

# Your Project Calculations



Project Name: MichaelMurphy

S3D Model Link:

[https://platform.skyciv.com/structural?preload\\_name=MichaelMurphy&preload\\_path=Shared%20Enterprise%20Folder/MT\\_Solar\\_Projects/4\\_2023](https://platform.skyciv.com/structural?preload_name=MichaelMurphy&preload_path=Shared%20Enterprise%20Folder/MT_Solar_Projects/4_2023)

Public Model Link:

[https://platform.skyciv.com/structural-viewer?project\\_id=3sCpAjS4OiCOB8r4NB4LdrRijNsEcKhewZitGbJ743AqMuvaEwu8a45Cm5ldGlx5](https://platform.skyciv.com/structural-viewer?project_id=3sCpAjS4OiCOB8r4NB4LdrRijNsEcKhewZitGbJ743AqMuvaEwu8a45Cm5ldGlx5)

## Array Specification

|                             |                              |
|-----------------------------|------------------------------|
| Product:                    | Beam                         |
| Unique ID:                  | 1P-0-6TOP-SD-45-L-5Hx2W-CH88 |
| Duty Classification:        | SD                           |
| Module Width:               | 40.00 in                     |
| Module Length:              | 91.15in                      |
| Number of Rows:             | 5                            |
| Number of Columns:          | 2                            |
| Total Number of Modules:    | 10                           |
| Desired Tilt Angle:         | 60                           |
| Front Edge Clearance:       | 4                            |
| Total Array Height at Tilt: | 18.52 ft                     |
| Total Frame Length:         | 15.00 ft                     |
| Frame Weight:               | 637 lbs                      |
| Array Dimensions N/S:       | 16.88 ft                     |
| Array Dimensions E/W:       | 15.36 ft                     |
| Rail Length:                | 202.50 in                    |
| Rail Spacing:               | 3.80 ft                      |
| Rail Check:                 | Not Checked                  |

## Support Specifications

|                          |                 |
|--------------------------|-----------------|
| Pole Size:               | 6in Pipe Sch 40 |
| Pole Length above Grade: | 11.31 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: 5.50 ft      |
| Foundation Volume:              | 3.259 y <sup>3</sup> |
| Foundation Result:              | PASSED               |

## Site Info

|                            |                               |
|----------------------------|-------------------------------|
| Risk Category:             | I                             |
| Exposure:                  | C                             |
| Soil Classification:       | sand                          |
| Site Location:             | I-90, Garrison, MT 59731, USA |
| Wind Speed:                | 75 mph                        |
| Snow Load:                 | 50 psf                        |
| Design Uplift Pressure:    | 0.010858 ksf                  |
| Design Downforce Pressure: | -0.010858 ksf                 |
| Design Snow Pressure:      | 0.002749 ksf                  |



### Design Disclaimer

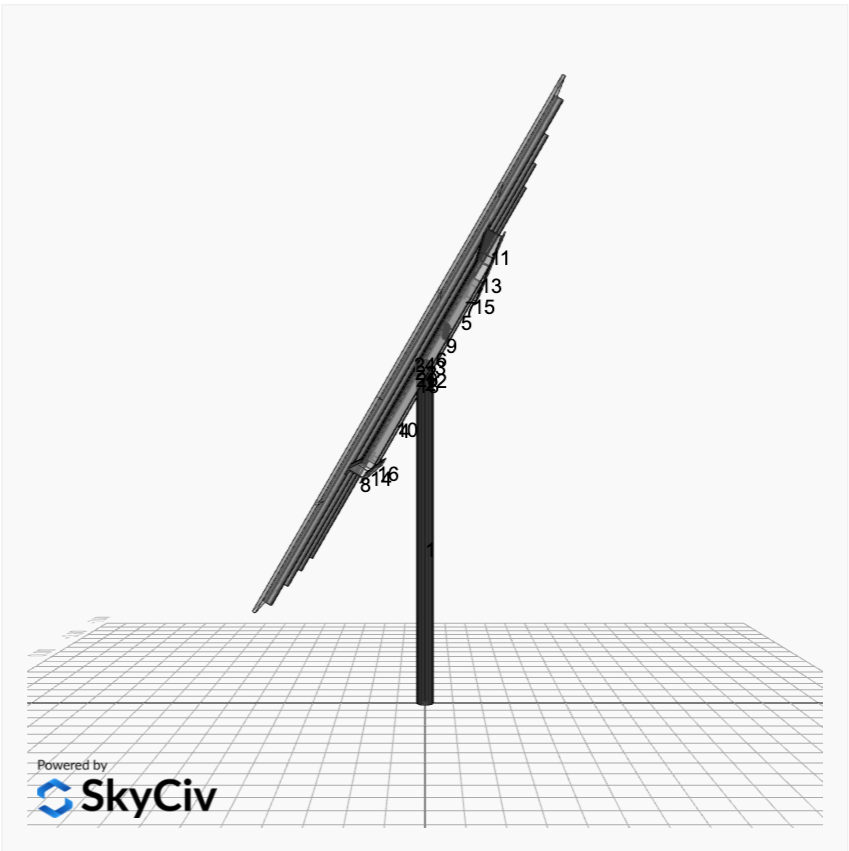
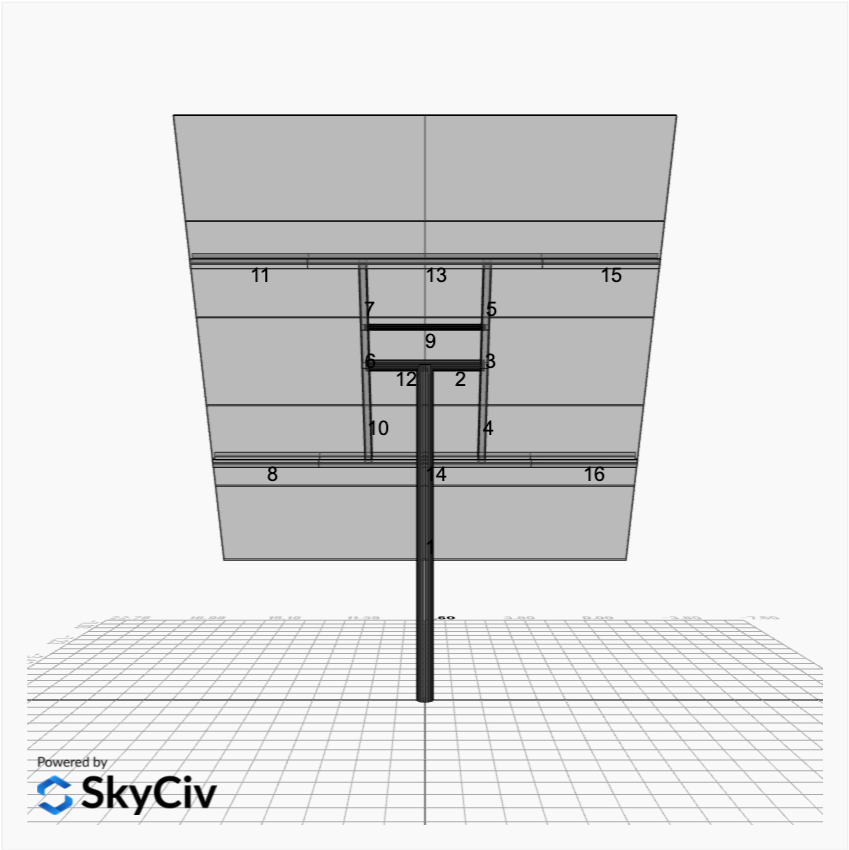
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

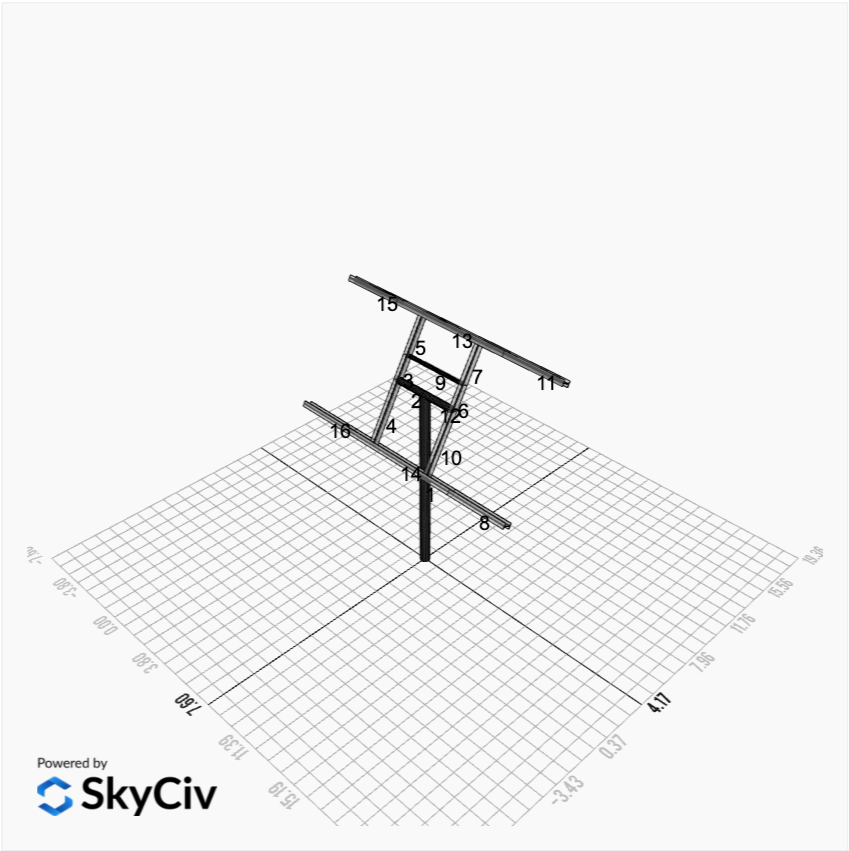
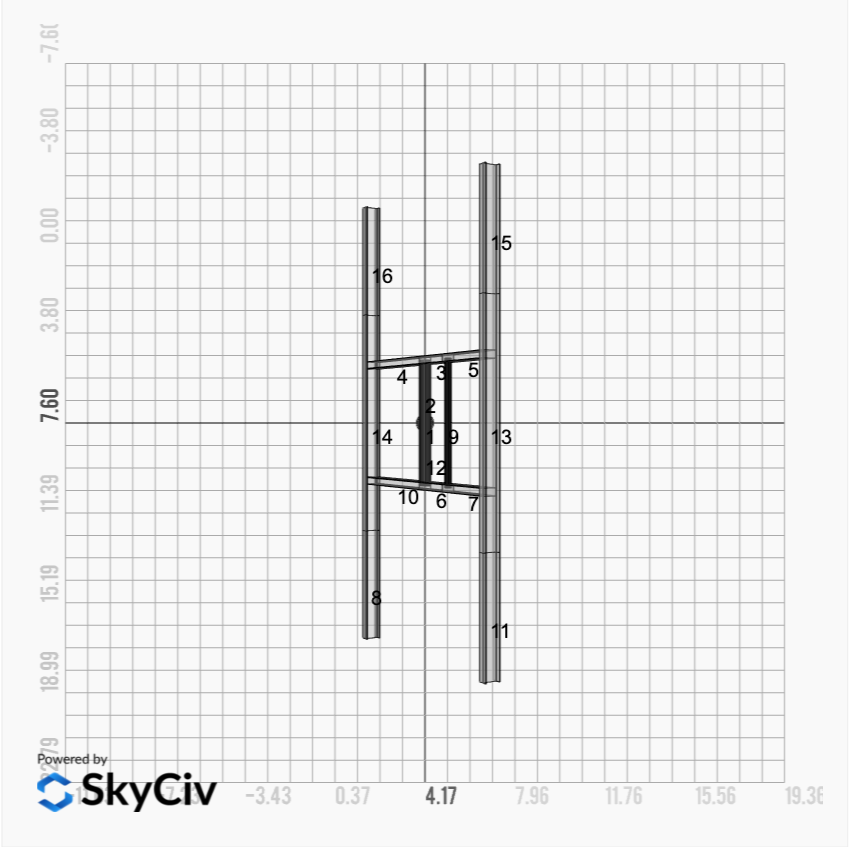
### AutoDesigner Input

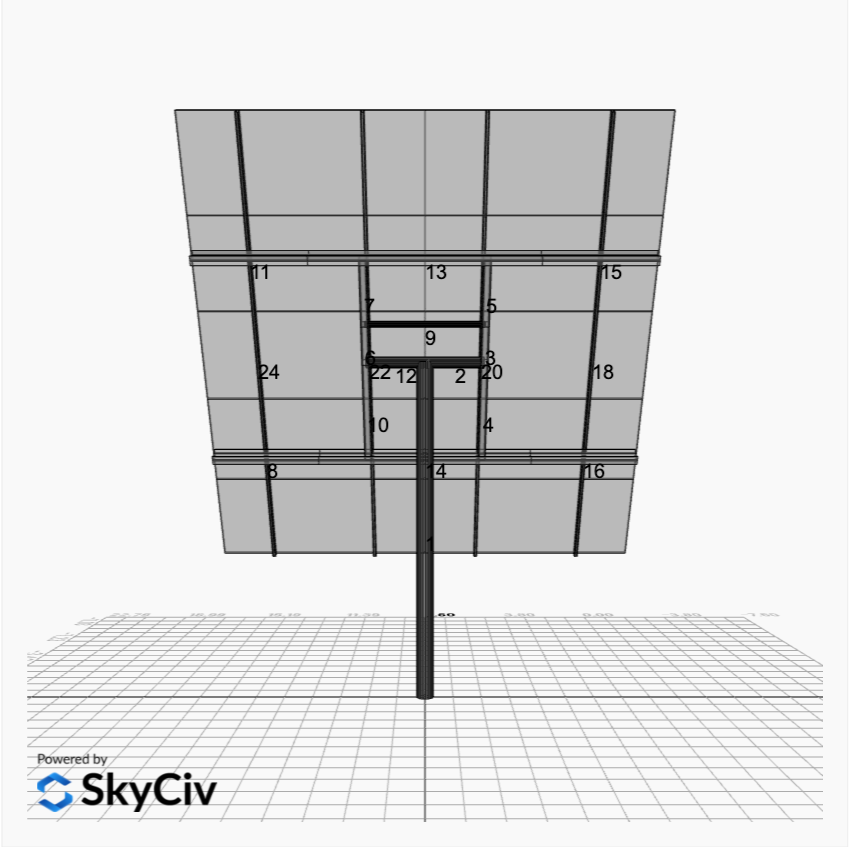
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### Design Notes:

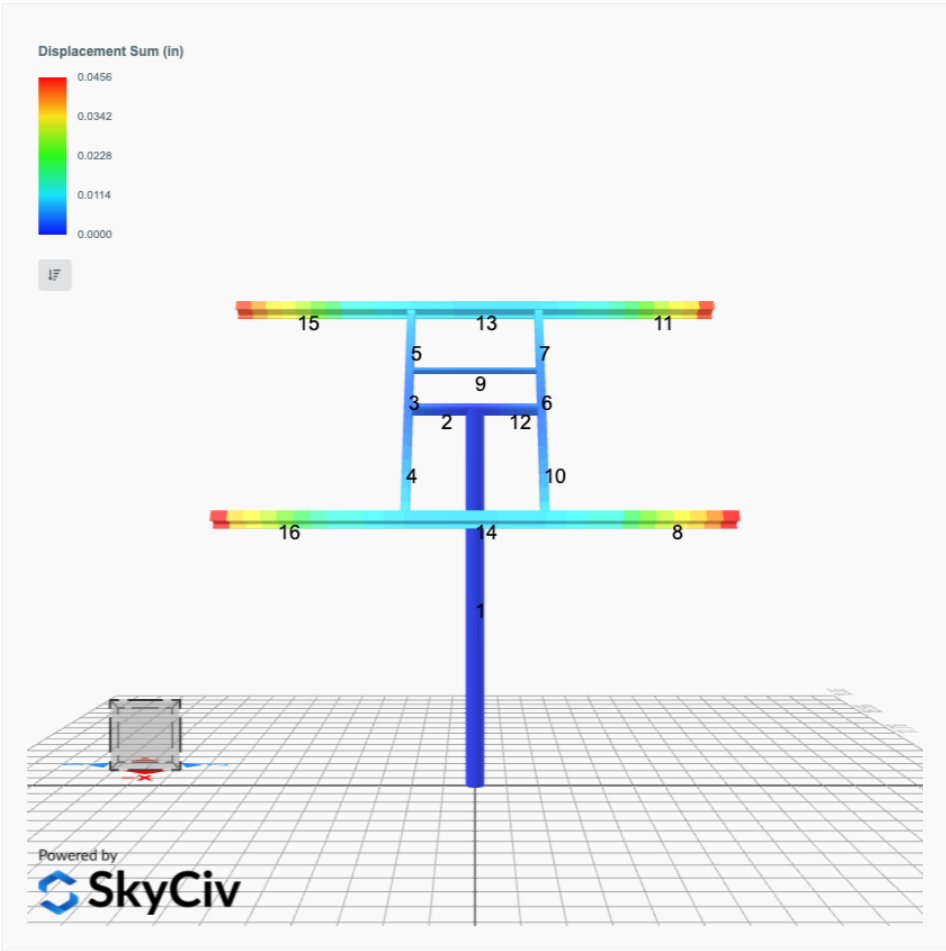
- AISC Deflection checks are set to L/1 due to structure design intent
- Foundation Design and Sizing is approximate only

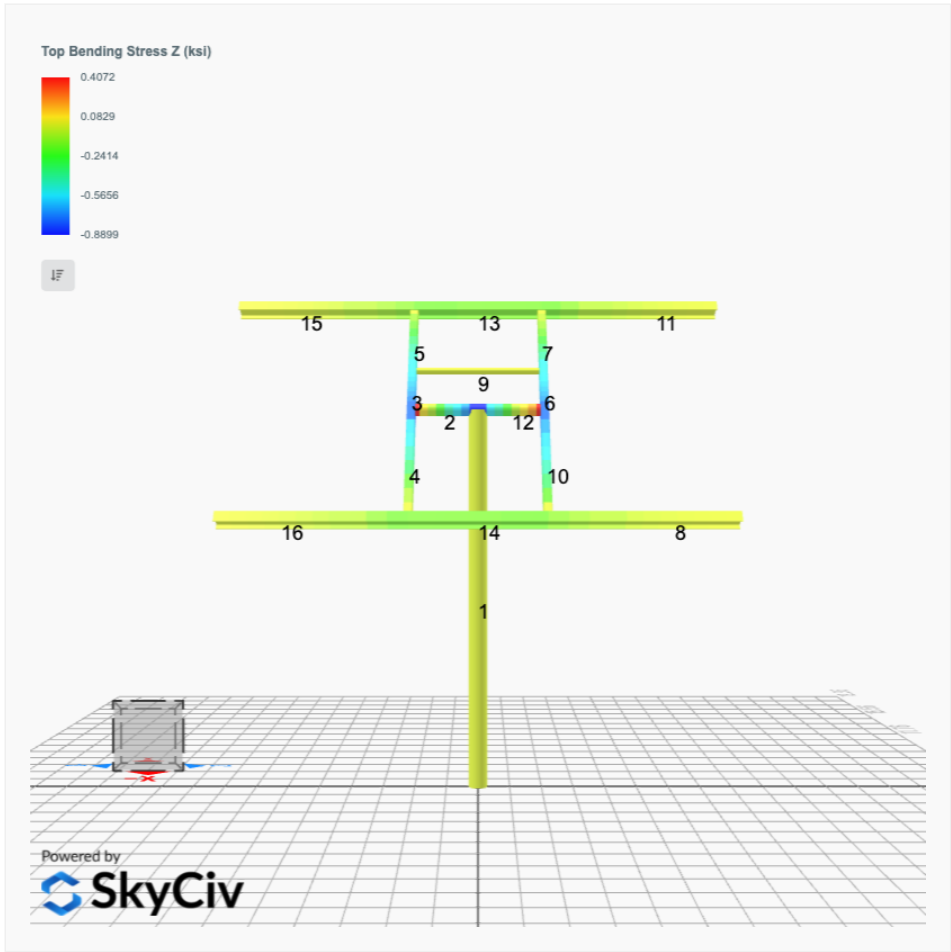


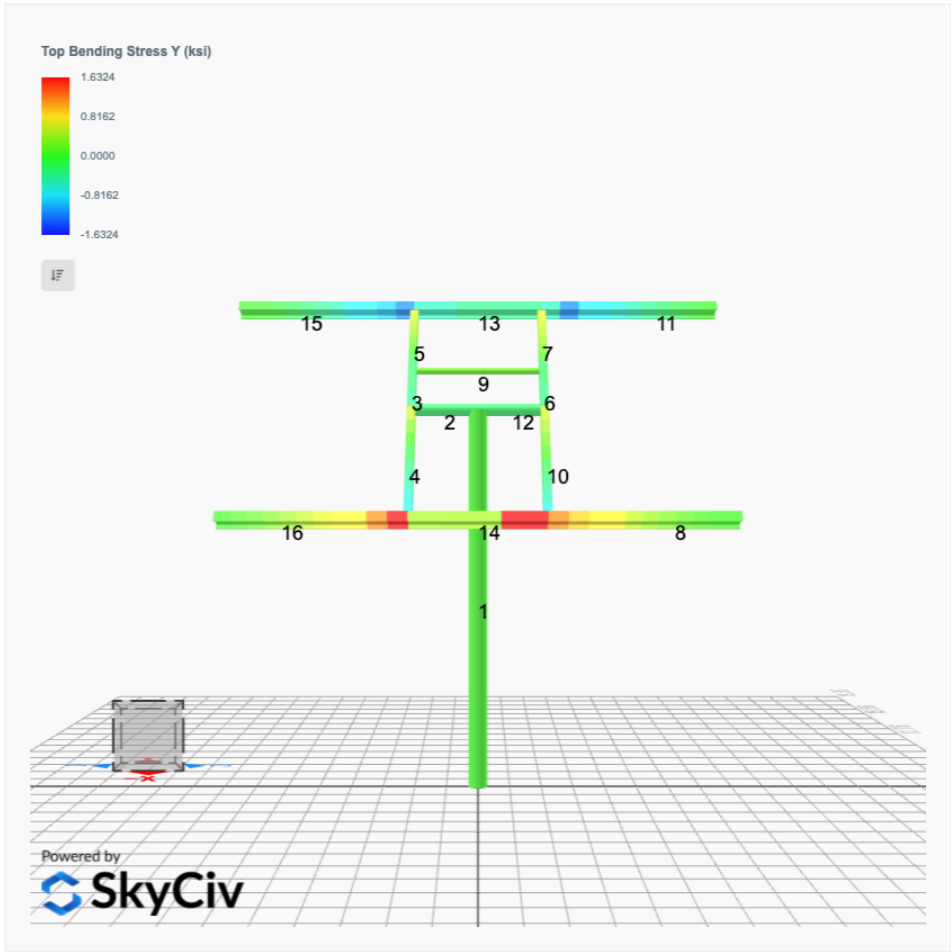




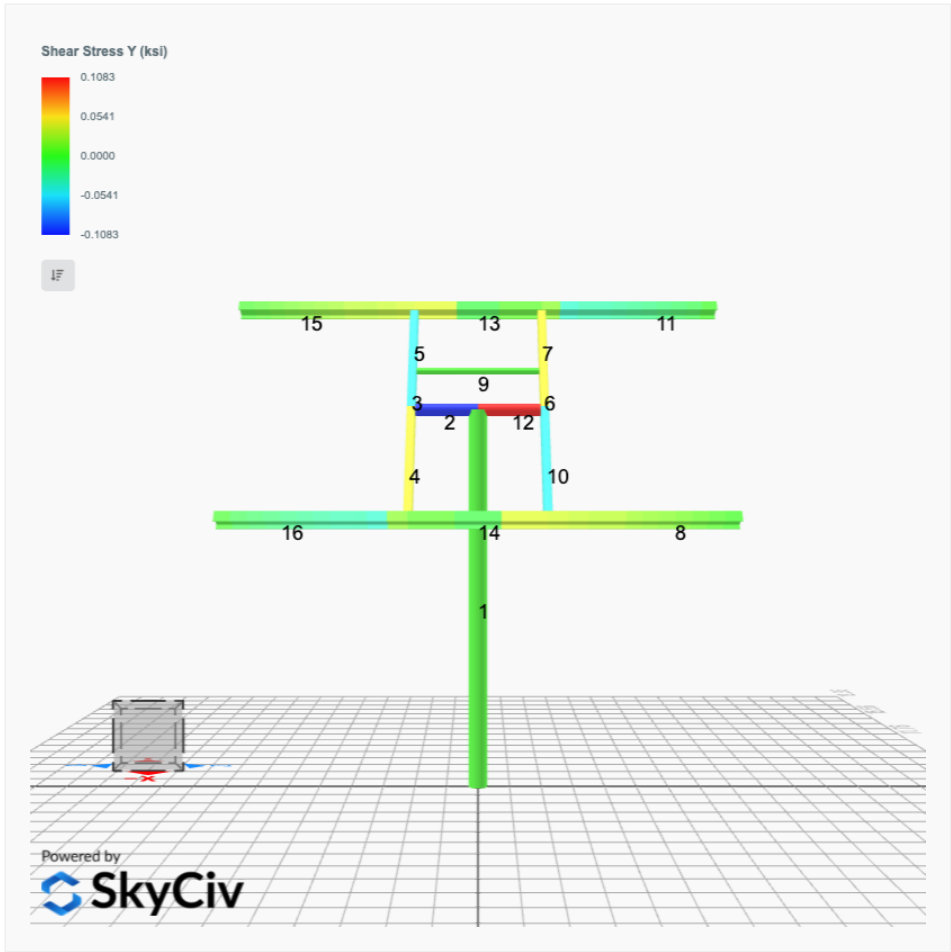
FEM Results (Envelope Worst Case for each member)

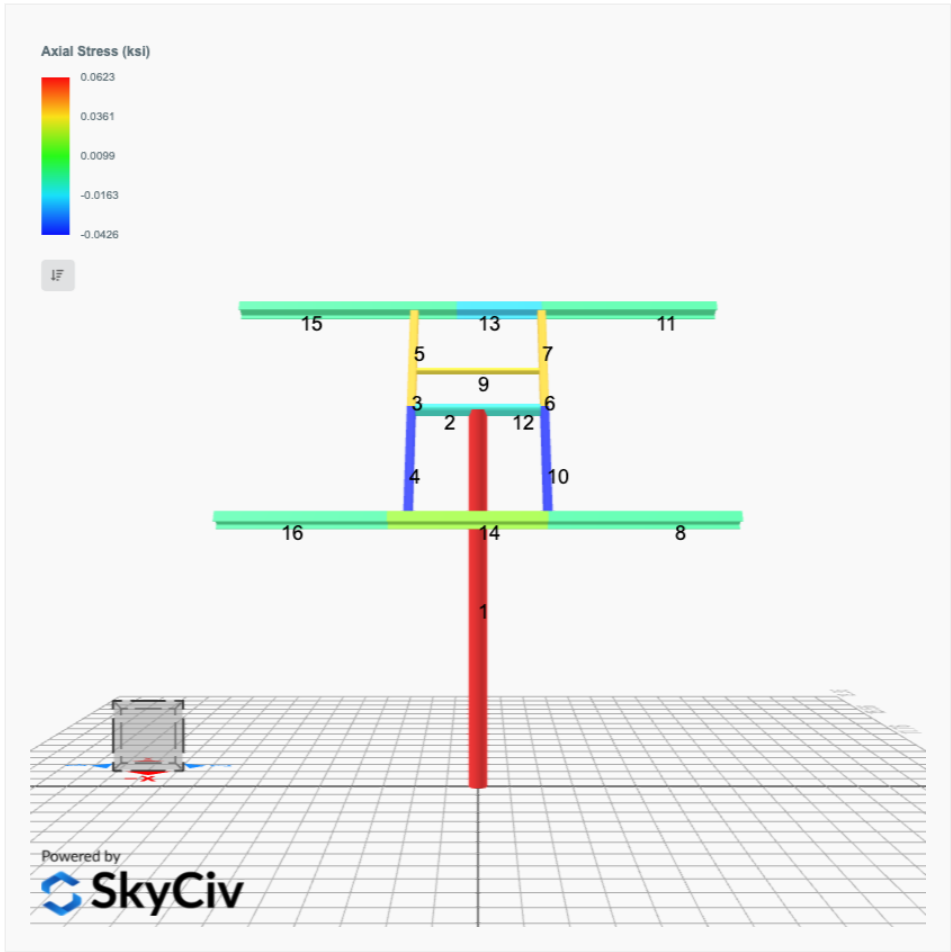












## Reaction Forces for Foundation 1 (Node ID#1), (kip, kip-ft)

### ASD Load Combination Results

| Name                                                                            | Fx      | Fy     | Fz      | Mx     | My      | Mz       |
|---------------------------------------------------------------------------------|---------|--------|---------|--------|---------|----------|
| ULS: 1. D                                                                       | 0.0000  | 1.7932 | -0.0000 | 0.0000 | -0.0000 | 0.0127   |
| ULS: 2. D + L                                                                   | 0.0000  | 1.7932 | -0.0000 | 0.0000 | -0.0000 | 0.0127   |
| ULS: 3. D + (S or Lr or R)                                                      | 0.0000  | 2.1411 | -0.0000 | 0.0000 | -0.0000 | 0.0129   |
| ULS: 3. D + (S or Lr or R)                                                      | 0.0000  | 1.7932 | -0.0000 | 0.0000 | -0.0000 | 0.0127   |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R)                                          | 0.0000  | 2.0541 | -0.0000 | 0.0000 | -0.0000 | 0.0129   |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R)                                          | 0.0000  | 1.7932 | -0.0000 | 0.0000 | -0.0000 | 0.0127   |
| ULS: 5b. D + 0.7E                                                               | 0.0000  | 1.7932 | -0.0000 | 0.0000 | -0.0000 | 0.0127   |
| ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S                                         | 0.0000  | 2.0541 | -0.0000 | 0.0000 | -0.0000 | 0.0129   |
| ULS: 8. 0.6D + 0.7E                                                             | 0.0000  | 1.0759 | -0.0000 | 0.0000 | -0.0000 | 0.0076   |
| ULS: 5a. D + 0.6W_Wind downforce Case A only                                    | -1.4623 | 2.6374 | 0.0000  | 0.0000 | -0.0000 | 16.7238  |
| ULS: 5a. D + 0.6W_Wind downforce Case B only                                    | 0.0000  | 1.7932 | -0.0000 | 0.0000 | -0.0000 | 0.0127   |
| ULS: 5a. D + 0.6W_Wind uplift Case A only                                       | 1.4623  | 0.9490 | -0.0000 | 0.0000 | -0.0000 | -16.3484 |
| ULS: 5a. D + 0.6W_Wind uplift Case B only                                       | 0.0000  | 1.7932 | -0.0000 | 0.0000 | -0.0000 | 0.0127   |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -1.0967 | 2.6873 | -0.0000 | 0.0000 | -0.0000 | 12.5462  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | 0.0000  | 2.0541 | -0.0000 | 0.0000 | -0.0000 | 0.0129   |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only    | 1.0967  | 1.4210 | -0.0000 | 0.0000 | -0.0000 | -12.2580 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only    | 0.0000  | 2.0541 | -0.0000 | 0.0000 | -0.0000 | 0.0129   |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -1.0967 | 2.4264 | 0.0000  | 0.0000 | -0.0000 | 12.5460  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | 0.0000  | 1.7932 | -0.0000 | 0.0000 | -0.0000 | 0.0127   |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only    | 1.0967  | 1.1600 | -0.0000 | 0.0000 | -0.0000 | -12.2581 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only    | 0.0000  | 1.7932 | -0.0000 | 0.0000 | -0.0000 | 0.0127   |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case A only                                  | -1.4623 | 1.9201 | 0.0000  | 0.0000 | -0.0000 | 16.7187  |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case B only                                  | 0.0000  | 1.0759 | -0.0000 | 0.0000 | -0.0000 | 0.0076   |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case A only                                     | 1.4623  | 0.2317 | -0.0000 | 0.0000 | -0.0000 | -16.3535 |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case B only                                     | 0.0000  | 1.0759 | -0.0000 | 0.0000 | -0.0000 | 0.0076   |

### 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   |
|----------|---------|
| Axial    | 3.7329  |
| Shear X  | -2.4371 |
| Shear Z  | -0.0000 |
| Moment X | 0.0000  |
| Moment Z | 28.3949 |

### 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   |
|----------|---------|
| Axial    | 2.6873  |
| Shear X  | -1.4623 |
| Shear Z  | -0.0000 |
| Moment X | 0.0000  |
| Moment Z | 16.7238 |

## Project Details

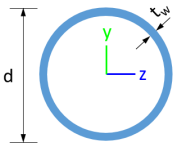
Design Code: AISC 360-16 LRFD  
 Provision: LRFD  
 Country: United States  
 User Name: sales@mtsolar.us  
 Unit System: imperial



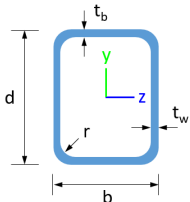
## Design Input Information

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

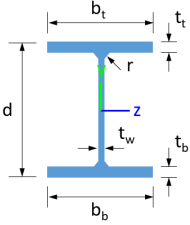
| Design Materials |         |             |             |
|------------------|---------|-------------|-------------|
| ID               | E (ksi) | $F_y$ (ksi) | $F_u$ (ksi) |
| 1                | 29000   | 50          | 65          |

| 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       |  |  |  |  |  |
| 7  | 6in Pipe Sch 40 | 6.63   | 0.28       |  |  |  |  |  |

|                                                                                     |  |  |  |  |  |  |  |  |
|-------------------------------------------------------------------------------------|--|--|--|--|--|--|--|--|
|  |  |  |  |  |  |  |  |  |
|-------------------------------------------------------------------------------------|--|--|--|--|--|--|--|--|

| 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) | $b_f$ (in) | $b_b$ (in) | $t_f$ (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                        |
| 7                  | 6in Pipe Sch 40 | 5.58                 | 56.28                | 28.14                       | 28.14                       | 0.00                     | 11.28                       | 11.28                       |



|    |        |        |       |       |       |       |
|----|--------|--------|-------|-------|-------|-------|
| 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 |

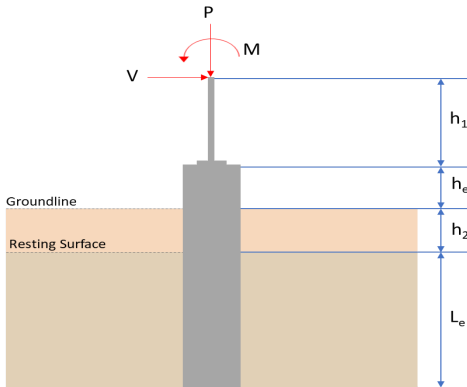
## Design Ratio

| 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         | 0.048 | 0.671          | 0.000          | 0.032          | 0.000          | 0.695                               | #13      | 0.634        | Not Required | Pass   |
| 2         | 0.001 | 0.166          | 0.154          | 0.041          | 0.028          | 0.321                               | #13      | 0.034        | Not Required | Pass   |
| 3         | 0.007 | 0.328          | 0.071          | 0.033          | 0.008          | 0.391                               | #13      | 0.044        | Not Required | Pass   |
| 4         | 0.006 | 0.327          | 0.149          | 0.033          | 0.019          | 0.417                               | #13      | 0.078        | Not Required | Pass   |
| 5         | 0.007 | 0.203          | 0.153          | 0.033          | 0.022          | 0.234                               | #13      | 0.073        | Not Required | Pass   |
| 6         | 0.007 | 0.328          | 0.071          | 0.033          | 0.008          | 0.391                               | #13      | 0.044        | Not Required | Pass   |
| 7         | 0.007 | 0.203          | 0.153          | 0.033          | 0.022          | 0.234                               | #13      | 0.073        | Not Required | Pass   |
| 8         | 0.000 | 0.038          | 0.072          | 0.016          | 0.005          | 0.097                               | #13      | Not Required | Not Required | Pass   |
| 9         | 0.005 | 0.016          | 0.035          | 0.001          | 0.000          | 0.053                               | #13      | 0.198        | Not Required | Pass   |
| 10        | 0.006 | 0.327          | 0.149          | 0.033          | 0.019          | 0.417                               | #13      | 0.078        | Not Required | Pass   |
| 11        | 0.000 | 0.038          | 0.072          | 0.016          | 0.005          | 0.097                               | #13      | Not Required | Not Required | Pass   |
| 12        | 0.001 | 0.166          | 0.154          | 0.041          | 0.028          | 0.321                               | #13      | 0.034        | Not Required | Pass   |
| 13        | 0.003 | 0.109          | 0.154          | 0.023          | 0.008          | 0.232                               | #13      | 0.177        | Not Required | Pass   |
| 14        | 0.003 | 0.111          | 0.154          | 0.023          | 0.008          | 0.232                               | #13      | 0.177        | Not Required | Pass   |
| 15        | 0.000 | 0.038          | 0.072          | 0.016          | 0.005          | 0.097                               | #13      | Not Required | Not Required | Pass   |
| 16        | 0.000 | 0.038          | 0.072          | 0.016          | 0.005          | 0.097                               | #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                                  |

no 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 = 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><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><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>2.687</td><td>3.733</td></tr><tr><td>Vx (kip)</td><td>-1.462</td><td>-2.437</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>16.724</td><td>28.395</td></tr></table></div><div><div>Material Properties</div><div>f'ck = 3 ksi - Concrete strength,</div></div></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) | 2.687 | 3.733 | Vx (kip) | -1.462 | -2.437 | Vz (kip) | 0.000 | 0.000 | Mx (kipft) | 0.000 | 0.000 | Mz (kipft) | 16.724 | 28.395 |  |
| 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)        | 2.687                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 3.733                                    |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| Vx (kip)       | -1.462                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | -2.437                                   |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| Vz (kip)       | 0.000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0.000                                    |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| Mx (kipft)     | 0.000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0.000                                    |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| Mz (kipft)     | 16.724                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 28.395                                   |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
|                | <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></div><div><div>Considering x-direction:</div><div>Ho - Lateral force per length of pile,</div><div><div><div><div><math>H_o = \frac{V_x}{1.57 D}</math></div><div><math>H_o = \frac{(-1.462 \text{ kip})}{1.57 \times (48 \text{ in})}</math></div><div><math>H_o = -0.2328 \text{ kip/ft}</math></div></div></div></div><div><div>Mo - Moment per length of pile,</div><div><div><div><div><math>M_o = \frac{M_z + (V_x H)}{1.57 D}</math></div></div></div></div></div></div></div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                          |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |



|          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                    |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|
|          | $M_o = \frac{(16.724 \text{ kipft}) + ((-1.462 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 2.6631 \text{ kipft/ft}$ <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} = 5.1979 \text{ ft}</math> - Required depth in x-direction,</p> <p><b>Considering z-direction:</b></p> <p><math>L_{e,z} = 0 \text{ ft}</math> - Required depth in z-direction,</p> <p><b>Minimum embedded depth required:</b></p> <p><math>L_{e,req}</math> - Depth of pile required,</p> $L_{e,req} = \text{MAX}[L_{e,x}, L_{e,z}]$ $L_{e,req} = \text{MAX}[(5.1979 \text{ ft}), (0 \text{ ft})]$ $L_{e,req} = 5.198 \text{ ft}$ <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><i>Ratio</i> - Embedded depth</p> $\text{Ratio} = \frac{L_{e,req}}{L_e}$ $\text{Ratio} = \frac{(5.198 \text{ ft})}{(5.5 \text{ ft})}$ $\text{Ratio} = 0.94509$ | <p>Status: <b>PASS</b><br/>Ratio: <b>0.950</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> $q = \frac{P_v}{A}$ $q = \frac{(2.687 \text{ kip})}{(16 \text{ ft}^2)}$ $q = 0.16794 \text{ kip/ft}^2$ <p><b>Check bearing capacity ratio:</b></p> <p><i>Ratio</i> - Capacity</p> $\text{Ratio} = \frac{q}{q_o}$ $\text{Ratio} = \frac{(0.16794 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $\text{Ratio} = 0.083969$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <p>Status: <b>PASS</b><br/>Ratio: <b>0.080</b></p> |
| Czerniak | <p><b>Lateral Soil Pressure (ASD):</b></p> <p><math>L/D</math> - Length to least lateral dimension ratio,</p> $L/D = \frac{L}{D}$ $L/D = \frac{(5.5 \text{ ft})}{(48 \text{ in})}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                    |

$$L/D = 1.375$$

Since  $L/D \leq 10$ ,

Pile is short.

**Considering x-direction:**

$H_o = -0.2328$  kip/ft - Lateral force per length of pile,

$M_o = 2.6631$  kipft/ft - Overturning moment per length of pile,

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

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

$$a = \frac{(4 \times (2.6631 \text{ kipft/ft}) \times (5.5 \text{ ft})) + (3 \times (-0.2328 \text{ kip/ft}) \times (5.5 \text{ ft})^2)}{(6 \times (2.6631 \text{ kipft/ft})) + (4 \times (-0.2328 \text{ kip/ft}) \times (5.5 \text{ ft}))}$$

$$a = 3.7779 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (2.6631 \text{ kipft/ft})) + (3 \times (-0.2328 \text{ kip/ft}) \times (5.5 \text{ ft}))]^2}{(5.5 \text{ ft})^3 \times [(3 \times (2.6631 \text{ kipft/ft})) + (2 \times (-0.2328 \text{ kip/ft}) \times (5.5 \text{ ft}))]}$$

$$p = 0.21188 \text{ kip/ft}^2$$

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

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

$$s = \frac{6 \times [(2 \times (2.6631 \text{ kipft/ft})) + ((-0.2328 \text{ kip/ft}) \times (5.5 \text{ ft}))]}{(5.5 \text{ ft})^2}$$

$$s = 0.80245 \text{ kip/ft}^2$$

**Check lateral soil pressure capacity:**

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(3.7779 \text{ ft})}{2}$$

$$p_a = 0.28334 \text{ kip/ft}^2$$

*Ratio* - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.21188 \text{ kip/ft}^2)}{(0.28334 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.74778$$

$p_s$  - 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

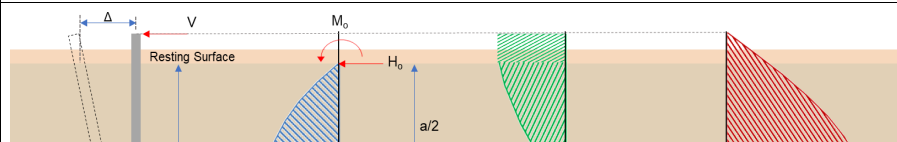
$$\text{Ratio} = \frac{s}{p_s}$$

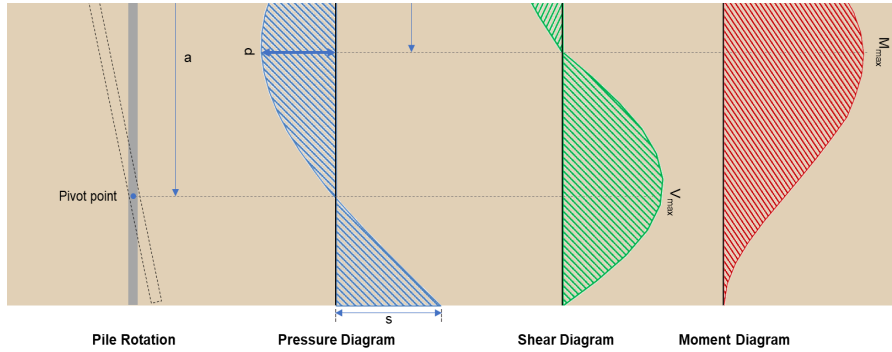
$$\text{Ratio} = \frac{(0.80245 \text{ kip/ft}^2)}{(0.825 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.97267$$

Status: **PASS**  
Ratio: **0.750**

Status: **PASS**  
Ratio: **0.970**





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

$H_o$  - Lateral force per length of pile,

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

$$H_o = \frac{(-2.437 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.38806 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

$$M_o = \frac{M_e + (V_e H)}{1.57 D}$$

$$M_o = \frac{(28.395 \text{ kipft}) + ((-2.437 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 4.5215 \text{ kipft/ft}$$

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

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

$$E = \frac{(4.5215 \text{ kipft/ft})}{(-0.38806 \text{ kip/ft})}$$

$$E = 11.652 \text{ ft}$$

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

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

$$a = \frac{(4 \times (4.5215 \text{ kipft/ft}) \times (5.5 \text{ ft})) + (3 \times (-0.38806 \text{ kip/ft}) \times (5.5 \text{ ft})^2)}{(6 \times (4.5215 \text{ kipft/ft})) + (4 \times (-0.38806 \text{ kip/ft}) \times (5.5 \text{ ft}))}$$

$$a = 3.7764 \text{ ft}$$

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

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

$$V_{max} = ((-0.38806 \text{ kip/ft}) \times (48 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (11.652 \text{ ft})}{(5.5 \text{ ft})} + 3 \right) \times \left( \frac{(3.7764 \text{ ft})}{(5.5 \text{ ft})} \right)^2 \right] + \left[ 4 \times \left( \frac{3 \times (11.652 \text{ ft})}{(5.5 \text{ ft})} + 2 \right) \times \left( \frac{(3.7764 \text{ ft})}{(5.5 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 6.8442 \text{ kip}$$

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

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

$$M_{max} = ((-0.38806 \text{ kip/ft}) \times (48 \text{ in}) \times (5.5 \text{ ft})) \times \left[ \left( \frac{(11.652 \text{ ft})}{(5.5 \text{ ft})} + \frac{(3.7764 \text{ ft})}{2 \times (5.5 \text{ ft})} \right) - \left[ \left( \frac{4 \times (11.652 \text{ ft})}{(5.5 \text{ ft})} + 3 \right) \times \left( \frac{(3.7764 \text{ ft})}{2 \times (5.5 \text{ ft})} \right)^3 \right] + \left[ \left( \frac{3 \times (11.652 \text{ ft})}{(5.5 \text{ ft})} + 2 \right) \times \left( \frac{(3.7764 \text{ ft})}{2 \times (5.5 \text{ ft})} \right)^4 \right] \right]$$

|  |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                       |
|--|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
|  |  | $M_{max} = 18.044 \text{ kipft}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                       |
|  |  | <p><b>Minimum Reinforcement Check (LRFD)</b></p> <p><b>Parameters:</b></p> <p><math>f'_{ck} = 3 \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> $A_{st,required} = \text{Min} \left[ \frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = \text{Min} \left[ \frac{\frac{(3.733 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (3 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -102.14 \text{ in}^2$ <p><math>A_{min}</math> - Governing minimum reinforcement area,</p> $A_{min} = \text{Max} [A_{st,required}, (0.0018 A_g)]$ $A_{min} = \text{Max} [(-102.14 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ <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\emptyset</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> $\phi P_N = \phi 0.80 \left[ (0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st}) \right]$ $\phi P_N = (0.65) \times 0.80 \times \left[ (0.85 \times (3 \text{ ksi}) \times [(2304 \text{ in}^2) - (4.2951 \text{ in}^2)]) + ((60 \text{ ksi}) \times (4.2951 \text{ in}^2)) \right]$ $\phi P_N = 3183.4 \text{ kip}$ <p>Ratio - Capacity</p> $\text{Ratio} = \frac{P}{\phi P_N}$ $\text{Ratio} = \frac{(3.733 \text{ kip})}{(3183.4 \text{ kip})}$ $\text{Ratio} = 0.0011726$                                                                                                                          | 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} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}</math>,<br/> <math>V_{c,max}</math> - Max shear strength of concrete</p> $V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$ $V_{c,max} = 5 \times (0.64282) \times \sqrt{(3000 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,max} = 324.49 \text{ kip}$                                                                                                                                                                                                                                                                                                            |                                            |
| 22.5.5.1.1(a) | <p>The following variables were converted to be consistent with empirical formula <math>f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}</math>, <math>P = 3.733 \text{ kip} \rightarrow 3733 \text{ lbf}</math>,<br/> <math>V_{c,a}</math> - Shear strength of concrete (a)</p> $V_{c,a} = \left[ 2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[ 2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + \frac{(3733 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,a} = 130.29 \text{ kip}$                                                                                                                                         |                                            |
| 22.5.5.1.2    | <p>The following variables were converted to be consistent with empirical formula <math>f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}</math>,<br/> <math>V_{c,b}</math> - Shear strength of concrete (b)</p> $V_{c,b} = \left[ 2 \lambda_s \sqrt{f'_{ck}} + (0.05 f'_{ck}) \right] b_w d$ $V_{c,b} = \left[ 2 \times (0.64282) \times \sqrt{(3000 \text{ psi})} + (0.05 \times (3000 \text{ psi})) \right] \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{c,b} = 406.27 \text{ kip}$ <p><math>V_c</math> - Governing shear strength of concrete</p> $V_c = \text{Min} [V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = \text{Min} [(324.49 \text{ kip}), (130.29 \text{ kip}), (406.27 \text{ kip})]$ $V_c = 130.29 \text{ kip}$ |                                            |

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                     |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| <p>22.5.1.2</p>  | <p>The following variables were converted to be consistent with empirical formula <math>f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}</math>,<br/> <math>V_{s,a}</math> - Shear strength of steel (a)</p> $V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$ $V_{s,a} = 8 \times \sqrt{(3000 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$ $V_{s,a} = 807.65 \text{ kip}$ <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> $V_s = MIN[V_{s,a}, V_{s,b}]$ $V_s = MIN[(807.65 \text{ kip}), (50.894 \text{ kip})]$ $V_s = 50.894 \text{ kip}$ <p>22.5.1.1 <math>\phi V_n</math> - Allowable shear strength</p> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((130.29 \text{ kip}) + (50.894 \text{ kip}))$ $\phi V_n = 117.77 \text{ kip}$ <p><b>Considering x-direction:</b></p> <p><math>V_{max} = 6.8442 \text{ kip}</math> - Maximum shear force in the x-direction,<br/> <math>Ratio</math> - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(6.8442 \text{ kip})}{(117.77 \text{ kip})}$ $Ratio = 0.058114$ | <p>Status: <b>PASS</b><br/> Ratio: <b>0.060</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> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(3 \text{ ksi})} \times 18432.001 \text{ in}^3$ $\phi M_{n,1} = 273.423 \text{ kip ft}$ <p><math>\phi M_{n,2}</math></p> $\phi M_{n,2} = 0.85 f'_c S_m$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                     |

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                            |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
|  | $\phi M_{n,2} = (0.65) \times 0.85 \times (3 \text{ ksi}) \times (18432 \text{ in}^3)$ $\phi M_{n,2} = 2545.9 \text{ kipft}$ <p>Therefore,<br/> <math>\phi M_n</math> - Allowable flexural strength,</p> $\phi M_n = \text{MIN}[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = \text{MIN}[(273.42 \text{ kipft}), (2545.9 \text{ kipft})]$ $\phi M_n = 273.42 \text{ kipft}$ <p><b>Considering x-direction:</b></p> <p><math>M_{max} = 18.044 \text{ kipft}</math> - Maximum moment in the x-direction,<br/> <i>Ratio</i> - Capacity</p> $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(18.044 \text{ kipft})}{(273.42 \text{ kipft})}$ $\text{Ratio} = 0.065994$ |                                            |
|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Status: <b>PASS</b><br>Ratio: <b>0.070</b> |