

## Project Details



**Project Name:** MTSOLAR\_CD1E18997779

**Date:** Tue Nov 19 2024

**Location:** Weaverville, NC 28787, USA

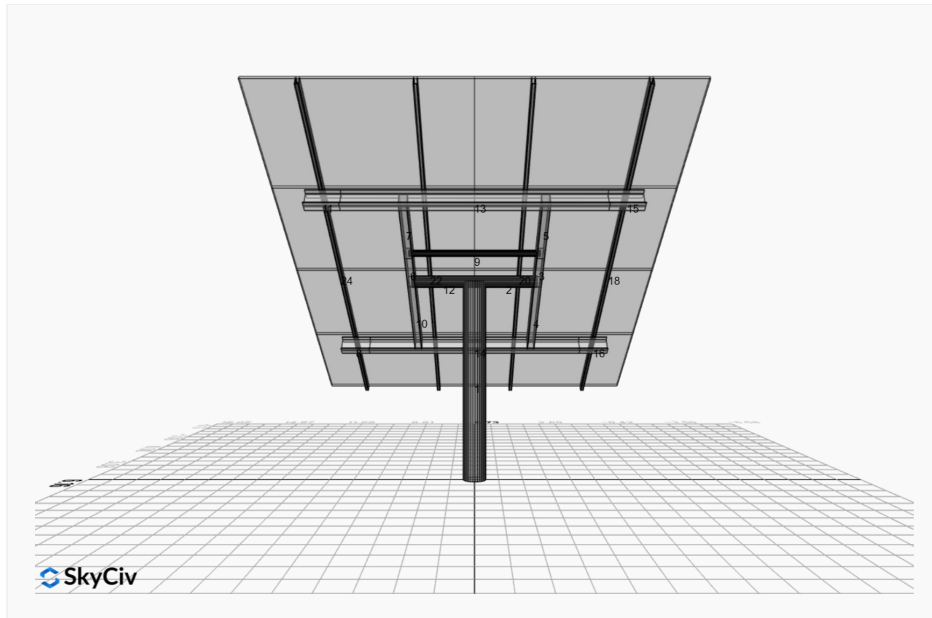
**Number of Modules:** 8

**Unique ID:** 1P-0-8TOP-SD-12-L-4Hx2W-3C6G

**Number of Poles:** 1

**Dealer:** \_\_\_\_\_

**Date Sold:** \_\_\_\_\_



|                             |          |
|-----------------------------|----------|
| <b>Array Dimensions N/S</b> | 15.03 ft |
| <b>Array Dimensions E/W</b> | 11.47 ft |
| <b>Winter Tilt Angle</b>    | 35       |
| <b>Front Edge Clearance</b> | 2 ft     |

### MT Solar Bill of Materials (1P-0-8TOP-SD-12-L-4Hx2W-3C6G)

| Part               | Short Description     | BOM Qty |
|--------------------|-----------------------|---------|
| MTS-PC-8           | 8IN Pole Cap Assembly | 1       |
| MTS-HF-SD          | H-Frame Assembly-SD   | 1       |
| MTS-SD-Wing-12     | 12IN SD Wing          | 4       |
| MTS-CLAMP-HOOK-4PK | Hook Clamp            | 2       |

### Rail Bill of Materials

| Part             | Qty |
|------------------|-----|
| Rails (178in)    | 4   |
| Rail Attachment  | 8   |
| Module Mid Clamp | 12  |
| Module End Clamp | 8   |
| Ground Lug       | 2   |

## Site Details:



**Site Address:** Weaverville, NC 28787, USA

### Array Specification

|                                    |           |
|------------------------------------|-----------|
| <b>Duty Classification:</b>        | SD        |
| <b>Module Width:</b>               | 44.60 in  |
| <b>Module Length:</b>              | 67.80in   |
| <b>Number of Rows:</b>             | 4         |
| <b>Number of Columns:</b>          | 2         |
| <b>Total Number of Modules:</b>    | 8         |
| <b>Winter Tilt Angle:</b>          | 35        |
| <b>Front Edge Clearance:</b>       | 2         |
| <b>Total Array Height at Tilt:</b> | 10.62 ft  |
| <b>Total Frame Length:</b>         | 9.50 ft   |
| <b>Frame Weight:</b>               | 671 lbs   |
| <b>Array Dimensions N/S:</b>       | 15.03 ft  |
| <b>Array Dimensions E/W:</b>       | 11.47 ft  |
| <b>Rail Length:</b>                | 180.40 in |
| <b>Rail Spacing:</b>               | 2.87 ft   |

### Support Specifications

|                                 |                 |
|---------------------------------|-----------------|
| <b>Pole Size:</b>               | 8in Pipe Sch 40 |
| <b>Pole Length above Grade:</b> | 6.31 ft         |
| <b>Number of Poles:</b>         | 1               |
| <b>Pole Spacing:</b>            | 0               |

### Foundation Specifications

|                                        |                      |
|----------------------------------------|----------------------|
| <b>Foundation Type:</b>                | Square               |
| <b>Foundation Dimensions:</b>          | 48 x 48 in           |
| <b>Foundation Depth (below grade):</b> | Pile 1: 5.50 ft      |
| <b>Foundation Volume:</b>              | 3.259 y <sup>3</sup> |

### Site Info

|                             |                            |
|-----------------------------|----------------------------|
| <b>Risk Category:</b>       | I                          |
| <b>Exposure:</b>            | C                          |
| <b>Soil Classification:</b> | sand                       |
| <b>Site Location:</b>       | Weaverville, NC 28787, USA |
| <b>Wind Speed:</b>          | 120 mph                    |
| <b>Snow Load:</b>           | 20 psf                     |

### **Design Disclaimer**

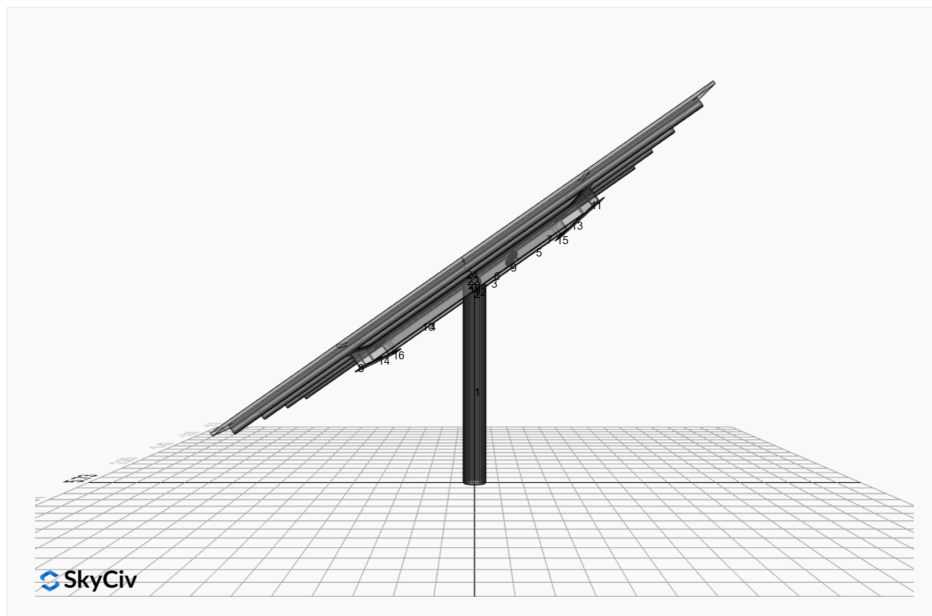
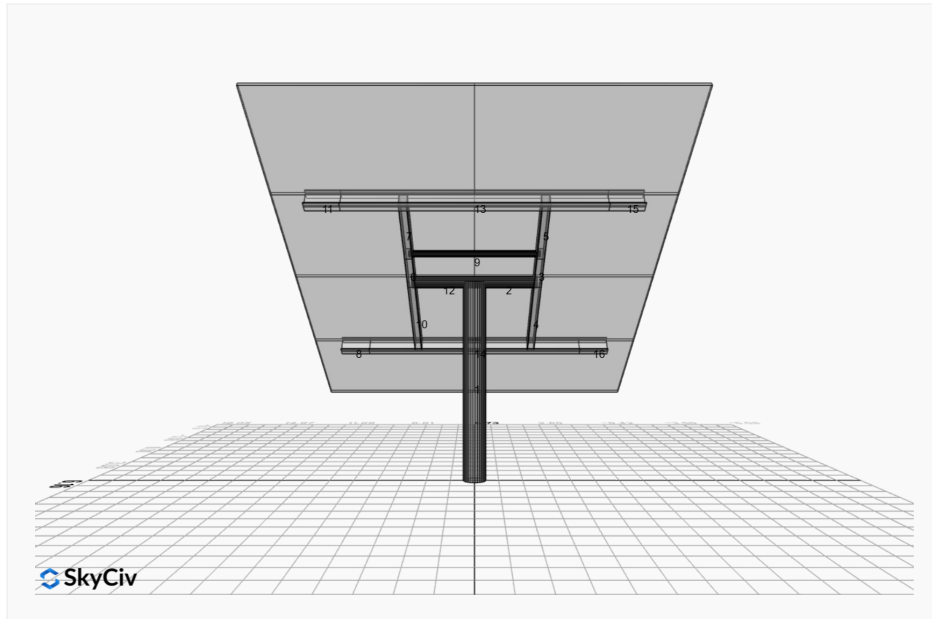
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

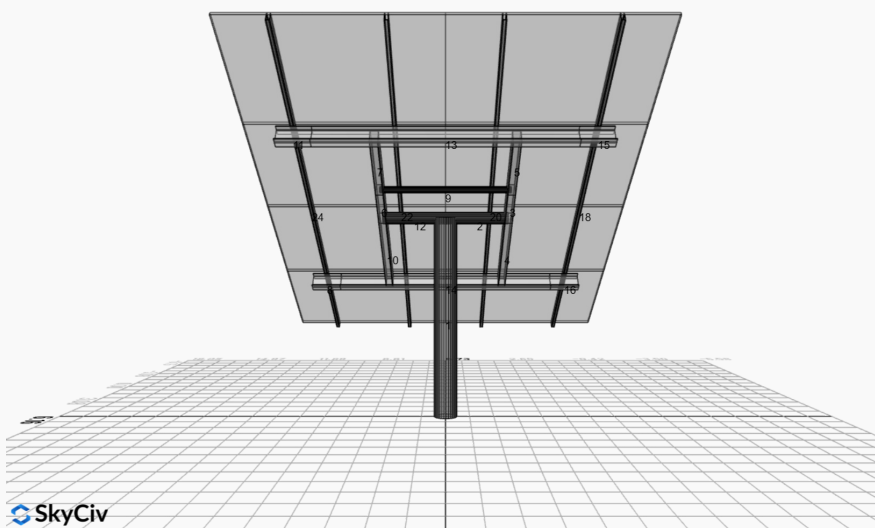
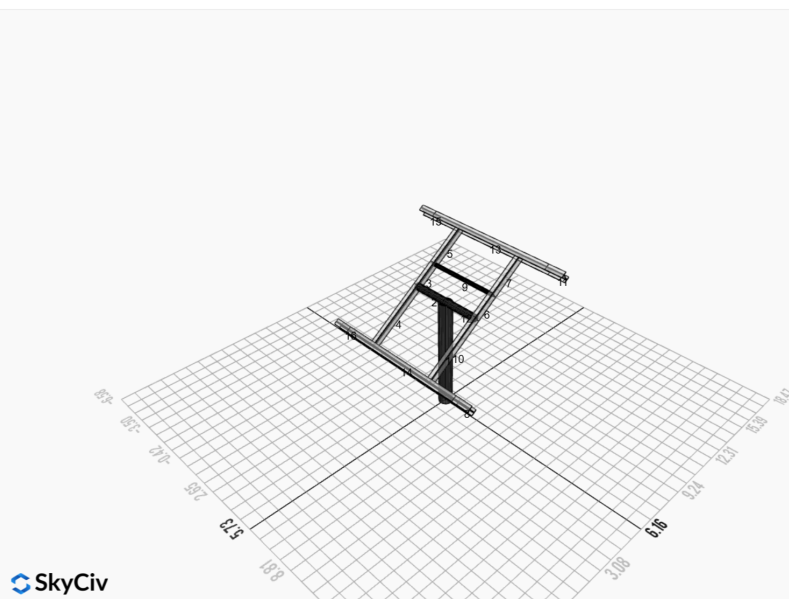
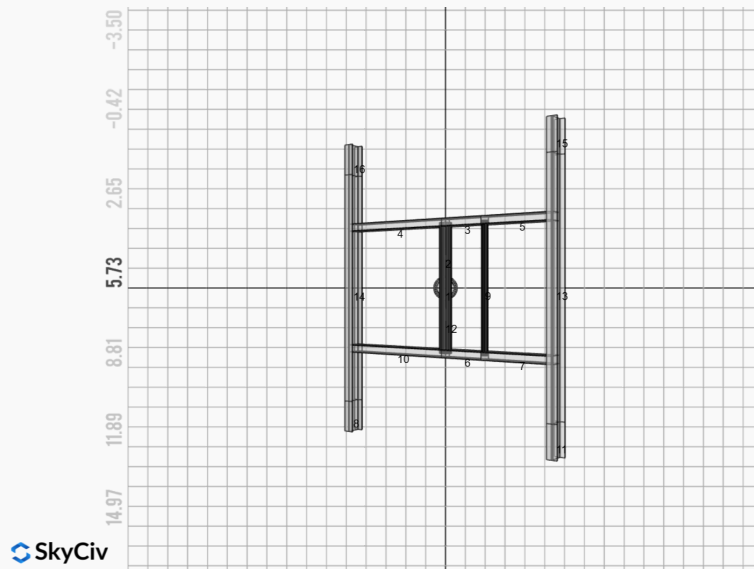
## AutoDesigner Input

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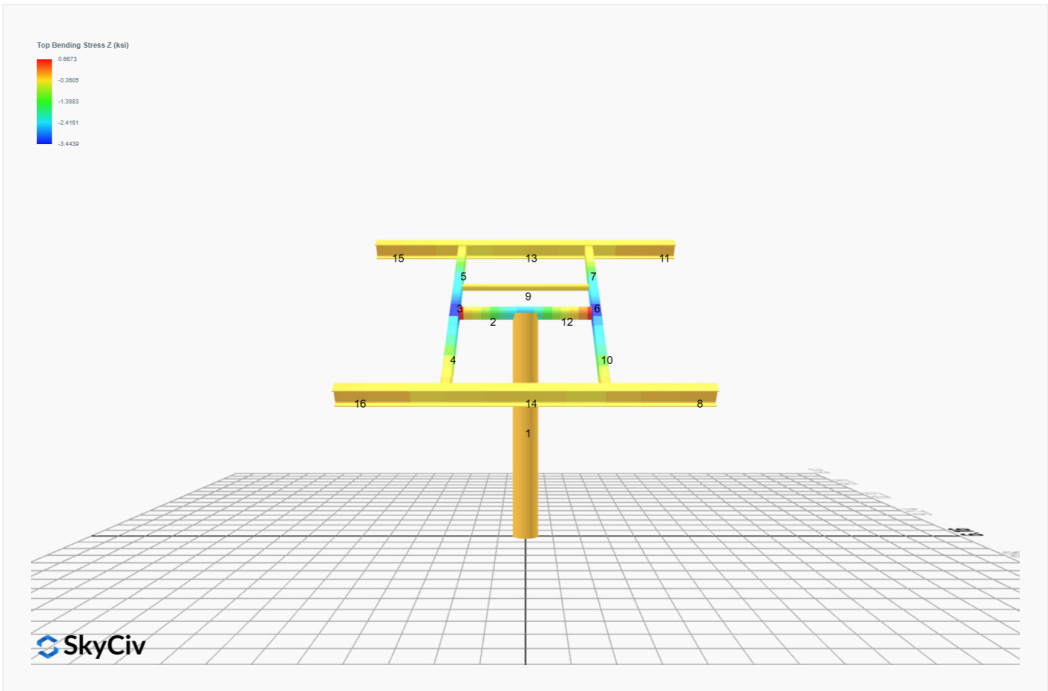
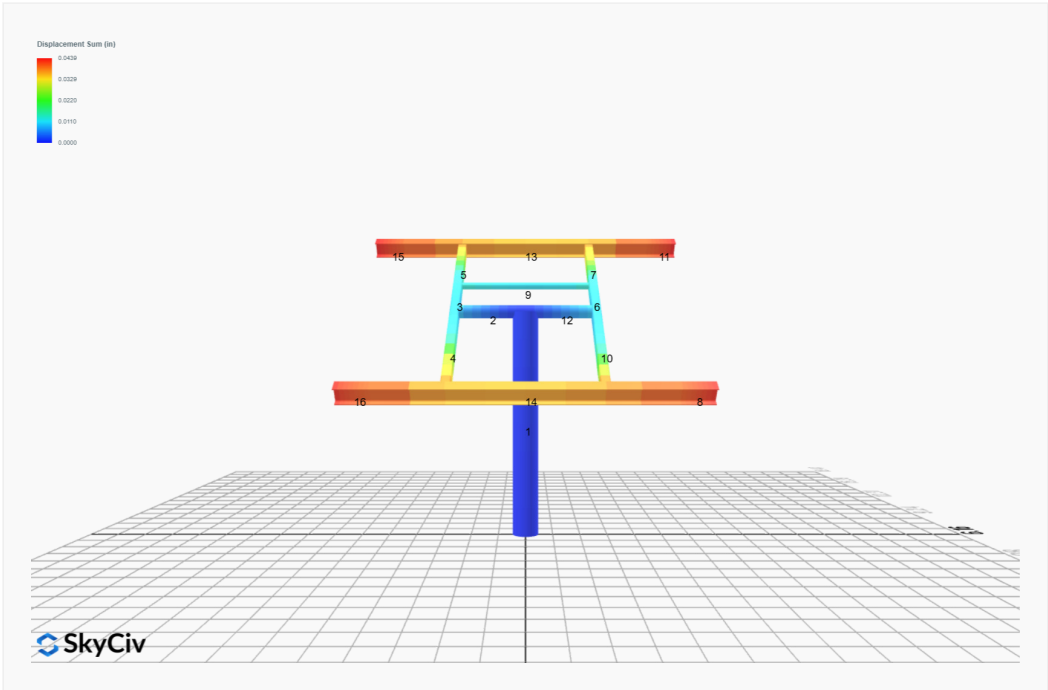
## Design Notes:

- 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)
- Foundation Design and Sizing is approximate only

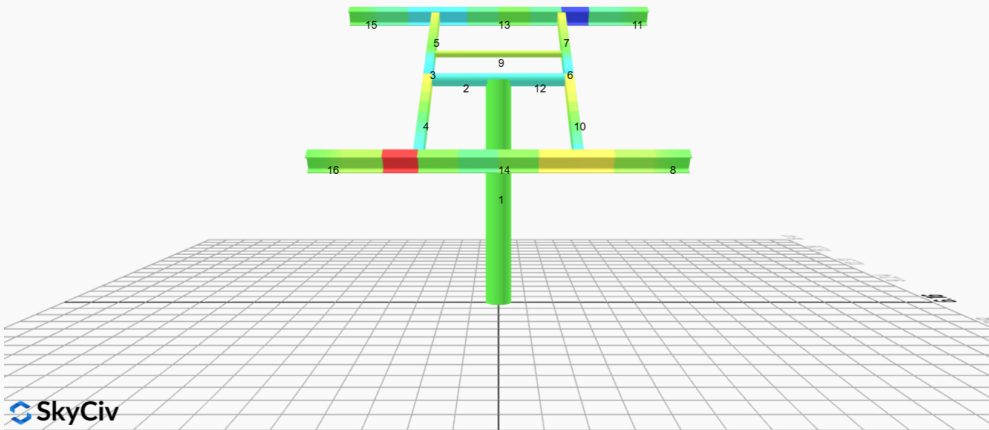




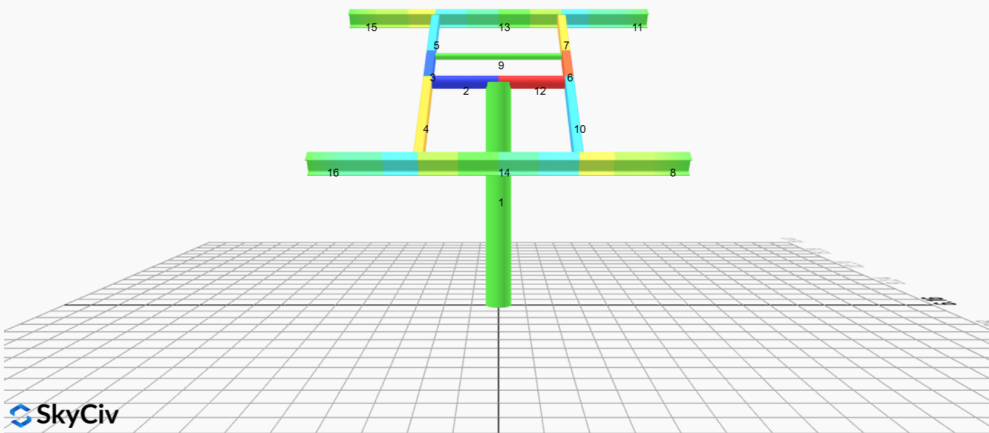
# FEM Results (Envelope Worst Case for each member)

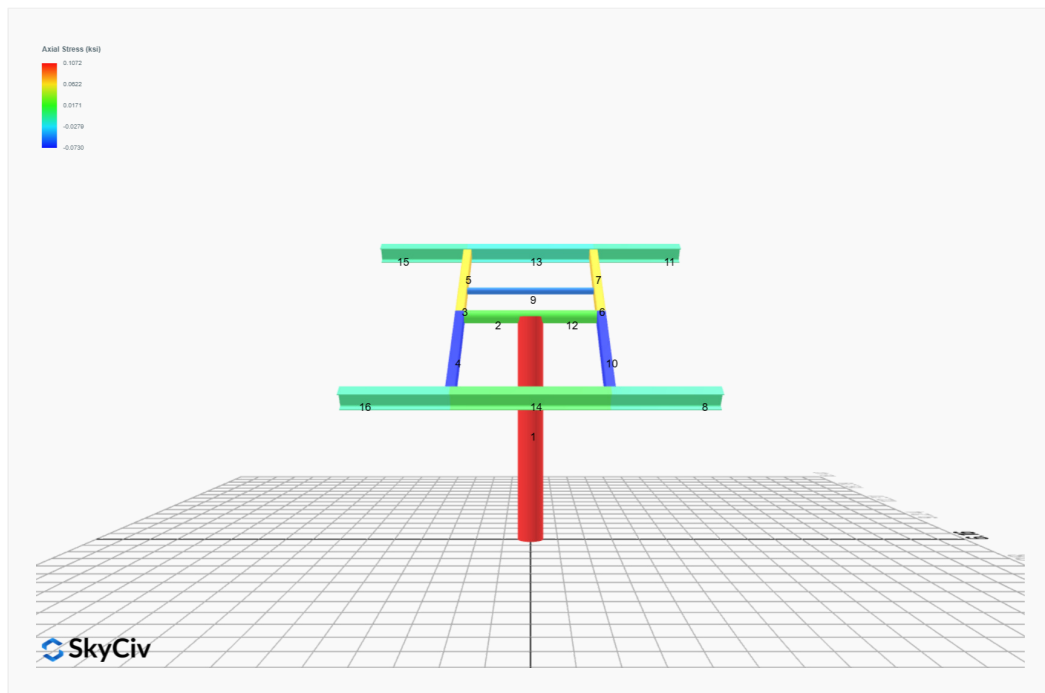


Top Bending Stress Y (ksi)



Shear Stress Y (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  | 1.3114  | 0.0000 | -0.0000 | -0.0000 | 0.0182   |
| ULS: 2. D + L                                                                   | 0.0000  | 1.3114  | 0.0000 | -0.0000 | -0.0000 | 0.0182   |
| ULS: 3. D + (S or Lr or R)                                                      | 0.0000  | 2.2119  | 0.0000 | -0.0000 | -0.0000 | 0.0196   |
| ULS: 3. D + (S or Lr or R)                                                      | 0.0000  | 1.3114  | 0.0000 | -0.0000 | -0.0000 | 0.0182   |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R)                                          | 0.0000  | 1.9867  | 0.0000 | -0.0000 | -0.0000 | 0.0192   |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R)                                          | 0.0000  | 1.3114  | 0.0000 | -0.0000 | -0.0000 | 0.0182   |
| ULS: 5b. D + 0.7E                                                               | 0.0000  | 1.3114  | 0.0000 | -0.0000 | -0.0000 | 0.0182   |
| ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S                                         | 0.0000  | 1.9867  | 0.0000 | -0.0000 | -0.0000 | 0.0192   |
| ULS: 8. 0.6D + 0.7E                                                             | 0.0000  | 0.7868  | 0.0000 | -0.0000 | -0.0000 | 0.0109   |
| ULS: 5a. D + 0.6W_Wind downforce Case A only                                    | -2.5979 | 5.0215  | 0.0000 | -0.0000 | -0.0000 | 16.7748  |
| ULS: 5a. D + 0.6W_Wind downforce Case B only                                    | -2.5979 | 5.0215  | 0.0000 | -0.0000 | -0.0000 | 16.7748  |
| ULS: 5a. D + 0.6W_Wind uplift Case A only                                       | 2.1919  | -1.8190 | 0.0000 | -0.0000 | -0.0000 | -13.7507 |
| ULS: 5a. D + 0.6W_Wind uplift Case B only                                       | 1.8266  | -1.2973 | 0.0000 | -0.0000 | -0.0000 | -18.8553 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -1.9484 | 4.7693  | 0.0000 | -0.0000 | -0.0000 | 12.5867  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | -1.9484 | 4.7693  | 0.0000 | -0.0000 | -0.0000 | 12.5867  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only    | 1.6440  | -0.3611 | 0.0000 | -0.0000 | -0.0000 | -10.3075 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only    | 1.3700  | 0.0302  | 0.0000 | -0.0000 | -0.0000 | -14.1359 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -1.9484 | 4.0939  | 0.0000 | -0.0000 | -0.0000 | 12.5857  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | -1.9484 | 4.0939  | 0.0000 | -0.0000 | -0.0000 | 12.5857  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only    | 1.6440  | -1.0364 | 0.0000 | -0.0000 | -0.0000 | -10.3085 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only    | 1.3700  | -0.6451 | 0.0000 | -0.0000 | -0.0000 | -14.1369 |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case A only                                  | -2.5979 | 4.4969  | 0.0000 | -0.0000 | -0.0000 | 16.7676  |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case B only                                  | -2.5979 | 4.4969  | 0.0000 | -0.0000 | -0.0000 | 16.7676  |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case A only                                     | 2.1919  | -2.3436 | 0.0000 | -0.0000 | -0.0000 | -13.7580 |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case B only                                     | 1.8266  | -1.8219 | 0.0000 | -0.0000 | -0.0000 | -18.8625 |

### 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            | 8.2074              |
| Shear X          | -4.3298             |
| Shear Z          | 0.0000              |
| Moment X         | -0.0000             |
| Moment Y (Twist) | 0.0000              |
| Moment Z         | 31.5186             |

### 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            | 5.0215              |
| Shear X          | -2.5979             |
| Shear Z          | 0.0000              |
| Moment X         | -0.0000             |
| Moment Y (Twist) | 0.0000              |
| Moment Z         | 18.8625             |

## Project Details

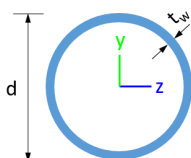
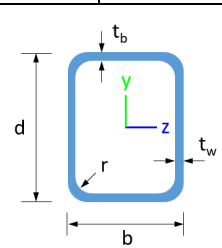
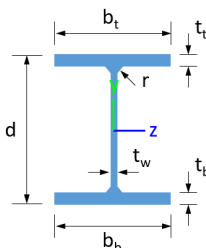
Design Code: AISC 360-16 LRFD  
 Provision: LRFD  
 Country: United States  
 User Name: sales@mtsolar.us  
 Unit System: imperial



## Design Input Information

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

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

| Section Dimensions                                                                  |                 |        |            |            |            |            |            |        |
|-------------------------------------------------------------------------------------|-----------------|--------|------------|------------|------------|------------|------------|--------|
|   |                 |        |            |            |            |            |            |        |
| ID                                                                                  | Name            | d (in) | $t_w$ (in) |            |            |            |            |        |
| 1                                                                                   | 2in Pipe Sch 40 | 2.38   | 0.15       |            |            |            |            |        |
| 4                                                                                   | 4in Pipe Sch 40 | 4.50   | 0.24       |            |            |            |            |        |
| 9                                                                                   | 8in Pipe Sch 40 | 8.63   | 0.32       |            |            |            |            |        |
|  |                 |        |            |            |            |            |            |        |
| ID                                                                                  | Name            | d (in) | b (in)     | $t_w$ (in) | $t_b$ (in) | r (in)     |            |        |
| 15                                                                                  | HSS5x3x1/8      | 5.00   | 3.00       | 0.12       | 0.12       | 0.12       |            |        |
|  |                 |        |            |            |            |            |            |        |
| ID                                                                                  | Name            | d (in) | $t_w$ (in) | $b_t$ (in) | $b_b$ (in) | $t_t$ (in) | $t_b$ (in) | r (in) |
| 18                                                                                  | W6x9            | 5.90   | 0.17       | 3.94       | 3.94       | 0.21       | 0.21       | 0.25   |

| Section Properties |      |                      |                      |                             |                             |                          |                             |                             |
|--------------------|------|----------------------|----------------------|-----------------------------|-----------------------------|--------------------------|-----------------------------|-----------------------------|
| ID                 | Name | A (in <sup>2</sup> ) | J (in <sup>4</sup> ) | $I_{yp}$ (in <sup>4</sup> ) | $I_{zp}$ (in <sup>4</sup> ) | $I_w$ (in <sup>6</sup> ) | $S_{yp}$ (in <sup>3</sup> ) | $S_{zp}$ (in <sup>3</sup> ) |
|                    |      |                      |                      |                             |                             |                          |                             |                             |



|    |        |        |       |      |       |       |
|----|--------|--------|-------|------|-------|-------|
| 15 | 120.60 | 113.97 | 23.36 | 6.45 | 30.09 | 45.74 |
| 16 | 120.60 | 113.97 | 23.36 | 6.45 | 30.09 | 45.74 |

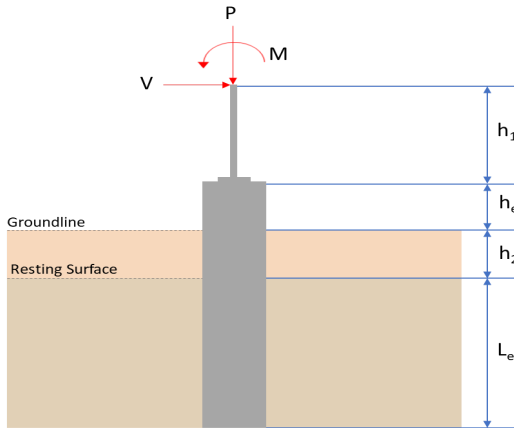
## Design Ratio

| Member ID | P     | M <sub>z</sub> | M <sub>y</sub> | V <sub>y</sub> | V <sub>z</sub> | (P,M <sub>z</sub> ,M <sub>y</sub> ) | Worst LC | KL/r         | δ            | Status |
|-----------|-------|----------------|----------------|----------------|----------------|-------------------------------------|----------|--------------|--------------|--------|
| 1         | 0.027 | 0.378          | 0.000          | 0.038          | 0.000          | 0.382                               | #32      | 0.271        | Not Required | Pass   |
| 2         | 0.001 | 0.425          | 0.248          | 0.093          | 0.051          | 0.674                               | #13      | 0.052        | Not Required | Pass   |
| 3         | 0.005 | 0.774          | 0.056          | 0.078          | 0.016          | 0.812                               | #13      | 0.044        | Not Required | Pass   |
| 4         | 0.005 | 0.752          | 0.035          | 0.076          | 0.006          | 0.776                               | #13      | 0.078        | Not Required | Pass   |
| 5         | 0.005 | 0.481          | 0.023          | 0.078          | 0.003          | 0.484                               | #13      | 0.073        | Not Required | Pass   |
| 6         | 0.005 | 0.774          | 0.056          | 0.078          | 0.016          | 0.812                               | #13      | 0.044        | Not Required | Pass   |
| 7         | 0.005 | 0.481          | 0.023          | 0.078          | 0.003          | 0.484                               | #13      | 0.073        | Not Required | Pass   |
| 8         | 0.000 | 0.010          | 0.006          | 0.015          | 0.002          | 0.014                               | #13      | Not Required | Not Required | Pass   |
| 9         | 0.004 | 0.057          | 0.041          | 0.001          | 0.000          | 0.100                               | #13      | 0.132        | Not Required | Pass   |
| 10        | 0.005 | 0.752          | 0.035          | 0.076          | 0.006          | 0.776                               | #13      | 0.078        | Not Required | Pass   |
| 11        | 0.000 | 0.010          | 0.006          | 0.016          | 0.002          | 0.014                               | #13      | Not Required | Not Required | Pass   |
| 12        | 0.001 | 0.425          | 0.248          | 0.093          | 0.051          | 0.674                               | #13      | 0.052        | Not Required | Pass   |
| 13        | 0.000 | 0.105          | 0.046          | 0.043          | 0.005          | 0.120                               | #13      | 0.177        | Not Required | Pass   |
| 14        | 0.001 | 0.107          | 0.046          | 0.042          | 0.005          | 0.120                               | #13      | 0.177        | Not Required | Pass   |
| 15        | 0.000 | 0.010          | 0.006          | 0.016          | 0.002          | 0.014                               | #13      | Not Required | Not Required | Pass   |
| 16        | 0.000 | 0.010          | 0.006          | 0.015          | 0.002          | 0.014                               | #13      | Not Required | Not Required | Pass   |

## Definitions

|                                     |                                                           |
|-------------------------------------|-----------------------------------------------------------|
| Φ <sub>t</sub>                      | Safety factor for tensile                                 |
| Φ <sub>c</sub>                      | Safety factor for compression                             |
| Φ <sub>b</sub>                      | Safety factor for flexure                                 |
| Φ <sub>v</sub>                      | Safety factor for shear                                   |
| E                                   | Modulus of elasticity                                     |
| F <sub>y</sub>                      | Specified minimum yield stress                            |
| F <sub>u</sub>                      | Specified minimum tensile strength                        |
| A                                   | Cross-sectional area                                      |
| J                                   | Torsional constant                                        |
| I <sub>yp</sub>                     | Moment of inertia about the Y axes                        |
| I <sub>zp</sub>                     | Moment of inertia about the Z axes                        |
| I <sub>w</sub>                      | Warping constant                                          |
| S <sub>yp</sub>                     | Plastic section modulus about the Y axis                  |
| S <sub>zp</sub>                     | Plastic section modulus about the Z axis                  |
| KL                                  | Effective length                                          |
| C <sub>b</sub>                      | Buckling modification factor (from all load combinations) |
| L <sub>b</sub>                      | Length between braced points                              |
| LST                                 | Limited slenderness for tension                           |
| LSC                                 | Limited slenderness for compression                       |
| LD                                  | Limited deflection                                        |
| P <sub>n</sub>                      | Nominal axial strength (tension/compression)              |
| M <sub>n</sub>                      | Nominal flexural strength (about Z/Y axis)                |
| V <sub>n</sub>                      | Nominal shear strength (along Z/Y axis)                   |
| P                                   | Design ratio in case of axial force                       |
| M <sub>z</sub>                      | Design ratio in case of bending about Z axis              |
| M <sub>y</sub>                      | Design ratio in case of bending about Y axis              |
| V <sub>y</sub>                      | Design ratio in case of shear along Y axis                |
| V <sub>z</sub>                      | Design ratio in case of shear along Z axis                |
| (P,M <sub>z</sub> ,M <sub>y</sub> ) | 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                                  |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|--------------------------------------------|------------------------------------------|--------------------------------------------|---|-------------------------------------------------------------|----------|---------|----------------|-----|------|---------|-------|-------|----------|--------|--------|----------|-------|-------|------------|-------|-------|------------|--------|--------|--|
|                | <div>SkyCiv Foundation Design</div> <div>Pile Foundation</div> <div>Design Information :</div> <div>Design code : IBC 2021 (International Building Code)</div> <div>Unit System : Imperial</div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                          |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
|                | <div>Pile Input</div> <div></div> <div>Geometry</div> <div>Pile shape: rectangular</div> <div>b = 48 in - Pile width</div> <div>D = 48 in - Pile depth</div> <div>L = 5.5 ft - Total pile length</div> <div>h1 = 0 ft - Lateral load height from the top of the pile,</div> <div>h2 = 0 ft - Depth to resisting surface</div> <div>he = 0 ft - Length of pile above the ground</div> <div>Tabulation of Soil Parameters</div> <table><tr><th>Layer</th><th>Label</th><th>Allowable Bearing Pressure (qa)<br/>(psf)</th><th>Allowable Lateral Pressure (R)<br/>(psf/ft)</th></tr><tr><td>1</td><td>Sand, silty sand, clayey sand, silty gravel &amp; clayey gravel</td><td>2000.000</td><td>150.000</td></tr></table> <div>Tabulation of Loads</div> <table><tr><th>Load Component</th><th>ASD</th><th>LRFD</th></tr><tr><td>P (kip)</td><td>5.021</td><td>8.207</td></tr><tr><td>Vx (kip)</td><td>-2.598</td><td>-4.330</td></tr><tr><td>Vz (kip)</td><td>0.000</td><td>0.000</td></tr><tr><td>Mx (kipft)</td><td>0.000</td><td>0.000</td></tr><tr><td>Mz (kipft)</td><td>18.863</td><td>31.519</td></tr></table> <div>Material Properties</div> <div>f'ck = 2.5 ksi - Concrete strength,</div> | Layer                                    | Label                                      | Allowable Bearing Pressure (qa)<br>(psf) | Allowable Lateral Pressure (R)<br>(psf/ft) | 1 | Sand, silty sand, clayey sand, silty gravel & clayey gravel | 2000.000 | 150.000 | Load Component | ASD | LRFD | P (kip) | 5.021 | 8.207 | Vx (kip) | -2.598 | -4.330 | Vz (kip) | 0.000 | 0.000 | Mx (kipft) | 0.000 | 0.000 | Mz (kipft) | 18.863 | 31.519 |  |
| Layer          | Label                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Allowable Bearing Pressure (qa)<br>(psf) | Allowable Lateral Pressure (R)<br>(psf/ft) |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| 1              | Sand, silty sand, clayey sand, silty gravel & clayey gravel                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 2000.000                                 | 150.000                                    |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| Load Component | ASD                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | LRFD                                     |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| P (kip)        | 5.021                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 8.207                                    |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| Vx (kip)       | -2.598                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | -4.330                                   |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| Vz (kip)       | 0.000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0.000                                    |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| Mx (kipft)     | 0.000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0.000                                    |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| Mz (kipft)     | 18.863                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 31.519                                   |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
|                | <div>Required depth to resist lateral loads (ASD)</div> <div>H - Point of application of the lateral load</div> <div><math display="block">H = h_1 + h_2 + h_e</math><math display="block">H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})</math><math display="block">H = 0 \text{ ft}</math></div> <div>Considering x-direction:</div> <div>Ho - Lateral force per length of pile,</div> <div><math display="block">H_o = \frac{V_x}{1.57 \; D}</math><math display="block">H_o = \frac{(-2.598 \text{ kip})}{1.57 \times (48 \text{ in})}</math><math display="block">H_o = -0.41369 \text{ kip/ft}</math></div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                          |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |

|          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                    |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|
|          | <p><math>M_o</math> - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$ $M_o = \frac{(18.863 \text{ kipft}) + ((-2.598 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 3.0037 \text{ kipft/ft}$ <p>Required depth of embedment in earth:</p> $L_x^3 - \left( 14.14 \times \frac{H_o \times L_x}{R} \right) - \left( 18.85 \times \frac{M_o}{R} \right) = 0$ <p>Solving the cubic equation:<br/> <math>L_{e,x} = 4.9105 \text{ ft}</math> - Required depth in x-direction,</p> <p><b>Considering z-direction:</b><br/> <math>L_{e,z} = 0 \text{ ft}</math> - Required depth in z-direction,</p> <p><b>Minimum embedded depth required:</b><br/> <math>L_{e,req}</math> - Depth of pile required,</p> $L_{e,req} = MAX[L_{e,x}, L_{e,z}]$ $L_{e,req} = MAX[(4.9105 \text{ ft}), (0 \text{ ft})]$ $L_{e,req} = 4.911 \text{ ft}$ <p><math>L_e</math> - Actual embedded length of pile,</p> $L_e = L - h_e - h_2$ $L_e = (5.5 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 5.5 \text{ ft}$ <p>Ratio - Embedded depth</p> $Ratio = \frac{L_{e,req}}{L_e}$ $Ratio = \frac{(4.911 \text{ ft})}{(5.5 \text{ ft})}$ $Ratio = 0.89291$ | <p>Status: <b>PASS</b><br/>Ratio: <b>0.890</b></p> |
|          | <p><b>End-bearing Capacity (ASD)</b><br/> <math>A</math> - Pile cross-section area</p> $A = b D$ $A = (48 \text{ in}) \times (48 \text{ in})$ $A = 16 \text{ ft}^2$ <p><math>q</math> - End-bearing pressure</p> $q = \frac{P_v}{A}$ $q = \frac{(5.021 \text{ kip})}{(16 \text{ ft}^2)}$ $q = 0.31381 \text{ kip/ft}^2$ <p><b>Check bearing capacity ratio:</b><br/> Ratio - Capacity</p> $Ratio = \frac{q}{q_a}$ $Ratio = \frac{(0.31381 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $Ratio = 0.15691$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <p>Status: <b>PASS</b><br/>Ratio: <b>0.160</b></p> |
| Czerniak | <p><b>Lateral Soil Pressure (ASD):</b><br/> <math>L/D</math> - Length to least lateral dimension ratio,</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                    |

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

$$L/D = \frac{(5.5 \text{ ft})}{(48 \text{ in})}$$

$$L/D = 1.375$$

Since  $L/D \leq 10$ ,

Pile is short.

**Considering x-direction:**

$H_o = -0.41369 \text{ kip/ft}$  - Lateral force per length of pile,

$M_o = 3.0037 \text{ kipft/ft}$  - Overturning moment per length of pile,

$a$  - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (3.0037 \text{ kipft/ft}) \times (5.5 \text{ ft})) + (3 \times (-0.41369 \text{ kip/ft}) \times (5.5 \text{ ft})^2)}{(6 \times (3.0037 \text{ kipft/ft})) + (4 \times (-0.41369 \text{ kip/ft}) \times (5.5 \text{ ft}))}$$

$$a = 3.8205 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (3.0037 \text{ kipft/ft})) + (3 \times (-0.41369 \text{ kip/ft}) \times (5.5 \text{ ft}))]^2}{(5.5 \text{ ft})^2 \times [(3 \times (3.0037 \text{ kipft/ft})) + (2 \times (-0.41369 \text{ kip/ft}) \times (5.5 \text{ ft}))]}$$

$$p = 0.14965 \text{ kip/ft}^2$$

$s$  - Earth pressure against the pile at distance  $L_e$ ,

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

$$s = \frac{6 \times [(2 \times (3.0037 \text{ kipft/ft})) + ((-0.41369 \text{ kip/ft}) \times (5.5 \text{ ft}))]}{(5.5 \text{ ft})^2}$$

$$s = 0.74023 \text{ kip/ft}^2$$

**Check lateral soil pressure capacity:**

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(3.8205 \text{ ft})}{2}$$

$$p_a = 0.28653 \text{ kip/ft}^2$$

**Ratio** - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.14965 \text{ kip/ft}^2)}{(0.28653 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.52228$$

$p_s$  - Allowable lateral soil pressure at depth  $L_e$ ,

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (5.5 \text{ ft})$$

$$p_s = 0.825 \text{ kip/ft}^2$$

**Ratio** - Lateral soil capacity

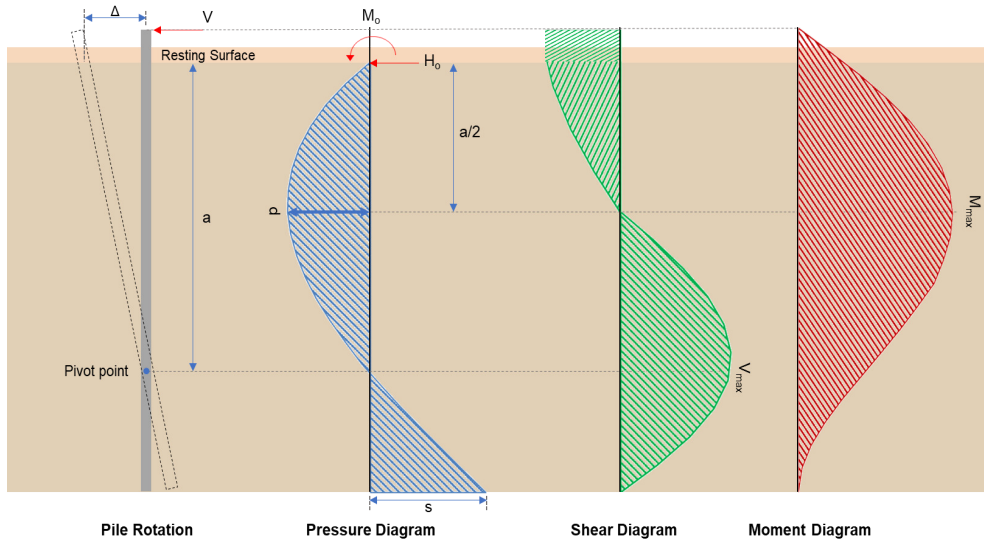
$$\text{Ratio} = \frac{s}{p_s}$$

$$\text{Ratio} = \frac{(0.74023 \text{ kip/ft}^2)}{(0.825 \text{ kip/ft}^2)}$$

Status: **PASS**  
Ratio: **0.520**

$$Ratio = 0.89725$$

Status: **PASS**  
Ratio: **0.900**



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

$H_o$  - Lateral force per length of pile,

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

$$H_o = \frac{(-4.33 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.68949 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

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

$$M_o = \frac{(31.519 \text{ kipft}) + ((-4.33 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 5.0189 \text{ kipft/ft}$$

$E$  - Distance from lateral load to resisting surface,

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

$$E = \frac{(5.0189 \text{ kipft/ft})}{(-0.68949 \text{ kip/ft})}$$

$$E = 7.2792 \text{ ft}$$

$a$  - Distance from resting surface to pivot point,

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

$$a = \frac{(4 \times (5.0189 \text{ kipft/ft}) \times (5.5 \text{ ft})) + (3 \times (-0.68949 \text{ kip/ft}) \times (5.5 \text{ ft})^2)}{(6 \times (5.0189 \text{ kipft/ft})) + (4 \times (-0.68949 \text{ kip/ft}) \times (5.5 \text{ ft}))}$$

$$a = 3.8202 \text{ ft}$$

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

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

$$V_{max} = ((-0.68949 \text{ kip/ft}) \times (48 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (7.2792 \text{ ft})}{(5.5 \text{ ft})} + 3 \right) \times \left( \frac{(3.8202 \text{ ft})}{(5.5 \text{ ft})} \right)^2 \right] + \left[ 4 \times \left( \frac{3 \times (7.2792 \text{ ft})}{(5.5 \text{ ft})} + 2 \right) \times \left( \frac{(3.8202 \text{ ft})}{(5.5 \text{ ft})} \right)^3 \right] \right]$$

|                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                    |
|-------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|
|                                                 | $V_{max} = 8.2111 \text{ kip}$ <p><math>M_{max}</math> - Max bending moment located at depth a/2,</p> $M_{max} = (H_o D L_e) \left[ \left( \frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[ \left( \frac{4 E}{L_e} + 3 \right) \left( \frac{a}{2 L_e} \right)^3 + \left[ \left( \frac{3 E}{L_e} + 2 \right) \left( \frac{a}{2 L_e} \right)^4 \right] \right] \right]$ $M_{max} = ((-0.68949 \text{ kip/ft}) \times (48 \text{ in}) \times (5.5 \text{ ft})) \times \left[ \left( \frac{(7.2792 \text{ ft})}{(5.5 \text{ ft})} + \frac{(3.8202 \text{ ft})}{2 \times (5.5 \text{ ft})} \right) - \left[ \left( \frac{4 \times (7.2792 \text{ ft})}{(5.5 \text{ ft})} + 3 \right) \times \left( \frac{(3.8202 \text{ ft})}{2 \times (5.5 \text{ ft})} \right)^3 + \left[ \left( \frac{3 \times (7.2792 \text{ ft})}{(5.5 \text{ ft})} + 2 \right) \times \left( \frac{(3.8202 \text{ ft})}{2 \times (5.5 \text{ ft})} \right)^4 \right] \right] \right]$ $M_{max} = 21.391 \text{ kipft}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                    |
| <p>Table 22.4.2.1</p> <p>22.4.2.2, 10.6.1.1</p> | <p><b>Minimum Reinforcement Check (LRFD)</b></p> <p><b>Parameters:</b></p> <p><math>f'_{ck} = 2.5 \text{ ksi}</math> - Concrete strength,<br/> <math>f_{yk} = 60 \text{ ksi}</math> - Longitudinal reinforcement strength,<br/> <math>\phi = 0.65</math> - Reduction factor for axial strength,<br/> <math>\alpha = 0.8</math> - Alpha factor for axial strength,<br/> <math>A_g = 2304 \text{ in}^2</math> - Gross area of concrete,</p> <p><b>Longitudinal reinforcement:</b></p> <p>Required reinforcement due to axial load, <math>A_{st,required}</math></p> $A_{st,required} = \text{Min} \left[ \frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = \text{Min} \left[ \frac{\frac{(8.207 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -84.323 \text{ in}^2$ <p><math>A_{min}</math> - Governing minimum reinforcement area,</p> $A_{min} = \text{Max} [A_{st,required}, (0.0018 A_g)]$ $A_{min} = \text{Max} [(-84.323 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ <p><math>n_{rebar}</math> - Required number of reinforcement,</p> $n_{rebar} = \frac{A_{min}}{A_{rebar}}$ $n_{rebar} = \frac{(4.1472 \text{ in}^2)}{(0.3068 \text{ in}^2)}$ $n_{rebar} = 14$ <p><math>A_{st}</math> - Actual total reinforcement area,</p> $A_{st} = n_{rebar} \frac{\pi d_{bar}^2}{4}$ $A_{st} = (14) \times \frac{\pi \times (0.625 \text{ in})^2}{4}$ $A_{st} = 4.2951 \text{ in}^2$ <p><b>Ratio</b> - Capacity</p> $\text{Ratio} = \frac{A_{min}}{A_{st}}$ $\text{Ratio} = \frac{(4.1472 \text{ in}^2)}{(4.2951 \text{ in}^2)}$ $\text{Ratio} = 0.96556$ <p>25.2.3 <math>s_{rebar}</math> - Minimum spacing of reinforcement,</p> $s_{rebar} = \text{Max} [1.5, (1.5 d_{bar})]$ | <p>Status: <b>PASS</b><br/>Ratio: <b>0.970</b></p> |



$$V_{c,a} = \left[ 2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(8207 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 119.58 \text{ kip}$$

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

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

$$V_c = \text{Min}[(296.21 \text{ kip}), (119.58 \text{ kip}), (348.89 \text{ kip})]$$

$$V_c = 119.58 \text{ kip}$$

22.5.1.2 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)

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

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

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

$V_s$  - 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  $\phi V_n$  - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((119.58 \text{ kip}) + (50.894 \text{ kip}))$$

$$\phi V_n = 110.81 \text{ kip}$$

**Considering x-direction:**

$V_{max} = 8.2777 \text{ kip}$  - Maximum shear force in the x-direction,

$Ratio$  - Capacity

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

$$Ratio = \frac{(8.2777 \text{ kip})}{(110.81 \text{ kip})}$$

$$Ratio = 0.074703$$

Status: **PASS**  
Ratio: **0.070**

**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,

$\phi M_n$  - 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:**

$M_{max} = 21.391 \text{ kipft}$  - Maximum moment in the x-direction,

Ratio - Capacity

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

$$\text{Ratio} = \frac{(21.391 \text{ kipft})}{(249.6 \text{ kipft})}$$

$$\text{Ratio} = 0.085703$$

Status: **PASS**  
Ratio: **0.090**