $V_{c,b}$ - Shear strength of concrete (b)

$$V_{c,b} = \left[2 \lambda_s \sqrt{f'_{ck} + (0.05 f'_{ck})} \right] b_w d$$

$$V_{c,b} = \left[2 \times (0.64282) \times \sqrt{(2500 \text{ psi}) + (0.05 \times (2500 \text{ psi}))} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,b} = 348.89 \text{ kip}$$

V_c - Governing shear strength of concrete

$$V_c = \text{Min}[V_{c,max}, V_{c,a}, V_{c,b}]$$

$$V_c = \text{Min}[(296.21 \text{ kip}), (120.22 \text{ kip}), (348.89 \text{ kip})]$$

$$V_c = 120.22 \text{ kip}$$

22.5.5.1.2 The following variables were converted to be consistent with empirical formula $f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}$,
 $V_{s,a}$ - Shear strength of steel (a)

$$V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$$

$$V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{s,a} = 737.28 \text{ kip}$$

A_v - Ties rebar area,

$$A_v = \frac{\pi d_{ties}^2}{4}$$

$$A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$$

$$A_v = 0.11045 \text{ in}^2$$

22.5.8.5.3 $V_{s,b}$ - Shear strength of steel (b)

$$V_{s,b} = \frac{2 A_v f_{yw} d}{s_{ties}}$$

$$V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$$

$$V_{s,b} = 50.894 \text{ kip}$$

V_s - Governing shear strength of steel

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

$$V_s = \text{MIN}[(737.28 \text{ kip}), (50.894 \text{ kip})]$$

$$V_s = 50.894 \text{ kip}$$

22.5.1.1 ϕV_n - Allowable shear strength

$$\phi V_n = \phi (V_c + V_s)$$

$$\phi V_n = (0.65) \times ((120.22 \text{ kip}) + (50.894 \text{ kip}))$$

$$\phi V_n = 111.22 \text{ kip}$$

Considering x-direction:

$V_{max} = 11.784 \text{ kip}$ - Maximum shear force in the x-direction,

Ratio - Capacity

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

$$Ratio = \frac{(11.784 \text{ kip})}{(111.22 \text{ kip})}$$

$$Ratio = 0.10595$$

Status: **PASS**
Ratio: **0.110**

Considering z-direction:

$V_{max} = 0.22604 \text{ kip}$ - Maximum shear force in the z-direction,
Ratio - Capacity

$$Ratio = \frac{V_{max}}{\phi V_n}$$

$$Ratio = \frac{(0.22604 \text{ kip})}{(111.22 \text{ kip})}$$

$$Ratio = 0.0020323$$

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

Flexural Strength (ACI 318-19, LRFD)

S_m - Section modulus

$$S_m = \frac{b D^2}{6}$$

$$S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$$

$$S_m = 18432 \text{ in}^3$$

$\lambda = 1$ - Concrete modification factor (Normal concrete),

Allowable flexural strength:

M_n shall be the lesser of:

$\phi M_{n,1}$

$$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$$

$$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 \text{ ksi})} \times 18432.001 \text{ in}^3$$

$$\phi M_{n,1} = 249.600 \text{ kipft}$$

14.5.2.1b

$\phi M_{n,2}$

$$\phi M_{n,2} = \phi \times 0.85 \times f'_c \times S_m$$

$$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (18432 \text{ in}^3)$$

$$\phi M_{n,2} = 2121.6 \text{ kipft}$$

Therefore,

ϕM_n - Allowable flexural strength,

$$\phi M_n = \text{MIN}[\phi M_{n,1}, \phi M_{n,2}]$$

$$\phi M_n = \text{MIN}[(249.6 \text{ kipft}), (2121.6 \text{ kipft})]$$

$$\phi M_n = 249.6 \text{ kipft}$$

Considering x-direction:

$M_{max} = 40.834 \text{ kipft}$ - Maximum moment in the x-direction,

Ratio - Capacity

$$Ratio = \frac{M_{max}}{\phi M_n}$$

$$Ratio = \frac{(40.834 \text{ kipft})}{(249.6 \text{ kipft})}$$

$$Ratio = 0.1636$$

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

Considering z-direction:

$M_{max} = 0.73271 \text{ kipft}$ - Maximum moment in the z-direction,

Ratio - Capacity

$$Ratio = \frac{M_{max}}{\phi M_n}$$

$$\text{Ratio} = \frac{(0.73271 \text{ kipft})}{(249.6 \text{ kipft})}$$

$$\text{Ratio} = 0.0029356$$

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