

# Your Project Calculations



Project Name: Chickaloon RevB- GS

S3D Model Link:

[https://platform.skyciv.com/structural?preload\\_name=Chickaloon%20RevB-%20GS&preload\\_path=Shared%20Enterprise%20Folder/MT\\_Solar\\_Projects/9\\_2023](https://platform.skyciv.com/structural?preload_name=Chickaloon%20RevB-%20GS&preload_path=Shared%20Enterprise%20Folder/MT_Solar_Projects/9_2023)

Public Model Link:

[https://platform.skyciv.com/structural-viewer?project\\_id=4Hcd5ohU0ry7oayHVVxaTzpxZleWCixJwDvK3jq8EKj7aR4ayUkwrU7RdKg8xYEc](https://platform.skyciv.com/structural-viewer?project_id=4Hcd5ohU0ry7oayHVVxaTzpxZleWCixJwDvK3jq8EKj7aR4ayUkwrU7RdKg8xYEc)

## Array Specification

|                             |                              |
|-----------------------------|------------------------------|
| Product:                    | Beam                         |
| Unique ID:                  | 1P-0-8TOP-SD-45-L-4Hx2W-03K9 |
| Duty Classification:        | SD                           |
| Module Width:               | 41.10 in                     |
| Module Length:              | 87.20in                      |
| Number of Rows:             | 4                            |
| Number of Columns:          | 2                            |
| Total Number of Modules:    | 8                            |
| Desired Tilt Angle:         | 65                           |
| Front Edge Clearance:       | 10                           |
| Total Array Height at Tilt: | 22.49 ft                     |
| Total Frame Length:         | 15.00 ft                     |
| Frame Weight:               | 1129 lbs                     |
| Array Dimensions N/S:       | 13.87 ft                     |
| Array Dimensions E/W:       | 14.70 ft                     |
| Rail Length:                | 166.40 in                    |
| Rail Spacing:               | 3.63 ft                      |
| Rail Check:                 | Not Checked                  |

## Support Specifications

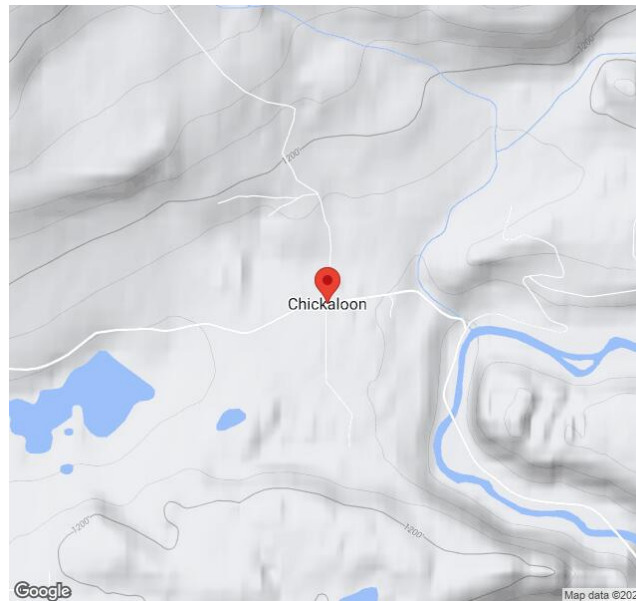
|                          |                 |
|--------------------------|-----------------|
| Pole Size:               | 8in Pipe Sch 80 |
| Pole Length above Grade: | 16.28 ft        |
| Number of Poles:         | 1               |
| Pole Spacing:            | 0               |

## Foundation Specifications

|                                 |                      |
|---------------------------------|----------------------|
| Foundation Type:                | Square               |
| Foundation Dimensions:          | 48 x 48 in           |
| Foundation Depth (below grade): | Pile 1: 8.25 ft      |
| Foundation Volume:              | 4.889 y <sup>3</sup> |
| Foundation Result:              | PASSED               |
| Mount Twist:                    | 0.000006 kip         |

## Site Info

|                            |                     |
|----------------------------|---------------------|
| Risk Category:             | I                   |
| Exposure:                  | C                   |
| Soil Classification:       | sand                |
| Site Location:             | Chickaloon, AK, USA |
| Wind Speed:                | 112 mph             |
| Snow Load:                 | 148 psf             |
| Design Uplift Pressure:    | 0.031561 ksf        |
| Design Downforce Pressure: | -0.031561 ksf       |
| Design Snow Pressure:      | 0.008137 ksf        |



### Design Disclaimer

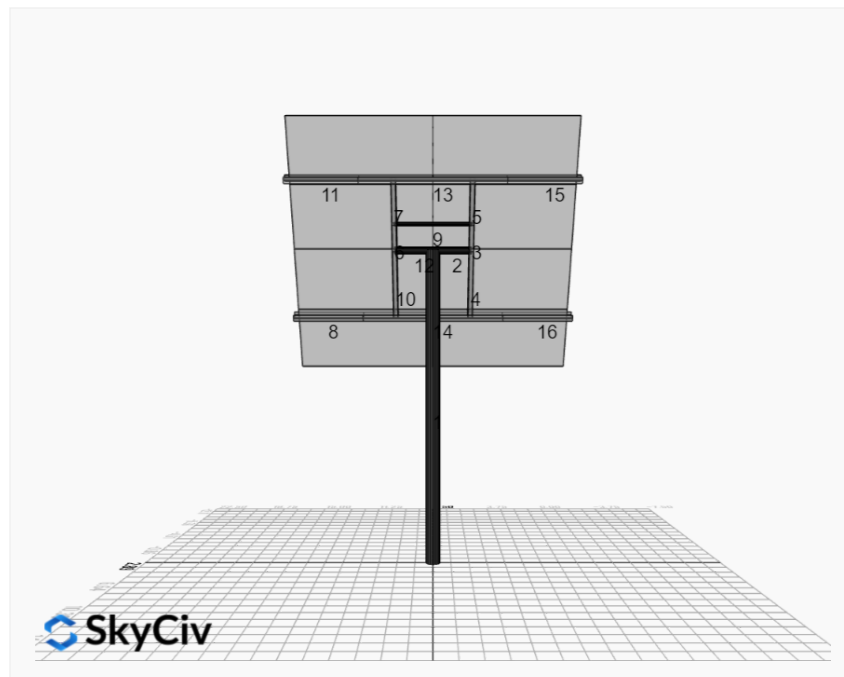
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

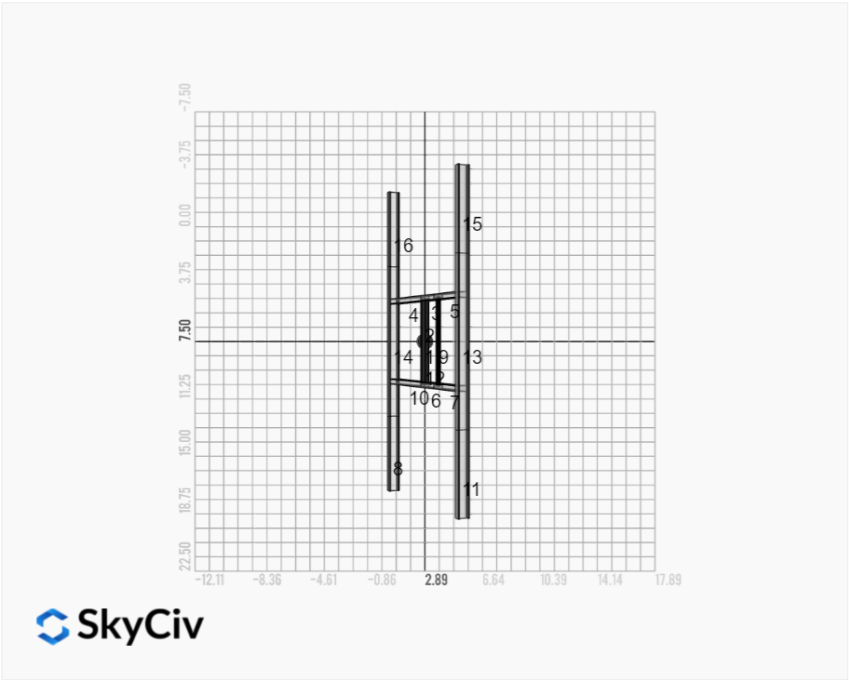
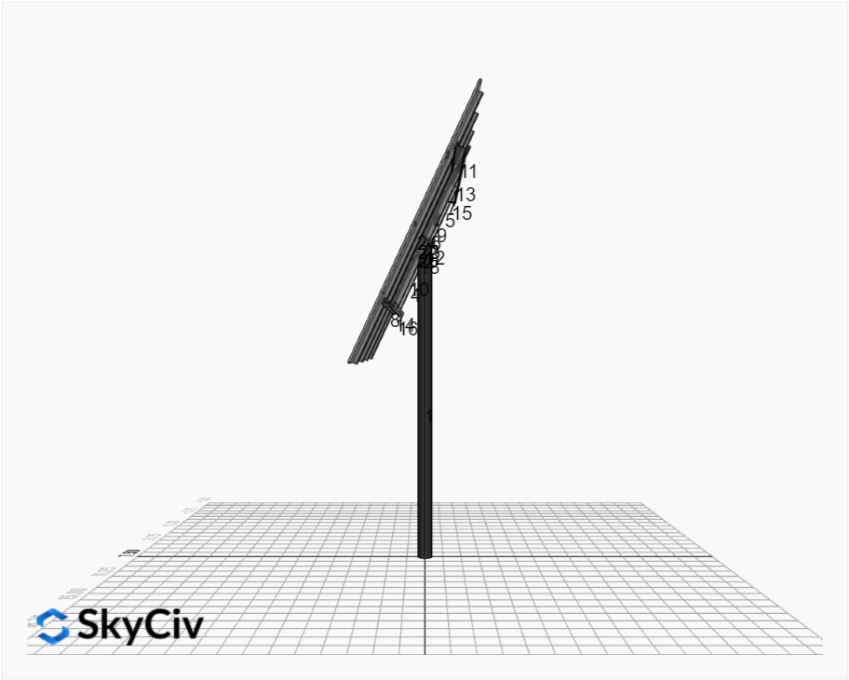
### AutoDesigner Input

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  "exposure_category": "C",
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### Design Notes:

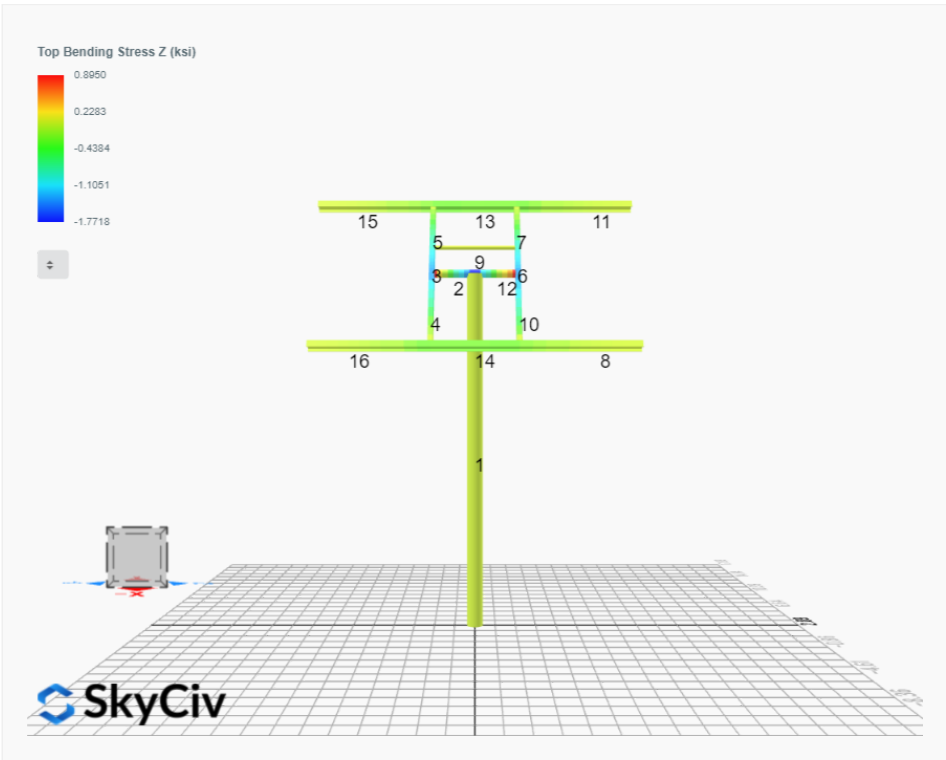
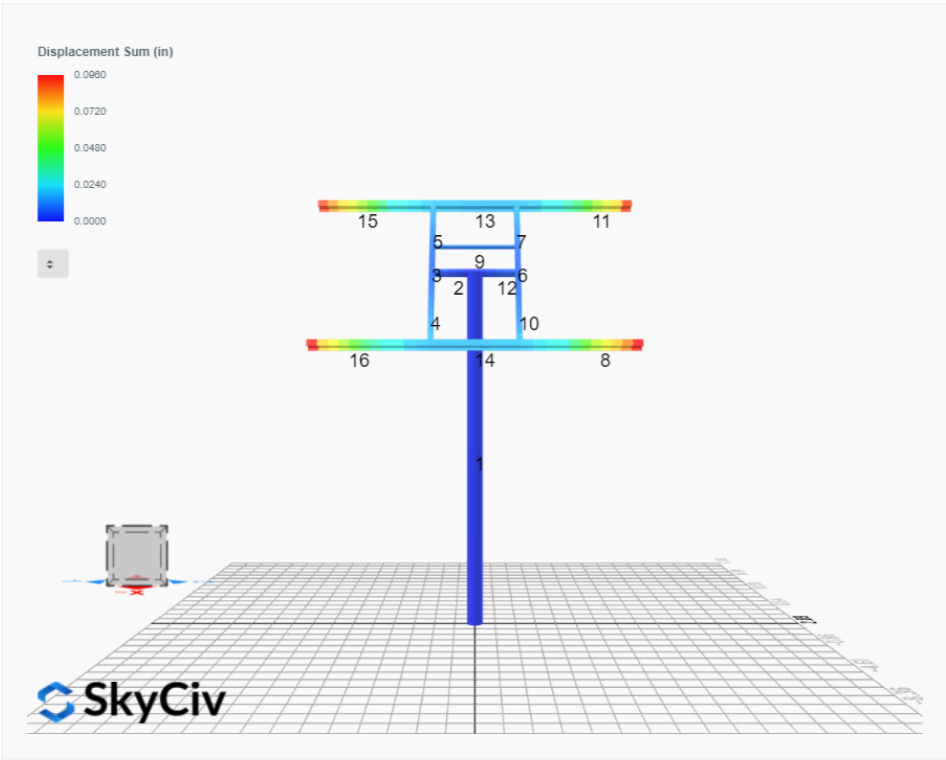
- AISC Deflection checks are set to L/1 due to structure design intent
- Foundation Design and Sizing is approximate only

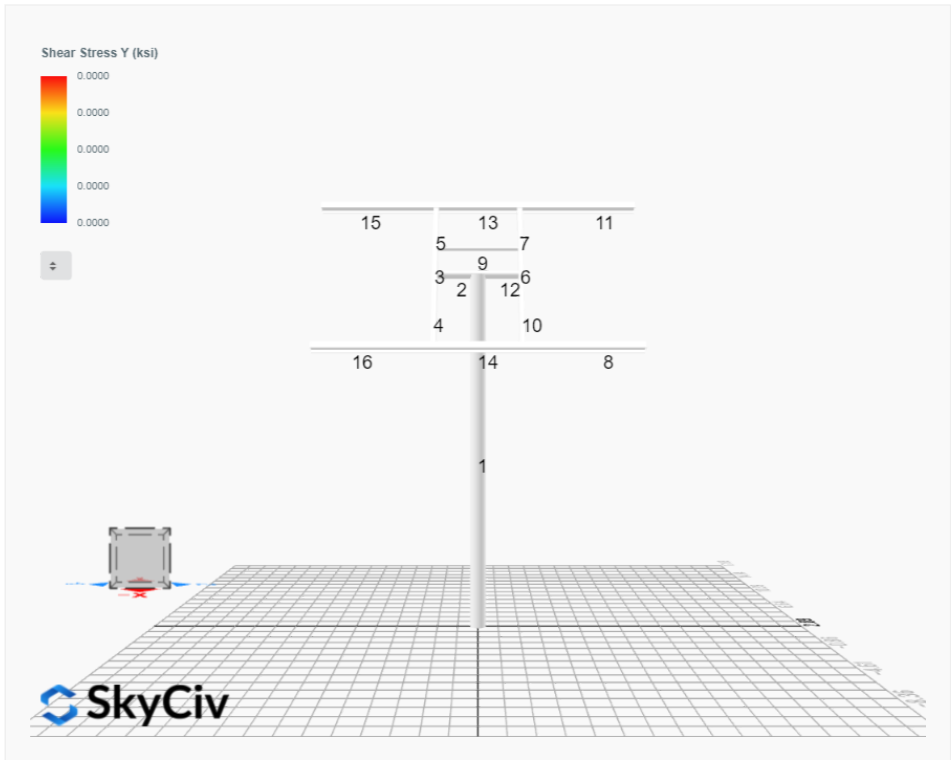
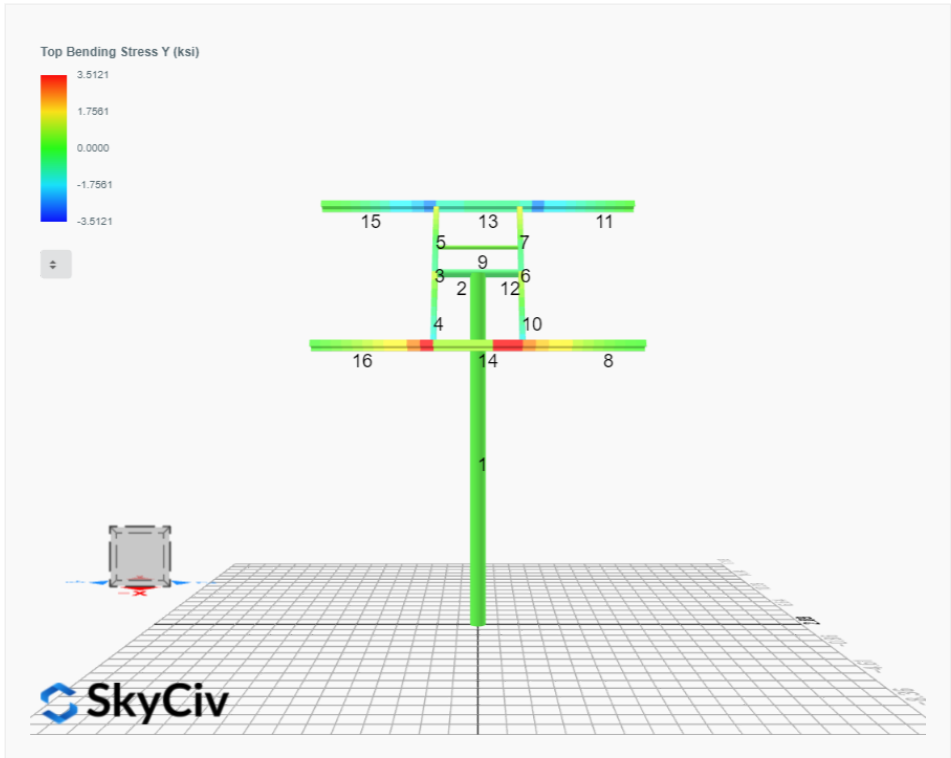


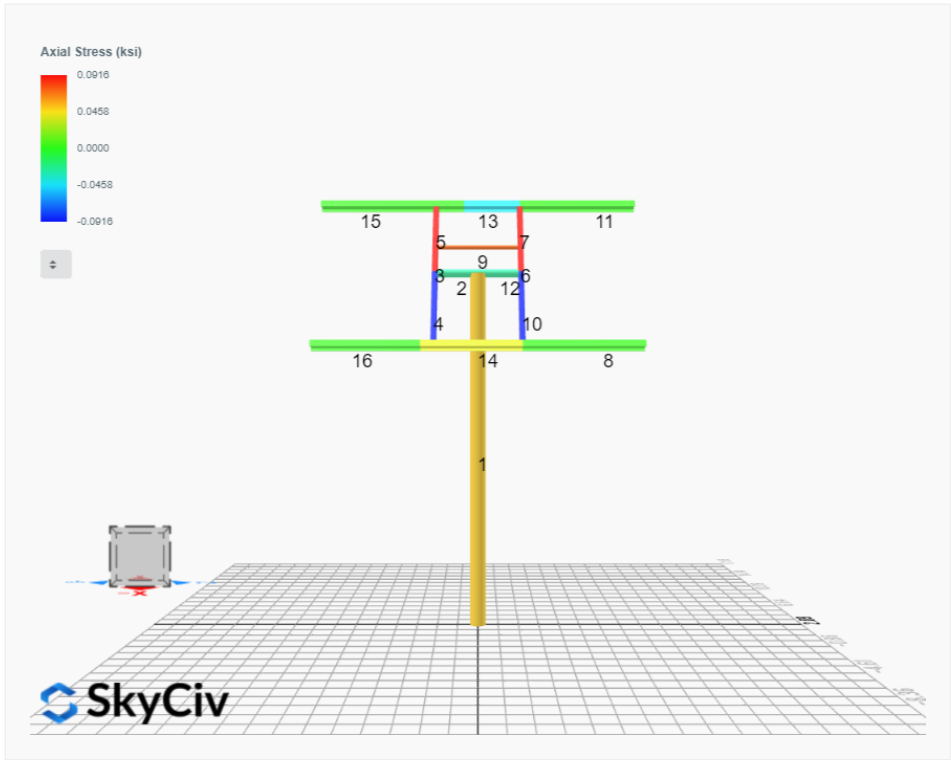




FEM Results (Envelope Worst Case for each member)







## 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 | 2.0643  | -0.0000 | 0.0000 | -0.0000 | 0.0102   |
| ULS: 2. D + L                                                                   | -0.0000 | 2.0643  | -0.0000 | 0.0000 | -0.0000 | 0.0102   |
| ULS: 3. D + (S or Lr or R)                                                      | 0.0000  | 2.7796  | -0.0000 | 0.0000 | -0.0000 | 0.0109   |
| ULS: 3. D + (S or Lr or R)                                                      | -0.0000 | 2.0643  | -0.0000 | 0.0000 | -0.0000 | 0.0102   |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R)                                          | 0.0000  | 2.6008  | -0.0000 | 0.0000 | -0.0000 | 0.0107   |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R)                                          | -0.0000 | 2.0643  | -0.0000 | 0.0000 | -0.0000 | 0.0102   |
| ULS: 5b. D + 0.7E                                                               | -0.0000 | 2.0643  | -0.0000 | 0.0000 | -0.0000 | 0.0102   |
| ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S                                         | 0.0000  | 2.6008  | -0.0000 | 0.0000 | -0.0000 | 0.0107   |
| ULS: 8. 0.6D + 0.7E                                                             | -0.0000 | 1.2386  | -0.0000 | 0.0000 | -0.0000 | 0.0061   |
| ULS: 5a. D + 0.6W_Wind downforce Case A only                                    | -3.4984 | 3.6956  | 0.0000  | 0.0000 | -0.0000 | 57.6288  |
| ULS: 5a. D + 0.6W_Wind downforce Case B only                                    | -0.0000 | 2.0643  | -0.0000 | 0.0000 | -0.0000 | 0.0102   |
| ULS: 5a. D + 0.6W_Wind uplift Case A only                                       | 3.4984  | 0.4330  | -0.0000 | 0.0000 | -0.0000 | -56.3221 |
| ULS: 5a. D + 0.6W_Wind uplift Case B only                                       | -0.0000 | 2.0643  | -0.0000 | 0.0000 | -0.0000 | 0.0102   |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -2.6238 | 3.8243  | 0.0000  | 0.0000 | -0.0000 | 43.2246  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | 0.0000  | 2.6008  | -0.0000 | 0.0000 | -0.0000 | 0.0107   |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only    | 2.6238  | 1.3773  | -0.0000 | 0.0000 | -0.0000 | -42.2385 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only    | 0.0000  | 2.6008  | -0.0000 | 0.0000 | -0.0000 | 0.0107   |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -2.6238 | 3.2878  | 0.0000  | 0.0000 | -0.0000 | 43.2241  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | -0.0000 | 2.0643  | -0.0000 | 0.0000 | -0.0000 | 0.0102   |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only    | 2.6238  | 0.8408  | -0.0000 | 0.0000 | -0.0000 | -42.2391 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only    | -0.0000 | 2.0643  | -0.0000 | 0.0000 | -0.0000 | 0.0102   |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case A only                                  | -3.4984 | 2.8699  | 0.0000  | 0.0000 | -0.0000 | 57.6247  |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case B only                                  | -0.0000 | 1.2386  | -0.0000 | 0.0000 | -0.0000 | 0.0061   |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case A only                                     | 3.4984  | -0.3927 | -0.0000 | 0.0000 | -0.0000 | -56.3262 |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case B only                                     | -0.0000 | 1.2386  | -0.0000 | 0.0000 | -0.0000 | 0.0061   |

### 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            | 5.5537              |
| Shear X          | -5.8306             |
| Shear Z          | 0.0000              |
| Moment X         | 0.0000              |
| Moment Y (Twist) | 0.0000              |
| Moment Z         | 97.2537             |

### 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            | 3.8243              |
| Shear X          | -3.4984             |
| Shear Z          | -0.0000             |
| Moment X         | 0.0000              |
| Moment Y (Twist) | 0.0000              |
| Moment Z         | 57.6288             |

## Project Details

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

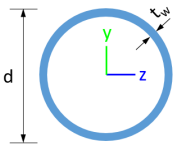
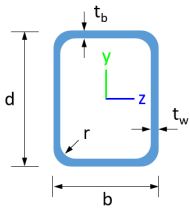
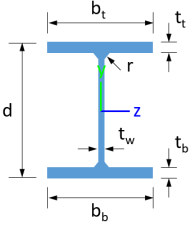
User Name: sales@mtsolar.us  
 Project Name: Chickaloon RevB- GS  
 Unit System: imperial



## 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       |            |            |            |            |        |
| 10                                                                                  | 8in Pipe Sch 80 | 8.63   | 0.50       |            |            |            |            |        |
|  |                 |        |            |            |            |            |            |        |
| 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> ) |
| 1                  | 2in Pipe Sch 40 | 1.07                 | 1.33                 | 0.67                        | 0.67                        | 0.00                     | 0.76                        | 0.76                        |
| 4                  | 4in Pipe Sch 40 | 3.17                 | 14.47                | 7.23                        | 7.23                        | 0.00                     | 4.31                        | 4.31                        |



|    |        |        |       |       |       |       |
|----|--------|--------|-------|-------|-------|-------|
| 10 | 79.65  | 72.01  | 10.99 | 4.60  | 29.14 | 16.61 |
| 11 | 120.60 | 54.44  | 23.36 | 6.45  | 30.09 | 45.74 |
| 12 | 142.83 | 141.72 | 16.17 | 16.17 | 42.85 | 42.85 |
| 13 | 120.60 | 98.23  | 18.31 | 6.45  | 30.09 | 45.74 |
| 14 | 120.60 | 98.23  | 18.31 | 6.45  | 30.09 | 45.74 |
| 15 | 120.60 | 54.44  | 23.36 | 6.45  | 30.09 | 45.74 |
| 16 | 120.60 | 54.44  | 23.36 | 6.45  | 30.09 | 45.74 |

## Design Ratio

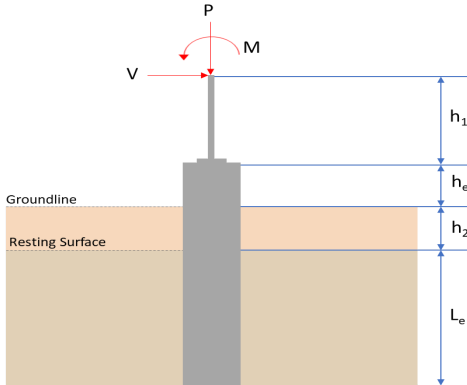
| Member ID | P     | M <sub>z</sub> | M <sub>y</sub> | V <sub>y</sub> | V <sub>z</sub> | (P,M <sub>z</sub> ,M <sub>y</sub> ) | Worst LC | KL/r         | δ            | Status |
|-----------|-------|----------------|----------------|----------------|----------------|-------------------------------------|----------|--------------|--------------|--------|
| 1         | 0.039 | 0.785          | 0.000          | 0.034          | 0.000          | 0.804                               | #13      | 0.713        | Not Required | Pass   |
| 2         | 0.002 | 0.235          | 0.343          | 0.055          | 0.068          | 0.578                               | #13      | 0.034        | Not Required | Pass   |
| 3         | 0.008 | 0.623          | 0.084          | 0.062          | 0.009          | 0.686                               | #13      | 0.044        | Not Required | Pass   |
| 4         | 0.008 | 0.621          | 0.177          | 0.062          | 0.022          | 0.711                               | #13      | 0.078        | Not Required | Pass   |
| 5         | 0.008 | 0.387          | 0.183          | 0.062          | 0.027          | 0.417                               | #13      | 0.073        | Not Required | Pass   |
| 6         | 0.008 | 0.623          | 0.084          | 0.062          | 0.009          | 0.686                               | #13      | 0.044        | Not Required | Pass   |
| 7         | 0.008 | 0.387          | 0.183          | 0.062          | 0.027          | 0.417                               | #13      | 0.073        | Not Required | Pass   |
| 8         | 0.000 | 0.072          | 0.086          | 0.030          | 0.006          | 0.132                               | #13      | Not Required | Not Required | Pass   |
| 9         | 0.007 | 0.029          | 0.066          | 0.001          | 0.000          | 0.095                               | #13      | 0.198        | Not Required | Pass   |
| 10        | 0.008 | 0.620          | 0.177          | 0.062          | 0.022          | 0.711                               | #13      | 0.078        | Not Required | Pass   |
| 11        | 0.000 | 0.072          | 0.086          | 0.030          | 0.006          | 0.132                               | #13      | Not Required | Not Required | Pass   |
| 12        | 0.002 | 0.235          | 0.343          | 0.055          | 0.068          | 0.578                               | #13      | 0.034        | Not Required | Pass   |
| 13        | 0.004 | 0.208          | 0.184          | 0.044          | 0.009          | 0.326                               | #13      | 0.177        | Not Required | Pass   |
| 14        | 0.004 | 0.212          | 0.184          | 0.044          | 0.009          | 0.326                               | #13      | 0.177        | Not Required | Pass   |
| 15        | 0.000 | 0.072          | 0.086          | 0.030          | 0.006          | 0.132                               | #13      | Not Required | Not Required | Pass   |
| 16        | 0.000 | 0.072          | 0.086          | 0.030          | 0.006          | 0.132                               | #13      | Not Required | Not Required | Pass   |

## Definitions

|                                     |                                                           |
|-------------------------------------|-----------------------------------------------------------|
| $\Phi_t$                            | Safety factor for tensile                                 |
| $\Phi_c$                            | Safety factor for compression                             |
| $\Phi_b$                            | Safety factor for flexure                                 |
| $\Phi_v$                            | Safety factor for shear                                   |
| E                                   | Modulus of elasticity                                     |
| F <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                                      |

OK  
NG

Capacity is provided  
Capacity is not provided

| REFERENCES     | CALCULATIONS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | RESULTS                                   |                                            |                                           |                                            |   |                                                             |          |         |                |     |      |         |       |       |           |        |        |           |       |       |             |       |       |             |        |        |  |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|--------------------------------------------|-------------------------------------------|--------------------------------------------|---|-------------------------------------------------------------|----------|---------|----------------|-----|------|---------|-------|-------|-----------|--------|--------|-----------|-------|-------|-------------|-------|-------|-------------|--------|--------|--|
|                | <div><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>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                           |                                            |                                           |                                            |   |                                                             |          |         |                |     |      |         |       |       |           |        |        |           |       |       |             |       |       |             |        |        |  |
|                | <div><div>Pile Input</div><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 = 8.25 ft - Total pile length</div><div>h_1 = 0 ft - Lateral load height from the top of the pile,</div><div>h_2 = 0 ft - Depth to resisting surface</div><div>h_e = 0 ft - Length of pile above the ground</div></div><div><div>Tabulation of Soil Parameters</div><table><tr><th>Layer</th><th>Label</th><th>Allowable Bearing Pressure (q_a)<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><div><div>Tabulation of Loads</div><table><tr><th>Load Component</th><th>ASD</th><th>LRFD</th></tr><tr><td>P (kip)</td><td>3.824</td><td>5.554</td></tr><tr><td>V_x (kip)</td><td>-3.498</td><td>-5.831</td></tr><tr><td>V_z (kip)</td><td>0.000</td><td>0.000</td></tr><tr><td>M_x (kipft)</td><td>0.000</td><td>0.000</td></tr><tr><td>M_z (kipft)</td><td>57.629</td><td>97.254</td></tr></table></div><div><div>Material Properties</div><div>f'_ck = 2.5 ksi - Concrete strength,</div></div></div> | Layer                                     | Label                                      | Allowable Bearing Pressure (q_a)<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) | 3.824 | 5.554 | V_x (kip) | -3.498 | -5.831 | V_z (kip) | 0.000 | 0.000 | M_x (kipft) | 0.000 | 0.000 | M_z (kipft) | 57.629 | 97.254 |  |
| Layer          | Label                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Allowable Bearing Pressure (q_a)<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)        | 3.824                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 5.554                                     |                                            |                                           |                                            |   |                                                             |          |         |                |     |      |         |       |       |           |        |        |           |       |       |             |       |       |             |        |        |  |
| V_x (kip)      | -3.498                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | -5.831                                    |                                            |                                           |                                            |   |                                                             |          |         |                |     |      |         |       |       |           |        |        |           |       |       |             |       |       |             |        |        |  |
| V_z (kip)      | 0.000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0.000                                     |                                            |                                           |                                            |   |                                                             |          |         |                |     |      |         |       |       |           |        |        |           |       |       |             |       |       |             |        |        |  |
| M_x (kipft)    | 0.000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0.000                                     |                                            |                                           |                                            |   |                                                             |          |         |                |     |      |         |       |       |           |        |        |           |       |       |             |       |       |             |        |        |  |
| M_z (kipft)    | 57.629                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 97.254                                    |                                            |                                           |                                            |   |                                                             |          |         |                |     |      |         |       |       |           |        |        |           |       |       |             |       |       |             |        |        |  |
|                | <div><div>Required depth to resist lateral loads (ASD)</div><div>H - Point of application of the lateral load</div><div><div><div><div><div><math>H = h_1 + h_2 + h_e</math></div><div><math>H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})</math></div><div><math>H = 0 \text{ ft}</math></div></div></div><div>Considering x-direction:</div><div>H_o - Lateral force per length of pile,</div><div><div><div><math>H_o = \frac{V_x}{1.57 D}</math></div><div><math>H_o = \frac{(-3.498 \text{ kip})}{1.57 \times (48 \text{ in})}</math></div><div><math>H_o = -0.55701 \text{ kip/ft}</math></div></div></div><div>M_o - Moment per length of pile,</div><div><div><math>M_o = \frac{M_z + (V_x H)}{1.57 D}</math></div></div></div></div></div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                           |                                            |                                           |                                            |   |                                                             |          |         |                |     |      |         |       |       |           |        |        |           |       |       |             |       |       |             |        |        |  |

|          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                    |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|
|          | $M_o = \frac{(57.629 \text{ kipft}) + ((-3.498 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 9.1766 \text{ kipft/ft}$ <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} = 7.7949 \text{ ft}</math> - Required depth in x-direction,</p> <p><b>Considering z-direction:</b></p> $L_{e,z} = 0 \text{ ft}$ - Required depth in z-direction, <p><b>Minimum embedded depth required:</b></p> $L_{e,req}$ - Depth of pile required, $L_{e,req} = \text{MAX}[L_{e,x}, L_{e,z}]$ $L_{e,req} = \text{MAX}[(7.7949 \text{ ft}), (0 \text{ ft})]$ $L_{e,req} = 7.795 \text{ ft}$ <p><math>L_e</math> - Actual embedded length of pile,</p> $L_e = L - h_e - h_2$ $L_e = (8.25 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 8.25 \text{ ft}$ <p><i>Ratio</i> - Embedded depth</p> $\text{Ratio} = \frac{L_{e,req}}{L_e}$ $\text{Ratio} = \frac{(7.795 \text{ ft})}{(8.25 \text{ ft})}$ $\text{Ratio} = 0.94485$ | <p>Status: <b>PASS</b><br/>Ratio: <b>0.940</b></p> |
|          | <p><b>End-bearing Capacity (ASD)</b></p> <p><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> $q = \frac{P_v}{A}$ $q = \frac{(3.824 \text{ kip})}{(16 \text{ ft}^2)}$ $q = 0.239 \text{ kip/ft}^2$ <p><b>Check bearing capacity ratio:</b></p> <p><i>Ratio</i> - Capacity</p> $\text{Ratio} = \frac{q}{q_a}$ $\text{Ratio} = \frac{(0.239 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $\text{Ratio} = 0.1195$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <p>Status: <b>PASS</b><br/>Ratio: <b>0.120</b></p> |
| Czerniak | <p><b>Lateral Soil Pressure (ASD):</b></p> <p><math>L/D</math> - Length to least lateral dimension ratio,</p> $L/D = \frac{L}{D}$ $L/D = \frac{(8.25 \text{ ft})}{(48 \text{ in})}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                    |

$$L/D = 2.0625$$

Since  $L/D \leq 10$ ,

Pile is short.

**Considering x-direction:**

$H_o = -0.55701$  kip/ft - Lateral force per length of pile,

$M_o = 9.1766$  kipft/ft - Overturning moment per length of pile,

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

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

$$a = \frac{(4 \times (9.1766 \text{ kipft/ft}) \times (8.25 \text{ ft})) + (3 \times (-0.55701 \text{ kip/ft}) \times (8.25 \text{ ft})^2)}{(6 \times (9.1766 \text{ kipft/ft})) + (4 \times (-0.55701 \text{ kip/ft}) \times (8.25 \text{ ft}))}$$

$$a = 5.6721 \text{ ft}$$

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

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

$$p = \frac{0.75 [(4 \times (9.1766 \text{ kipft/ft})) + (3 \times (-0.55701 \text{ kip/ft}) \times (8.25 \text{ ft}))]^2}{(8.25 \text{ ft})^3 [(3 \times (9.1766 \text{ kipft/ft})) + (2 \times (-0.55701 \text{ kip/ft}) \times (8.25 \text{ ft}))]}$$

$$p = 0.31566 \text{ kip/ft}^2$$

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

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

$$s = \frac{6 [(2 \times (9.1766 \text{ kipft/ft})) + ((-0.55701 \text{ kip/ft}) \times (8.25 \text{ ft}))]}{(8.25 \text{ ft})^2}$$

$$s = 1.2128 \text{ kip/ft}^2$$

**Check lateral soil pressure capacity:**

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(5.6721 \text{ ft})}{2}$$

$$p_a = 0.42541 \text{ kip/ft}^2$$

*Ratio* - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.31566 \text{ kip/ft}^2)}{(0.42541 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.74202$$

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

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (8.25 \text{ ft})$$

$$p_s = 1.2375 \text{ kip/ft}^2$$

*Ratio* - Lateral soil capacity

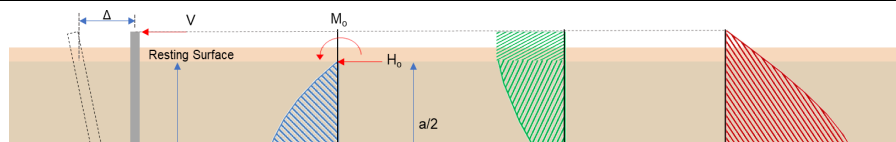
$$\text{Ratio} = \frac{s}{p_s}$$

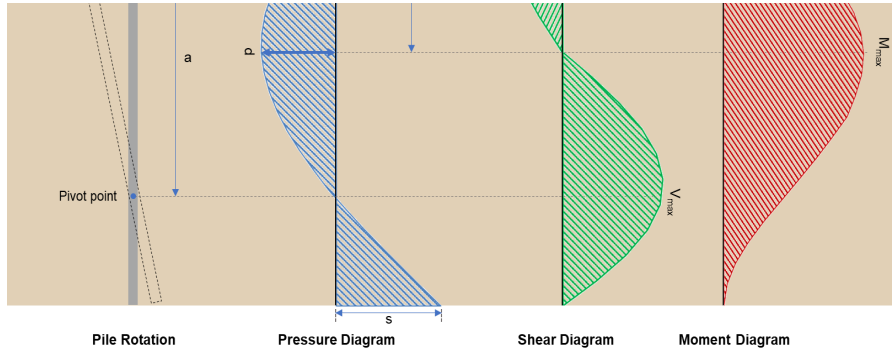
$$\text{Ratio} = \frac{(1.2128 \text{ kip/ft}^2)}{(1.2375 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.98005$$

Status: **PASS**  
Ratio: **0.740**

Status: **PASS**  
Ratio: **0.980**





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

$H_o$  - Lateral force per length of pile,

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

$$H_o = \frac{(-5.831 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.9285 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

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

$$M_o = \frac{(97.254 \text{ kipft}) + ((-5.831 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 15.486 \text{ kipft/ft}$$

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

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

$$E = \frac{(15.486 \text{ kipft/ft})}{(-0.9285 \text{ kip/ft})}$$

$$E = 16.679 \text{ ft}$$

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

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

$$a = \frac{(4 \times (15.486 \text{ kipft/ft}) \times (8.25 \text{ ft})) + (3 \times (-0.9285 \text{ kip/ft}) \times (8.25 \text{ ft})^2)}{(6 \times (15.486 \text{ kipft/ft})) + (4 \times (-0.9285 \text{ kip/ft}) \times (8.25 \text{ ft}))}$$

$$a = 5.6705 \text{ ft}$$

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

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

$$V_{max} = ((-0.9285 \text{ kip/ft}) \times (48 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (16.679 \text{ ft})}{(8.25 \text{ ft})} + 3 \right) \times \left( \frac{(5.6705 \text{ ft})}{(8.25 \text{ ft})} \right)^2 \right] + \left[ 4 \times \left( \frac{3 \times (16.679 \text{ ft})}{(8.25 \text{ ft})} + 2 \right) \times \left( \frac{(5.6705 \text{ ft})}{(8.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 15.739 \text{ kip}$$

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

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

$$M_{max} = ((-0.9285 \text{ kip/ft}) \times (48 \text{ in}) \times (8.25 \text{ ft})) \times \left[ \left( \frac{(16.679 \text{ ft})}{(8.25 \text{ ft})} + \frac{(5.6705 \text{ ft})}{2 \times (8.25 \text{ ft})} \right) - \left[ \left( \frac{4 \times (16.679 \text{ ft})}{(8.25 \text{ ft})} + 3 \right) \times \left( \frac{(5.6705 \text{ ft})}{2 \times (8.25 \text{ ft})} \right)^3 \right] + \left[ \left( \frac{3 \times (16.679 \text{ ft})}{(8.25 \text{ ft})} + 2 \right) \times \left( \frac{(5.6705 \text{ ft})}{2 \times (8.25 \text{ ft})} \right)^4 \right] \right]$$

|  |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                       |
|--|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
|  |  | $M_{max} = 62.134 \text{ kipft}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                       |
|  |  | <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> <p><math>A_{st,required}</math></p> $A_{st,required} = \text{Min} \left[ \frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = \text{Min} \left[ \frac{\frac{(5.554 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -84.412 \text{ in}^2$ <p><math>A_{min}</math> - Governing minimum reinforcement area,</p> $A_{min} = \text{Max} [A_{st,required}, (0.0018 A_g)]$ $A_{min} = \text{Max} [(-84.412 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ <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 - Capacity</b></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> $s_{rebar} = \text{Max} [1.5, (1.5 d_{bar})]$ $s_{rebar} = \text{Max} [1.5, (1.5 \times (0.625 \text{ in}))]$ $s_{rebar} = 1.5 \text{ in}$ <p><b>Ties:</b></p> <p>25.7.2.2 Since longitudinal reinforcement is <math>\leq \text{No. } 10\phi</math>: Use #3(0.375 in)</p> <p>25.7.2.1 <math>s_{ties}</math> - Maximum spacing of ties,</p> $s_{ties} = \text{Min} [(16 d_{bar}), (48 d_{ties}), \text{Min}(D, b)]$ $s_{ties} = \text{Min} [(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), \text{Min}((48 \text{ in}), (48 \text{ in}))]$ $s_{ties} = 10 \text{ in}$ <p><b>Summary:</b></p> <p>Main reinforcement: <b>14 - #5 (0.625 in)</b></p> |                                                       |
|  |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <p>Status: <b>PASS</b></p> <p>Ratio: <b>0.970</b></p> |

|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                            |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
|               | Ties: #3(0.375 in) - 10 in                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                            |
| 22.4.2.2      | <p><b>Axial Compression Strength (ACI 318-19, LRFD)</b></p> <p><math>\phi P_N</math> - Allowable axial compressive strength</p> $\phi P_N = \phi 0.80 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st})]$ $\phi P_N = (0.65) \times 0.80 \times [(0.85 \times (2.5 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2))]$ $\phi P_N = 2675.2 \text{ kip}$ <p>Ratio - Capacity</p> $\text{Ratio} = \frac{P}{\phi P_N}$ $\text{Ratio} = \frac{(5.554 \text{ kip})}{(2675.2 \text{ kip})}$ $\text{Ratio} = 0.0020761$                                                                                                                                                    | Status: <b>PASS</b><br>Ratio: <b>0.000</b> |
| 22.5.2.2      | <p><b>Shear Strength (ACI 318-19, LRFD)</b></p> <p><b>Parameters:</b></p> <p><math>b_w = 48 \text{ in}</math> - Effective width,<br/> <math>d</math> - Effective depth</p> $d = 0.80 D$ $d = 0.80 \times (48 \text{ in})$ $d = 38.4 \text{ in}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                            |
| 22.5.5.1.3    | <p><math>\lambda_s</math> - size effect modification factor</p> $\lambda_s = \text{MIN} \left[ \sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = \text{MIN} \left[ \sqrt{\frac{2}{1 + \frac{(38.4 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.64282$                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                            |
| 22.5.5.1.1    | <p>The following variables were converted to be consistent with empirical formula <math>f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}</math>,</p> <p><math>V_{c,max}</math> - Max shear strength of concrete</p> $V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$ $V_{c,max} = 5 \times (0.64282) \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,max} = 296.21 \text{ kip}$                                                                                                                                                                                                                                                                                                          |                                            |
| 22.5.5.1.1(a) | <p>The following variables were converted to be consistent with empirical formula <math>f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}</math>, <math>P = 5.554 \text{ kip} \rightarrow 5554 \text{ lbf}</math>,</p> <p><math>V_{c,a}</math> - Shear strength of concrete (a)</p> $V_{c,a} = \left[ 2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[ 2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(5554 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 119.23 \text{ kip}$                                                                                                                                       |                                            |
| 22.5.5.1.2    | <p>The following variables were converted to be consistent with empirical formula <math>f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}</math>,</p> <p><math>V_{c,b}</math> - Shear strength of concrete (b)</p> $V_{c,b} = \left[ 2 \lambda_s \sqrt{f'_{ck}} + (0.05 f'_{ck}) \right] b_w d$ $V_{c,b} = \left[ 2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + (0.05 \times (2500 \text{ psi})) \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,b} = 348.89 \text{ kip}$ <p><math>V_c</math> - Governing shear strength of concrete</p> $V_c = \text{Min}[V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = \text{Min}[(296.21 \text{ kip}), (119.23 \text{ kip}), (348.89 \text{ kip})]$ $V_c = 119.23 \text{ kip}$ |                                            |

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                     |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| <p>22.5.1.2</p>  | <p>The following variables were converted to be consistent with empirical formula <math>f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}</math>,<br/> <math>V_{s,a}</math> - Shear strength of steel (a)</p> $V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$ $V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{s,a} = 737.28 \text{ kip}$ <p><math>A_v</math> - Ties rebar area,</p> $A_v = \frac{\pi d_{ties}^2}{4}$ $A_v = \frac{\pi \times (0.375 \text{ in})^2}{4}$ $A_v = 0.11045 \text{ in}^2$ <p>22.5.8.5.3 <math>V_{s,b}</math> - Shear strength of steel (b)</p> $V_{s,b} = \frac{2 A_v f_{yw} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 50.894 \text{ kip}$ <p><math>V_s</math> - Governing shear strength of steel</p> $V_s = MIN[V_{s,a}, V_{s,b}]$ $V_s = MIN[(737.28 \text{ kip}), (50.894 \text{ kip})]$ $V_s = 50.894 \text{ kip}$ <p>22.5.1.1 <math>\phi V_n</math> - Allowable shear strength</p> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((119.23 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 110.58 \text{ kip}$ <p><b>Considering x-direction:</b></p> <p><math>V_{max} = 15.739 \text{ kip}</math> - Maximum shear force in the x-direction,<br/> <math>Ratio</math> - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(15.739 \text{ kip})}{(110.58 \text{ kip})}$ $Ratio = 0.14233$ | <p>Status: <b>PASS</b><br/> Ratio: <b>0.140</b></p> |
| <p>14.5.2.1b</p> | <p><b>Flexural Strength (ACI 318-19, LRFD)</b></p> <p><math>S_m</math> - Section modulus</p> $S_m = \frac{b D^2}{6}$ $S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$ $S_m = 18432 \text{ in}^3$ <p><math>\lambda = 1</math> - Concrete modification factor (Normal concrete),<br/> Allowable flexural strength:<br/> <math>M_n</math> shall be the lesser of:</p> <p><math>\phi M_{n,1}</math></p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 \text{ ksi})} \times 18432.001 \text{ in}^3$ $\phi M_{n,1} = 249.600 \text{ kipft}$ <p><math>\phi M_{n,2}</math></p> $\phi M_{n,2} = 0.85 f'_c S_m$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                     |

$$\phi M_{n,2} = \phi M_{n,1}$$

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

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

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:**

$M_{max} = 62.134 \text{ kipft}$  - Maximum moment in the x-direction,

*Ratio* - Capacity

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

$$\text{Ratio} = \frac{(62.134 \text{ kipft})}{(249.6 \text{ kipft})}$$

$$\text{Ratio} = 0.24893$$

Status: **PASS**  
Ratio: **0.250**