

## Project Details



**Project Name:** csu\_westerncampus - Square - Rev2Jb **Date:** Thu Jan 02 2025

**Location:** 4777 National Western Dr, Denver, CO

**Number of Modules:** 12

80216, USA

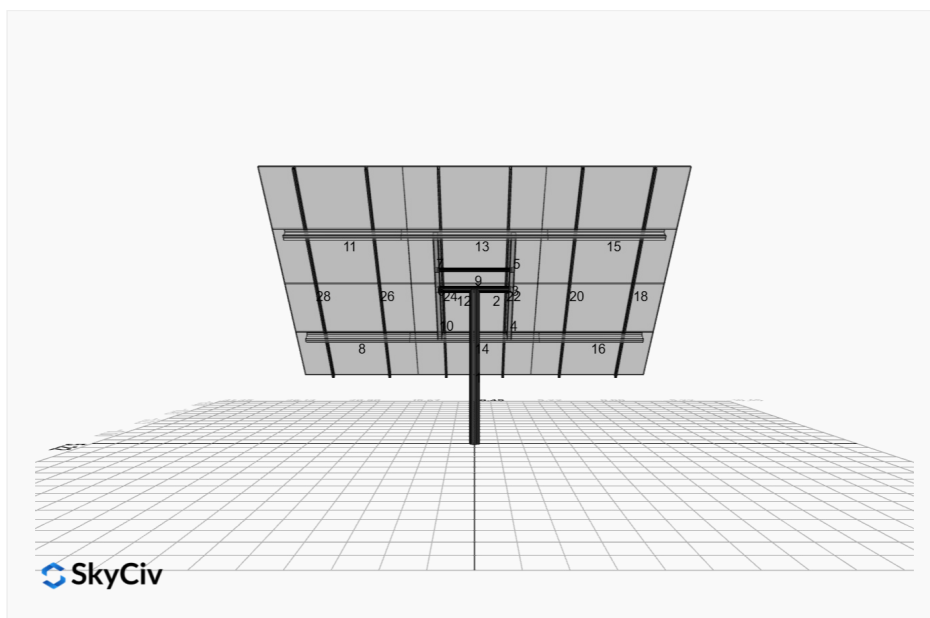
**Number of Poles:** 1

**Unique ID:** 1P-0-6TOP-SD-72-L-4Hx3W-J4D1

**Date Sold:**

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

\_\_\_\_\_



|                             |          |
|-----------------------------|----------|
| <b>Array Dimensions N/S</b> | 15.03 ft |
| <b>Array Dimensions E/W</b> | 20.90 ft |
| <b>Winter Tilt Angle</b>    | 46       |
| <b>Front Edge Clearance</b> | 3 ft     |

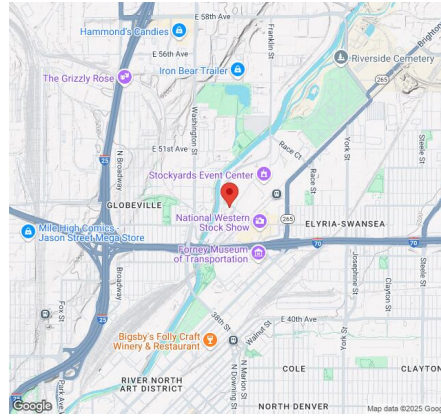
### MT Solar Bill of Materials (1P-0-6TOP-SD-72-L-4Hx3W-J4D1)

| Part               | Short Description     | BOM Qty |
|--------------------|-----------------------|---------|
| MTS-PC-6           | 6IN Pole Cap Assembly | 1       |
| MTS-HF-SD          | H-Frame Assembly-SD   | 1       |
| MTS-SD-Wing-72     | 72IN SD Wing          | 4       |
| MTS-CLAMP-HOOK-4PK | Hook Clamp            | 3       |

### Rail Bill of Materials

| Part             | Qty |
|------------------|-----|
| Rails (178in)    | 6   |
| Rail Attachment  | 12  |
| Module Mid Clamp | 18  |
| Module End Clamp | 12  |
| Ground Lug       | 3   |

## Site Details:



**Site Address:** 4777 National Western Dr, Denver, CO 80216, USA

### Array Specification

|                                    |           |
|------------------------------------|-----------|
| <b>Duty Classification:</b>        | SD        |
| <b>Module Width:</b>               | 44.60 in  |
| <b>Module Length:</b>              | 82.60in   |
| <b>Number of Rows:</b>             | 4         |
| <b>Number of Columns:</b>          | 3         |
| <b>Total Number of Modules:</b>    | 12        |
| <b>Winter Tilt Angle:</b>          | 46        |
| <b>Front Edge Clearance:</b>       | 3         |
| <b>Total Array Height at Tilt:</b> | 13.81 ft  |
| <b>Total Frame Length:</b>         | 19.50 ft  |
| <b>Frame Weight:</b>               | 918 lbs   |
| <b>Array Dimensions N/S:</b>       | 15.03 ft  |
| <b>Array Dimensions E/W:</b>       | 20.90 ft  |
| <b>Rail Length:</b>                | 180.40 in |
| <b>Rail Spacing:</b>               | 3.48 ft   |

### Support Specifications

|                                 |                 |
|---------------------------------|-----------------|
| <b>Pole Size:</b>               | 6in Pipe Sch 40 |
| <b>Pole Length above Grade:</b> | 8.41 ft         |
| <b>Number of Poles:</b>         | 1               |
| <b>Pole Spacing:</b>            | 0               |

### Foundation Specifications

|                                        |                      |
|----------------------------------------|----------------------|
| <b>Foundation Type:</b>                | Round                |
| <b>Foundation Dimensions:</b>          | Ø36 in               |
| <b>Foundation Depth (below grade):</b> | Pile 1: 8.00 ft      |
| <b>Foundation Volume:</b>              | 2.094 y <sup>3</sup> |

### Site Info

|                             |                                                 |
|-----------------------------|-------------------------------------------------|
| <b>Risk Category:</b>       | I                                               |
| <b>Exposure:</b>            | C                                               |
| <b>Soil Classification:</b> | sand                                            |
| <b>Site Location:</b>       | 4777 National Western Dr, Denver, CO 80216, USA |
| <b>Wind Speed:</b>          | 115 mph                                         |
| <b>Snow Load:</b>           | 35 psf                                          |

### **Design Disclaimer**

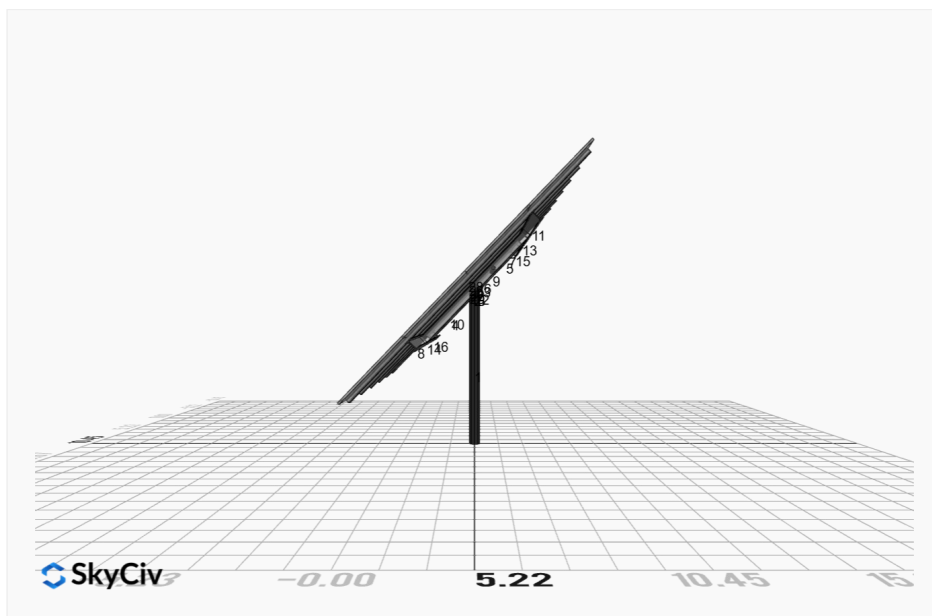
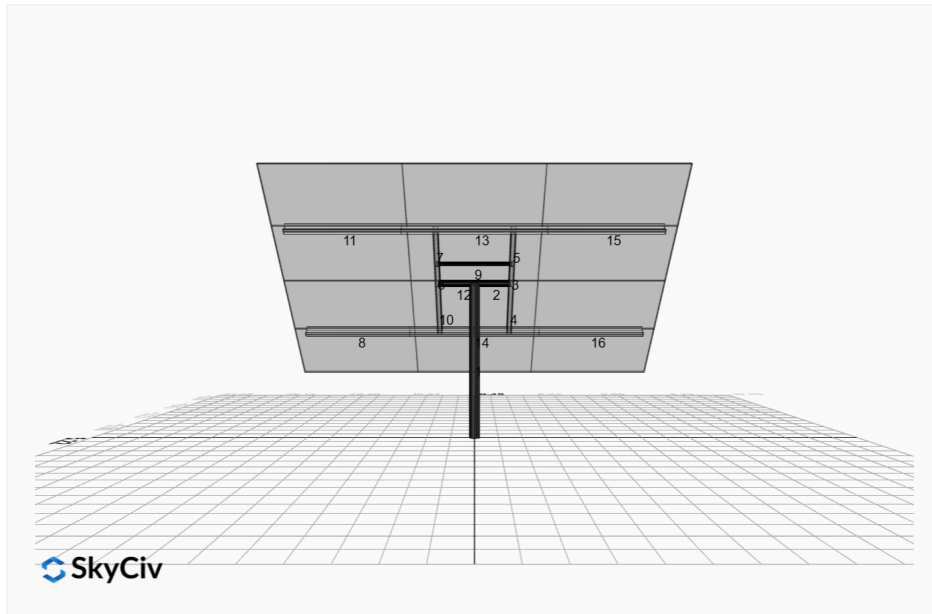
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

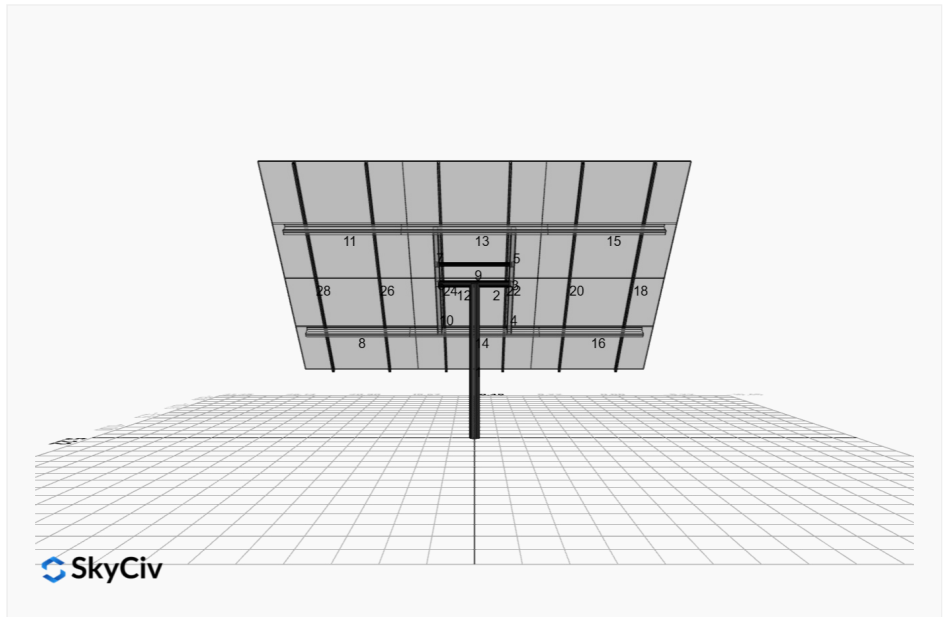
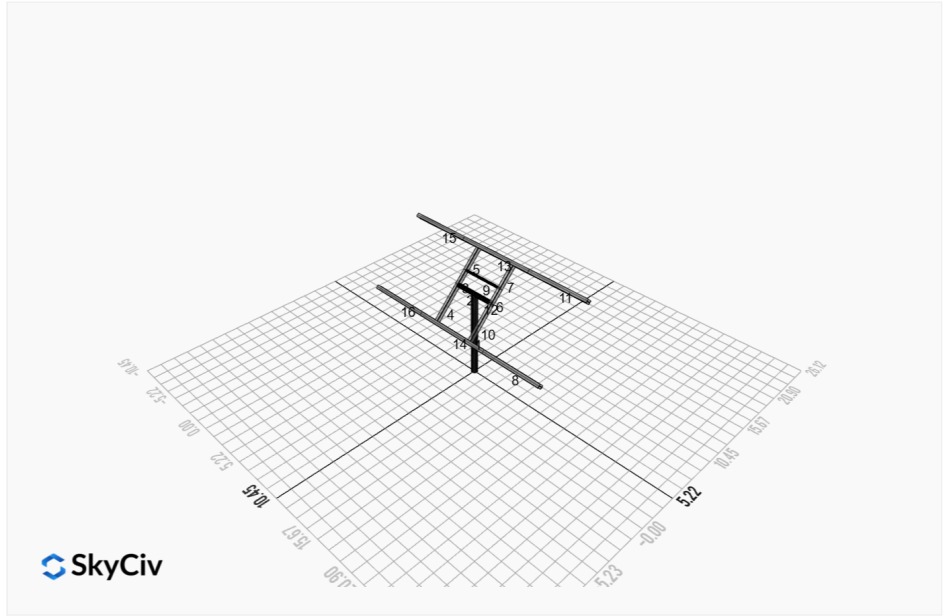
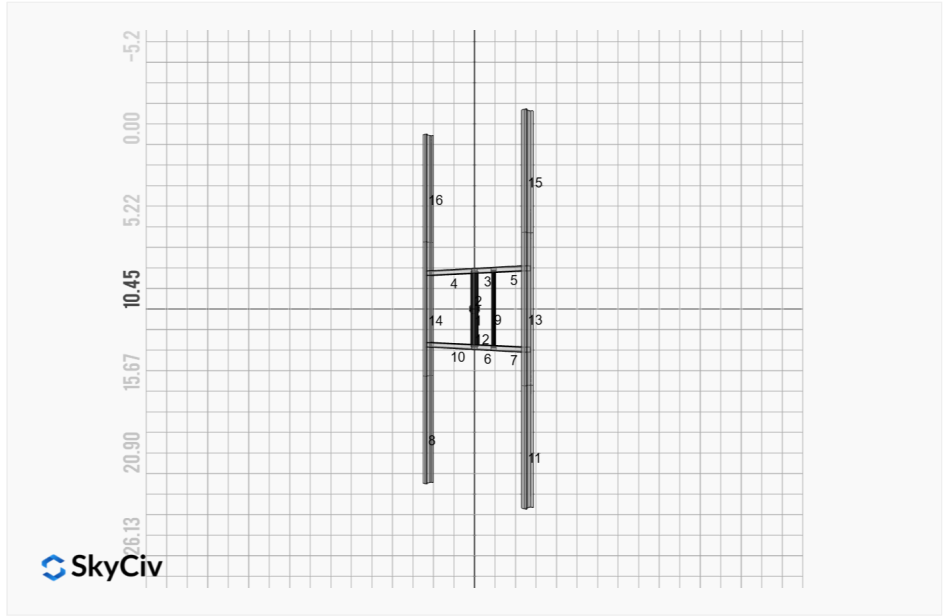
## AutoDesigner Input

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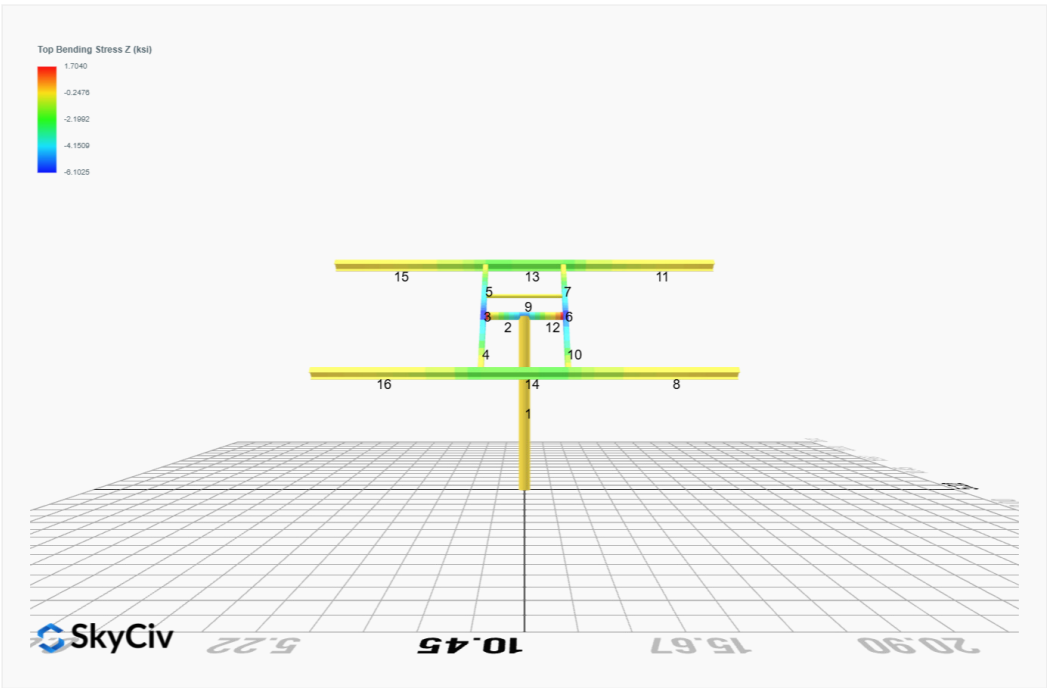
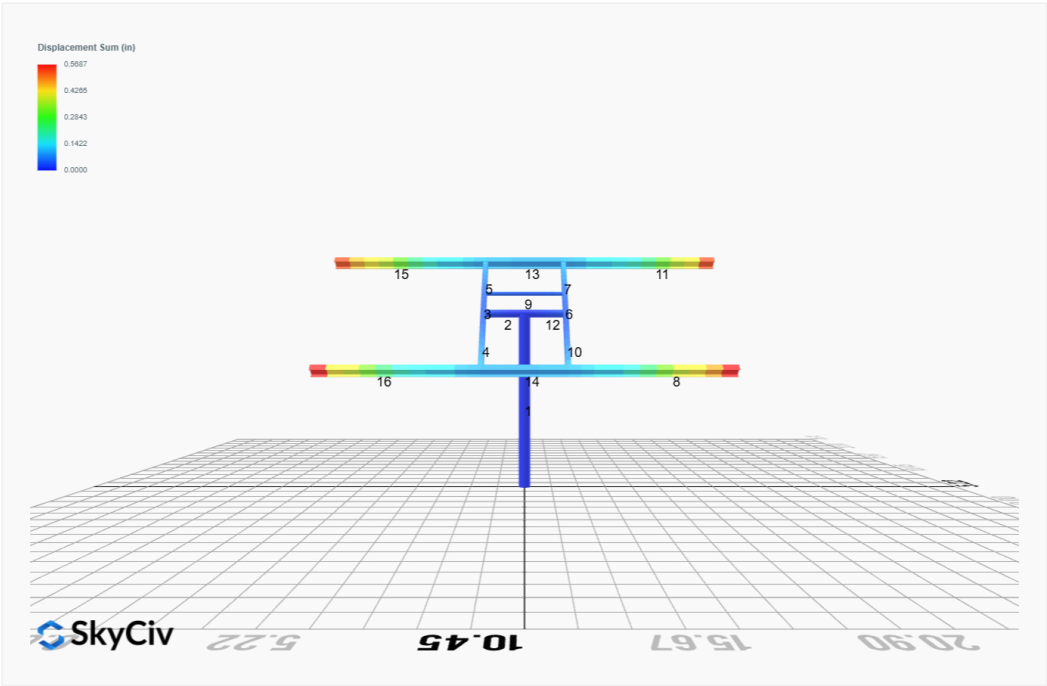
### Design Notes:

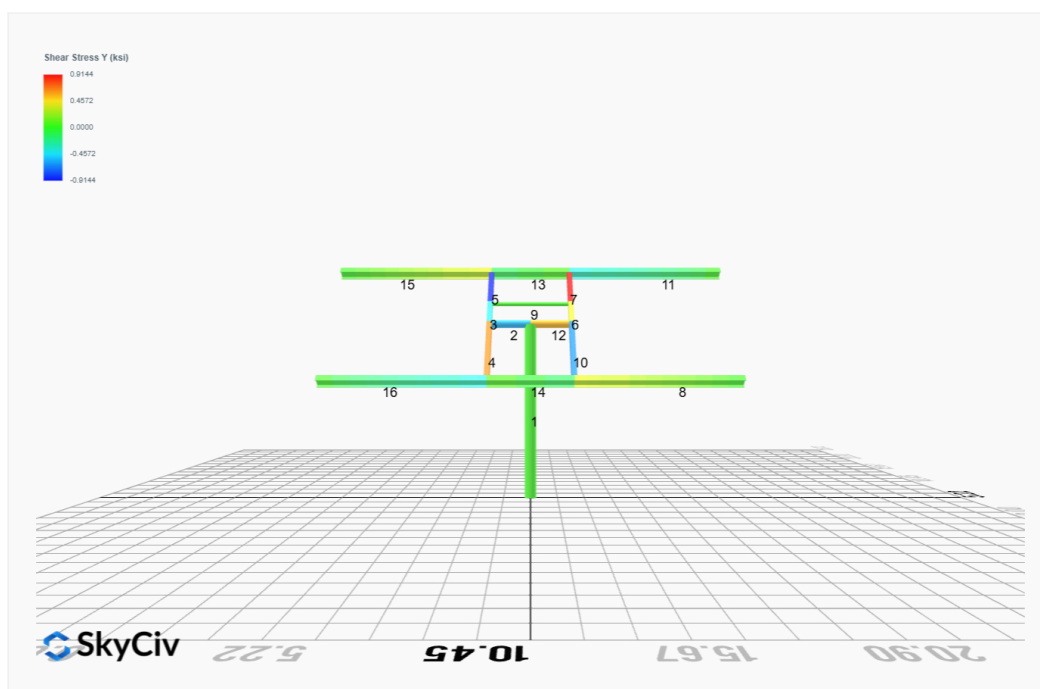
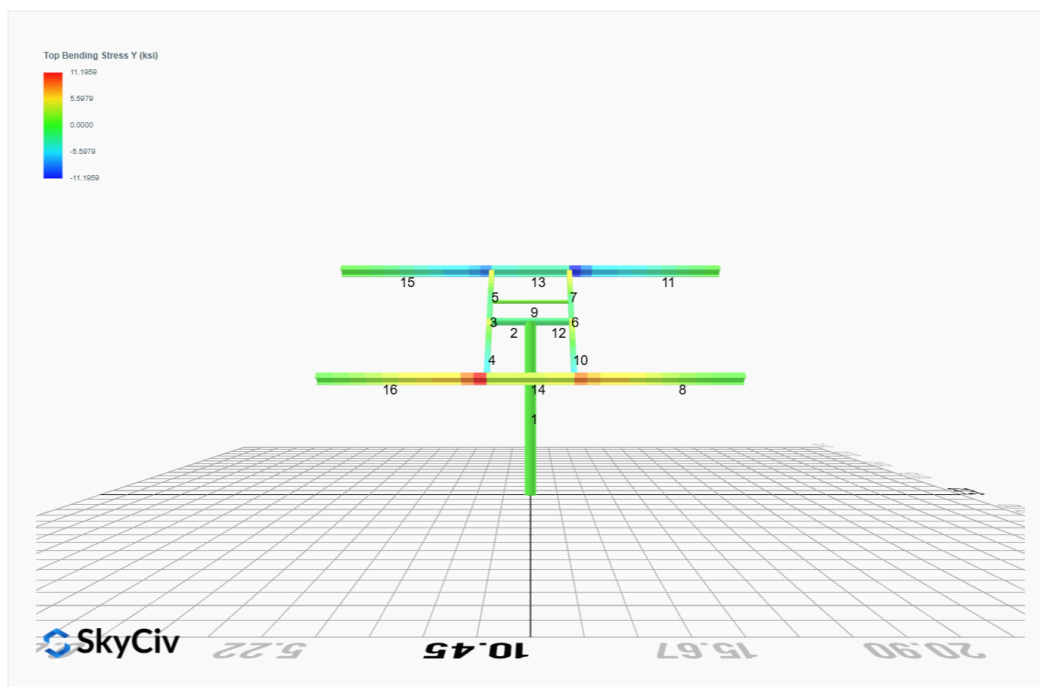
- AISC Deflection checks are set to L/1 due to structure design intent
- Foundation Soil Parameters used in this Autodesign are all estimates, proper geotechnical reports are required to confirm soil profiles
- Wind speeds, snow loads and other site specific results are based on ASCE 7 2016
- Steel frame design checks are based on AISC 360 2016 (LRFD)
- Foundation Design and Sizing is approximate only

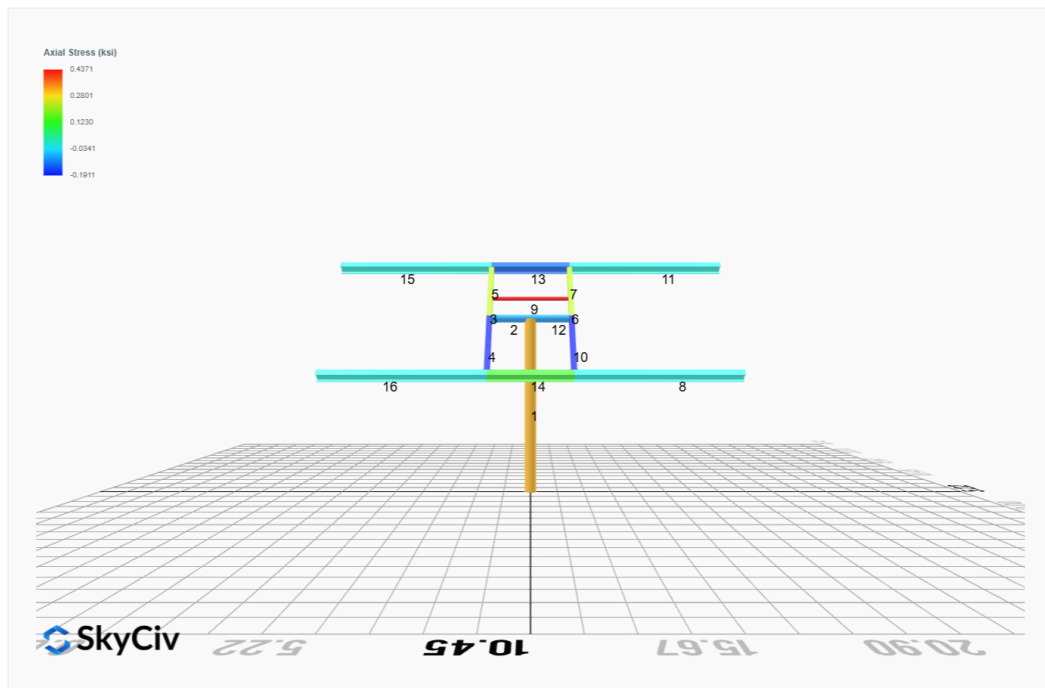




# FEM Results (Envelope Worst Case for each member)







## 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  | 2.1003  | 0.0000 | 0.0000 | -0.0000 | 0.0185   |
| ULS: 2. D + L                                                                   | 0.0000  | 2.1003  | 0.0000 | 0.0000 | -0.0000 | 0.0185   |
| ULS: 3. D + (S or Lr or R)                                                      | 0.0000  | 3.9813  | 0.0000 | 0.0000 | -0.0000 | 0.0250   |
| ULS: 3. D + (S or Lr or R)                                                      | 0.0000  | 2.1003  | 0.0000 | 0.0000 | -0.0000 | 0.0185   |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R)                                          | 0.0000  | 3.5110  | 0.0000 | 0.0000 | -0.0000 | 0.0234   |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R)                                          | 0.0000  | 2.1003  | 0.0000 | 0.0000 | -0.0000 | 0.0185   |
| ULS: 5b. D + 0.7E                                                               | 0.0000  | 2.1003  | 0.0000 | 0.0000 | -0.0000 | 0.0185   |
| ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S                                         | 0.0000  | 3.5110  | 0.0000 | 0.0000 | -0.0000 | 0.0234   |
| ULS: 8. 0.6D + 0.7E                                                             | 0.0000  | 1.2602  | 0.0000 | 0.0000 | -0.0000 | 0.0111   |
| ULS: 5a. D + 0.6W_Wind downforce Case A only                                    | -2.6282 | 4.6383  | 0.0000 | 0.0000 | -0.0000 | 22.5106  |
| ULS: 5a. D + 0.6W_Wind downforce Case B only                                    | 0.0000  | 2.1003  | 0.0000 | 0.0000 | -0.0000 | 0.0185   |
| ULS: 5a. D + 0.6W_Wind uplift Case A only                                       | 2.6282  | -0.4377 | 0.0000 | 0.0000 | -0.0000 | -21.6962 |
| ULS: 5a. D + 0.6W_Wind uplift Case B only                                       | 0.0000  | 2.1003  | 0.0000 | 0.0000 | -0.0000 | 0.0185   |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -1.9711 | 5.4145  | 0.0000 | 0.0000 | -0.0000 | 16.8924  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | 0.0000  | 3.5110  | 0.0000 | 0.0000 | -0.0000 | 0.0234   |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only    | 1.9711  | 1.6075  | 0.0000 | 0.0000 | -0.0000 | -16.2627 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only    | 0.0000  | 3.5110  | 0.0000 | 0.0000 | -0.0000 | 0.0234   |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -1.9711 | 4.0038  | 0.0000 | 0.0000 | -0.0000 | 16.8876  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | 0.0000  | 2.1003  | 0.0000 | 0.0000 | -0.0000 | 0.0185   |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only    | 1.9711  | 0.1968  | 0.0000 | 0.0000 | -0.0000 | -16.2675 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only    | 0.0000  | 2.1003  | 0.0000 | 0.0000 | -0.0000 | 0.0185   |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case A only                                  | -2.6282 | 3.7982  | 0.0000 | 0.0000 | -0.0000 | 22.5032  |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case B only                                  | 0.0000  | 1.2602  | 0.0000 | 0.0000 | -0.0000 | 0.0111   |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case A only                                     | 2.6282  | -1.2778 | 0.0000 | 0.0000 | -0.0000 | -21.7036 |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case B only                                     | 0.0000  | 1.2602  | 0.0000 | 0.0000 | -0.0000 | 0.0111   |

### 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            | 7.6909              |
| Shear X          | -4.3803             |
| Shear Z          | 0.0000              |
| Moment X         | 0.0000              |
| Moment Y (Twist) | 0.0000              |
| Moment Z         | 38.1399             |

### Worst Case Reactions ASD

These results are taken from the worst case values in the above table and are used in the Soil Checks in the Foundation Module.

Note: Worst case values are assumed as downforce wind load cases.

| Result           | Value (kip, kip-ft) |
|------------------|---------------------|
| Axial            | 5.4145              |
| Shear X          | -2.6282             |
| Shear Z          | 0.0000              |
| Moment X         | 0.0000              |
| Moment Y (Twist) | 0.0000              |
| Moment Z         | 22.5106             |

## 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) | $b_t$ (in) | $b_b$ (in) | $t_t$ (in) | $t_b$ (in) | r (in) |
| 18                 | W6x9            | 5.90   | 0.17       | 3.94       | 3.94       | 0.21       | 0.21       | 0.25   |

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



|    |        |       |       |      |       |       |
|----|--------|-------|-------|------|-------|-------|
| 15 | 120.60 | 21.74 | 23.36 | 6.45 | 30.09 | 45.74 |
| 16 | 120.60 | 21.74 | 23.36 | 6.45 | 30.09 | 45.74 |

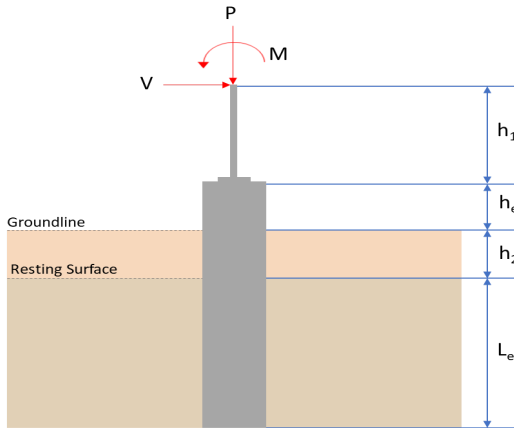
## Design Ratio

| 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         | 0.059 | 0.902          | 0.000          | 0.058          | 0.000          | 0.931                               | #13      | 0.472        | Not Required | Pass   |
| 2         | 0.007 | 0.398          | 0.290          | 0.088          | 0.051          | 0.690                               | #13      | 0.034        | Not Required | Pass   |
| 3         | 0.013 | 0.714          | 0.083          | 0.072          | 0.007          | 0.754                               | #13      | 0.044        | Not Required | Pass   |
| 4         | 0.012 | 0.710          | 0.323          | 0.071          | 0.052          | 0.830                               | #13      | 0.078        | Not Required | Pass   |
| 5         | 0.013 | 0.443          | 0.342          | 0.071          | 0.070          | 0.500                               | #13      | 0.073        | Not Required | Pass   |
| 6         | 0.013 | 0.714          | 0.083          | 0.072          | 0.007          | 0.754                               | #13      | 0.044        | Not Required | Pass   |
| 7         | 0.013 | 0.443          | 0.342          | 0.071          | 0.070          | 0.500                               | #13      | 0.073        | Not Required | Pass   |
| 8         | 0.000 | 0.163          | 0.266          | 0.042          | 0.012          | 0.397                               | #21      | Not Required | Not Required | Pass   |
| 9         | 0.029 | 0.061          | 0.075          | 0.001          | 0.000          | 0.143                               | #13      | 0.198        | Not Required | Pass   |
| 10        | 0.012 | 0.710          | 0.323          | 0.071          | 0.052          | 0.830                               | #13      | 0.078        | Not Required | Pass   |
| 11        | 0.000 | 0.163          | 0.266          | 0.042          | 0.012          | 0.397                               | #21      | Not Required | Not Required | Pass   |
| 12        | 0.007 | 0.398          | 0.290          | 0.088          | 0.051          | 0.690                               | #13      | 0.034        | Not Required | Pass   |
| 13        | 0.010 | 0.356          | 0.443          | 0.054          | 0.016          | 0.727                               | #21      | 0.177        | Not Required | Pass   |
| 14        | 0.010 | 0.362          | 0.443          | 0.054          | 0.016          | 0.727                               | #21      | 0.177        | Not Required | Pass   |
| 15        | 0.000 | 0.163          | 0.266          | 0.042          | 0.012          | 0.397                               | #21      | Not Required | Not Required | Pass   |
| 16        | 0.000 | 0.163          | 0.266          | 0.042          | 0.012          | 0.397                               | #21      | Not Required | Not Required | Pass   |

## Definitions

|                                     |                                                           |
|-------------------------------------|-----------------------------------------------------------|
| Φ <sub>t</sub>                      | Safety factor for tensile                                 |
| Φ <sub>c</sub>                      | Safety factor for compression                             |
| Φ <sub>b</sub>                      | Safety factor for flexure                                 |
| Φ <sub>v</sub>                      | Safety factor for shear                                   |
| E                                   | Modulus of elasticity                                     |
| F <sub>y</sub>                      | Specified minimum yield stress                            |
| F <sub>u</sub>                      | Specified minimum tensile strength                        |
| A                                   | Cross-sectional area                                      |
| J                                   | Torsional constant                                        |
| I <sub>yp</sub>                     | Moment of inertia about the Y axes                        |
| I <sub>zp</sub>                     | Moment of inertia about the Z axes                        |
| I <sub>w</sub>                      | Warping constant                                          |
| S <sub>yp</sub>                     | Plastic section modulus about the Y axis                  |
| S <sub>zp</sub>                     | Plastic section modulus about the Z axis                  |
| KL                                  | Effective length                                          |
| C <sub>b</sub>                      | Buckling modification factor (from all load combinations) |
| L <sub>b</sub>                      | Length between braced points                              |
| LST                                 | Limited slenderness for tension                           |
| LSC                                 | Limited slenderness for compression                       |
| LD                                  | Limited deflection                                        |
| P <sub>n</sub>                      | Nominal axial strength (tension/compression)              |
| M <sub>n</sub>                      | Nominal flexural strength (about Z/Y axis)                |
| V <sub>n</sub>                      | Nominal shear strength (along Z/Y axis)                   |
| P                                   | Design ratio in case of axial force                       |
| M <sub>z</sub>                      | Design ratio in case of bending about Z axis              |
| M <sub>y</sub>                      | Design ratio in case of bending about Y axis              |
| V <sub>y</sub>                      | Design ratio in case of shear along Y axis                |
| V <sub>z</sub>                      | Design ratio in case of shear along Z axis                |
| (P,M <sub>z</sub> ,M <sub>y</sub> ) | Design ratio in case of axial force and bending action    |
| KL/r                                | Design ratio in case of section slenderness               |
| δ                                   | Design ratio in case of member deflection                 |
| OK                                  | Capacity is provided                                      |
| NG                                  | Capacity is not provided                                  |



| REFERENCES     | CALCULATIONS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | RESULTS                                  |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|--------------------------------------------|------------------------------------------|--------------------------------------------|---|-------------------------------------------------------------|----------|---------|----------------|-----|------|---------|-------|-------|----------|--------|--------|----------|-------|-------|------------|-------|-------|------------|--------|--------|--|
|                | <div>SkyCiv Foundation Design</div> <div>Pile Foundation</div> <div>Design Information :</div> <div>Design code : IBC 2021 (International Building Code)</div> <div>Unit System : Imperial</div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                          |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
|                | <div>Pile Input</div> <div></div> <div>Geometry</div> <div>Pile shape: round</div> <div>D = 36 in - Pile diameter</div> <div>L = 8 ft - Total pile length</div> <div>h1 = 0 ft - Lateral load height from the top of the pile,</div> <div>h2 = 0 ft - Depth to resisting surface</div> <div>he = 0 ft - Length of pile above the ground</div> <div>Tabulation of Soil Parameters</div> <table><tr><th>Layer</th><th>Label</th><th>Allowable Bearing Pressure (qa)<br/>(psf)</th><th>Allowable Lateral Pressure (R)<br/>(psf/ft)</th></tr><tr><td>1</td><td>Sand, silty sand, clayey sand, silty gravel &amp; clayey gravel</td><td>2000.000</td><td>150.000</td></tr></table> <div>Tabulation of Loads</div> <table><tr><th>Load Component</th><th>ASD</th><th>LRFD</th></tr><tr><td>P (kip)</td><td>5.415</td><td>7.691</td></tr><tr><td>Vx (kip)</td><td>-2.628</td><td>-4.380</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>22.511</td><td>38.140</td></tr></table> <div>Material Properties</div> <div>f'ck = 2.5 ksi - Concrete strength,</div> | Layer                                    | Label                                      | Allowable Bearing Pressure (qa)<br>(psf) | Allowable Lateral Pressure (R)<br>(psf/ft) | 1 | Sand, silty sand, clayey sand, silty gravel & clayey gravel | 2000.000 | 150.000 | Load Component | ASD | LRFD | P (kip) | 5.415 | 7.691 | Vx (kip) | -2.628 | -4.380 | Vz (kip) | 0.000 | 0.000 | Mx (kipft) | 0.000 | 0.000 | Mz (kipft) | 22.511 | 38.140 |  |
| Layer          | Label                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Allowable Bearing Pressure (qa)<br>(psf) | Allowable Lateral Pressure (R)<br>(psf/ft) |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| 1              | Sand, silty sand, clayey sand, silty gravel & clayey gravel                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 2000.000                                 | 150.000                                    |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| Load Component | ASD                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | LRFD                                     |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| P (kip)        | 5.415                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 7.691                                    |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| Vx (kip)       | -2.628                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | -4.380                                   |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| Vz (kip)       | 0.000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 0.000                                    |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| Mx (kipft)     | 0.000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 0.000                                    |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
| Mz (kipft)     | 22.511                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 38.140                                   |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |
|                | <div>Required depth to resist lateral loads (ASD)</div> <div>H - Point of application of the lateral load</div> <div><math display="block">H = h_1 + h_2 + h_e</math><math display="block">H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})</math><math display="block">H = 0 \text{ ft}</math></div> <div>Considering x-direction:</div> <div>Ho - Lateral force per length of pile,</div> <div><math display="block">H_o = \frac{V_x}{D}</math><math display="block">H_o = \frac{(-2.628 \text{ kip})}{(36 \text{ in})}</math><math display="block">H_o = -0.876 \text{ kip/ft}</math></div> <div>Mo - Moment per length of pile,</div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                          |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |        |        |  |

|          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                    |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|
|          | $M_o = \frac{M_z + (V_x H)}{D}$ $M_o = \frac{(22.511 \text{ kipft}) + ((-2.628 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$ $M_o = 7.5037 \text{ kipft/ft}$ <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} = 7.0946 \text{ ft}</math> - Required depth in x-direction,</p> <p><b>Considering z-direction:</b><br/> <math>L_{e,z} = 0 \text{ ft}</math> - Required depth in z-direction,</p> <p><b>Minimum embedded depth required:</b><br/> <math>L_{e,req}</math> - Depth of pile required,</p> $L_{e,req} = MAX[L_{e,x}, L_{e,z}]$ $L_{e,req} = MAX[(7.0946 \text{ ft}), (0 \text{ ft})]$ $L_{e,req} = 7.095 \text{ ft}$ <p><math>L_e</math> - Actual embedded length of pile,</p> $L_e = L - h_e - h_2$ $L_e = (8 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 8 \text{ ft}$ <p>Ratio - Embedded depth</p> $Ratio = \frac{L_{e,req}}{L_e}$ $Ratio = \frac{(7.095 \text{ ft})}{(8 \text{ ft})}$ $Ratio = 0.88687$ | <p>Status: <b>PASS</b><br/>Ratio: <b>0.890</b></p> |
|          | <p><b>End-bearing Capacity (ASD)</b><br/> <math>A</math> - Pile cross-section area</p> $A = \pi \left( \frac{D}{2} \right)^2$ $A = \pi \times \left( \frac{(36 \text{ in})}{2} \right)^2$ $A = 7.0686 \text{ ft}^2$ <p><math>q</math> - End-bearing pressure</p> $q = \frac{P_v}{A}$ $q = \frac{(5.415 \text{ kip})}{(7.0686 \text{ ft}^2)}$ $q = 0.76607 \text{ kip/ft}^2$ <p><b>Check bearing capacity ratio:</b><br/> Ratio - Capacity</p> $Ratio = \frac{q}{q_a}$ $Ratio = \frac{(0.76607 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $Ratio = 0.38303$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <p>Status: <b>PASS</b><br/>Ratio: <b>0.380</b></p> |
| Czerniak | <b>Lateral Soil Pressure (ASD):</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                    |

$L/D$  - Length to least lateral dimension ratio,

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

$$L/D = \frac{(8 \text{ ft})}{(36 \text{ in})}$$

$$L/D = 2.6667$$

Since  $L/D \leq 10$ ,

Pile is short.

**Considering x-direction:**

$H_o = -0.876 \text{ kip/ft}$  - Lateral force per length of pile,

$M_o = 7.5037 \text{ kipft/ft}$  - Overturning moment per length of pile,

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

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

$$a = \frac{(4 \times (7.5037 \text{ kipft/ft}) \times (8 \text{ ft})) + (3 \times (-0.876 \text{ kip/ft}) \times (8 \text{ ft})^2)}{(6 \times (7.5037 \text{ kipft/ft})) + (4 \times (-0.876 \text{ kip/ft}) \times (8 \text{ ft}))}$$

$$a = 5.5891 \text{ ft}$$

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

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

$$p = \frac{1.178 \times [(4 \times (7.5037 \text{ kipft/ft})) + (3 \times (-0.876 \text{ kip/ft}) \times (8 \text{ ft}))]^2}{(8 \text{ ft})^2 \times [(3 \times (7.5037 \text{ kipft/ft})) + (2 \times (-0.876 \text{ kip/ft}) \times (8 \text{ ft}))]}$$

$$p = 0.17514 \text{ kip/ft}^2$$

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

$$s = \frac{9.425 [(2 M_o) + (H_o L_e)]}{L_e^2}$$

$$s = \frac{9.425 \times [(2 \times (7.5037 \text{ kipft/ft})) + ((-0.876 \text{ kip/ft}) \times (8 \text{ ft}))]}{(8 \text{ ft})^2}$$

$$s = 1.178 \text{ kip/ft}^2$$

**Check lateral soil pressure capacity:**

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(5.5891 \text{ ft})}{2}$$

$$p_a = 0.41919 \text{ kip/ft}^2$$

*Ratio* - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.17514 \text{ kip/ft}^2)}{(0.41919 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.41781$$

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

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (8 \text{ ft})$$

$$p_s = 1.2 \text{ kip/ft}^2$$

*Ratio* - Lateral soil capacity

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

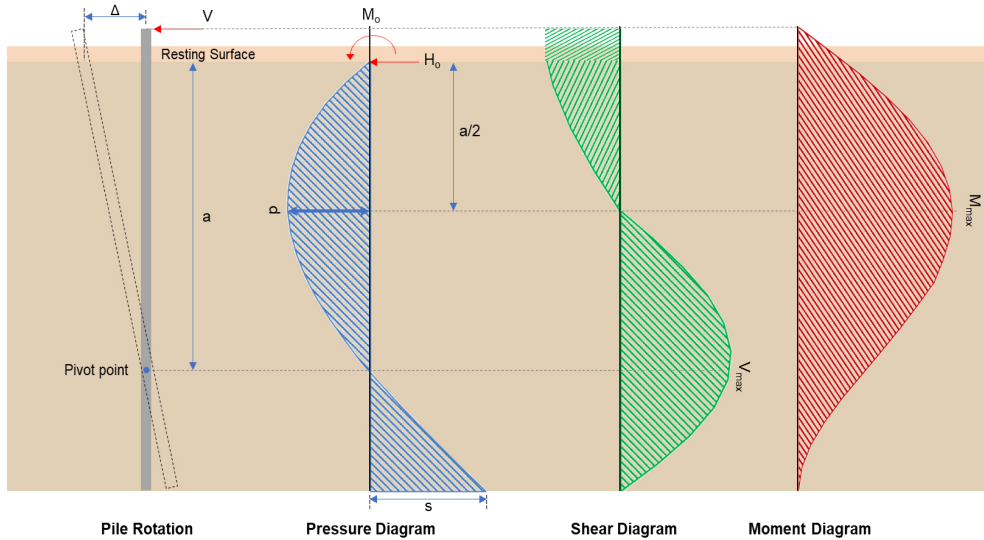
$$= \frac{(1.178 \text{ kip/ft}^2)}{(1.2 \text{ kip/ft}^2)}$$

Status: **PASS**  
Ratio: **0.420**

$$Ratio = \frac{\dots}{(1.2 \text{ kip/ft}^2)}$$

$$Ratio = 0.98169$$

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



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

$H_o$  - Lateral force per length of pile,

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

$$H_o = \frac{(-4.38 \text{ kip})}{(36 \text{ in})}$$

$$H_o = -1.46 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

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

$$M_o = \frac{(38.14 \text{ kipft}) + ((-4.38 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 12.713 \text{ kipft/ft}$$

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

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

$$E = \frac{(12.713 \text{ kipft/ft})}{(-1.46 \text{ kip/ft})}$$

$$E = 8.7078 \text{ ft}$$

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

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

$$a = \frac{(4 \times (12.713 \text{ kipft/ft}) \times (8 \text{ ft})) + (3 \times (-1.46 \text{ kip/ft}) \times (8 \text{ ft})^2)}{(6 \times (12.713 \text{ kipft/ft})) + (4 \times (-1.46 \text{ kip/ft}) \times (8 \text{ ft}))}$$

$$a = 5.5866 \text{ ft}$$

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

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

$$V_{max} = ((-1.46 \text{ kip/ft}) \times (36 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (8.7078 \text{ ft})}{(8 \text{ ft})} + 3 \right) \times \left( \frac{(5.5866 \text{ ft})}{(8 \text{ ft})} \right)^2 \right] + \left[ 4 \times \left( \frac{3 \times (8.7078 \text{ ft})}{(8 \text{ ft})} + 2 \right) \times \left( \frac{(5.5866 \text{ ft})}{(8 \text{ ft})} \right)^3 \right] \right]$$

|                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                    |
|-------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|
|                                                 | $V_{max} = 11.327 \text{ kip}$ <p><math>M_{max}</math> - Max bending moment located at depth <math>a/2</math>,</p> $M_{max} = (H_o D L_e) \left[ \left( \frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[ \left( \frac{4 E}{L_e} + 3 \right) \left( \frac{a}{2 L_e} \right)^3 + \left[ \left( \frac{3 E}{L_e} + 2 \right) \left( \frac{a}{2 L_e} \right)^4 \right] \right] \right]$ $M_{max} = ((-1.46 \text{ kip/ft}) \times (36 \text{ in}) \times (8 \text{ ft})) \times \left[ \left( \frac{(8.7078 \text{ ft})}{(8 \text{ ft})} + \frac{(5.5866 \text{ ft})}{2 \times (8 \text{ ft})} \right) - \left[ \left( \frac{4 \times (8.7078 \text{ ft})}{(8 \text{ ft})} + 3 \right) \times \left( \frac{(5.5866 \text{ ft})}{2 \times (8 \text{ ft})} \right)^3 + \left[ \left( \frac{3 \times (8.7078 \text{ ft})}{(8 \text{ ft})} + 2 \right) \times \left( \frac{(5.5866 \text{ ft})}{2 \times (8 \text{ ft})} \right)^4 \right] \right] \right]$ $M_{max} = 42.148 \text{ kipft}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                    |
| <p>Table 22.4.2.1</p> <p>22.4.2.2, 10.6.1.1</p> | <p><b>Minimum Reinforcement Check (LRFD)</b></p> <p><b>Parameters:</b></p> <p><math>f'_{ck} = 2.5 \text{ ksi}</math> - Concrete strength,<br/> <math>f_{yk} = 60 \text{ ksi}</math> - Longitudinal reinforcement strength,<br/> <math>\phi = 0.65</math> - Reduction factor for axial strength,<br/> <math>\alpha = 0.85</math> - Alpha factor for axial strength,<br/> <math>A_g = 1017.9 \text{ in}^2</math> - Gross area of concrete,</p> <p><b>Longitudinal reinforcement:</b></p> <p>Required reinforcement due to axial load, <math>A_{st,required}</math></p> $A_{st,required} = \text{Min} \left[ \frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = \text{Min} \left[ \frac{\frac{(7.691 \text{ kip})}{(0.65) \times (0.85)} - (0.85 \times (2.5 \text{ ksi}) \times (1017.9 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (1017.9 \text{ in}^2)) \right]$ $A_{st,required} = -37.133 \text{ in}^2$ <p><math>A_{min}</math> - Governing minimum reinforcement area,</p> $A_{min} = \text{Max} [A_{st,required}, (0.0018 A_g)]$ $A_{min} = \text{Max} [(-37.133 \text{ in}^2), (0.0018 \times (1017.9 \text{ in}^2))]$ $A_{min} = 1.8322 \text{ in}^2$ <p><math>n_{rebar}</math> - Required number of reinforcement,</p> $n_{rebar} = \frac{A_{min}}{A_{rebar}}$ $n_{rebar} = \frac{(1.8322 \text{ in}^2)}{(0.3068 \text{ in}^2)}$ $n_{rebar} = 6$ <p><math>A_{st}</math> - Actual total reinforcement area,</p> $A_{st} = n_{rebar} \frac{\pi d_{bar}^2}{4}$ $A_{st} = (6) \times \frac{\pi \times (0.625 \text{ in})^2}{4}$ $A_{st} = 1.8408 \text{ in}^2$ <p><b>Ratio - Capacity</b></p> $\text{Ratio} = \frac{A_{min}}{A_{st}}$ $\text{Ratio} = \frac{(1.8322 \text{ in}^2)}{(1.8408 \text{ in}^2)}$ $\text{Ratio} = 0.99533$ <p>25.2.3 <math>s_{rebar}</math> - Minimum spacing of reinforcement,</p> | <p>Status: <b>PASS</b><br/>Ratio: <b>1.000</b></p> |

|                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                    |
|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|
|                                                                          | $s_{rebar} = Max [1.5, (1.5 d_{bar})]$ $s_{rebar} = Max [1.5, (1.5 \times (0.625 \text{ in}))]$ $s_{rebar} = 1.5 \text{ in}$ <p><b>Ties:</b></p> <p>25.7.2.2 Since longitudinal reinforcement is <math>\leq</math> No. 10e: Use #3(0.375 in)</p> <p>25.7.2.1 <math>s_{ties}</math> - Maximum center-to-center spacing of ties,</p> $s_{ties} = Min [(16 d_{bar}), (48 d_{ties}), D]$ $s_{ties} = Min [(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), (36 \text{ in})]$ $s_{ties} = 10 \text{ in}$ <p><b>Summary:</b></p> <p>Main reinforcement: <b>6 - #5 (0.625 in)</b><br/>Ties: <b>#3(0.375 in) - 10 in</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                    |
| <p>22.4.2.2</p>                                                          | <p><b>Axial Compression Strength (ACI 318-19, LRFD)</b></p> <p><math>\phi P_N</math> - Allowable axial compressive strength</p> $\phi P_N = \phi 0.85 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st})]$ $\phi P_N = (0.65) \times 0.85 \times [(0.85 \times (2.5 \text{ ksi}) \times [(1017.9 \text{ in}^2) - (1.8408 \text{ in}^2)]) + ((60 \text{ ksi}) \times (1.8408 \text{ in}^2))]$ $\phi P_N = 1253.9 \text{ kip}$ <p><i>Ratio - Capacity</i></p> $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(7.691 \text{ kip})}{(1253.9 \text{ kip})}$ $Ratio = 0.0061336$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <p>Status: <b>PASS</b><br/>Ratio: <b>0.010</b></p> |
| <p>22.5.2.2</p> <p>22.5.5.1.3</p> <p>22.5.5.1.1</p> <p>22.5.5.1.1(a)</p> | <p><b>Shear Strength (ACI 318-19, LRFD)</b></p> <p><b>Parameters:</b></p> <p><math>b_w = 36 \text{ in}</math> - Effective width,<br/><math>d</math> - Effective depth</p> $d = 0.80 D$ $d = 0.80 \times (36 \text{ in})$ $d = 28.8 \text{ in}$ <p><math>\lambda_s</math> - size effect modification factor</p> $\lambda_s = MIN \left[ \sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = MIN \left[ \sqrt{\frac{2}{1 + \frac{(28.8 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.71796$ <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> $V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$ $V_{c,max} = 5 \times (0.71796) \times \sqrt{(2500 \text{ psi})} \times (36 \text{ in}) \times (28.8 \text{ in})$ $V_{c,max} = 186.09 \text{ kip}$ <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 = 7.691 \text{ kip} \rightarrow 7691 \text{ lbf}</math>,</p> <p><math>V_{c,a}</math> - Shear strength of concrete (a)</p> $V_{c,a} = \left[ 2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ |                                                    |

$$V_{c,a} = \left[ 2 \times (0.71796) \times \sqrt{(2500 \text{ psi})} + \frac{(7691 \text{ lbf})}{6 \times (1017.9 \text{ in}^2)} \right] \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{c,a} = 75.744 \text{ kip}$$

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

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

$$V_{c,b} = \left[ 2 \times (0.71796) \times \sqrt{(2500 \text{ psi})} + (0.05 \times (2500 \text{ psi})) \right] \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{c,b} = 204.04 \text{ kip}$$

$V_c$  - Governing shear strength of concrete

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

$$V_c = \text{Min}[(186.09 \text{ kip}), (75.744 \text{ kip}), (204.04 \text{ kip})]$$

$$V_c = 75.744 \text{ kip}$$

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

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

$$V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{s,a} = 414.72 \text{ kip}$$

$A_v$  - Ties rebar area,

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

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

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

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

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

$$V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (28.8 \text{ in})}{(10 \text{ in})}$$

$$V_{s,b} = 38.17 \text{ kip}$$

$V_s$  - Governing shear strength of steel

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

$$V_s = \text{MIN}[(414.72 \text{ kip}), (38.17 \text{ kip})]$$

$$V_s = 38.17 \text{ kip}$$

22.5.1.1  $\phi V_n$  - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((75.744 \text{ kip}) + (38.17 \text{ kip}))$$

$$\phi V_n = 74.044 \text{ kip}$$

**Considering x-direction:**

$V_{max} = 11.327 \text{ kip}$  - Maximum shear force in the x-direction,  
 $Ratio$  - Capacity

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

$$Ratio = \frac{(11.327 \text{ kip})}{(74.044 \text{ kip})}$$

$$Ratio = 0.15298$$

Status: **PASS**  
 Ratio: **0.15298**

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                     |
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|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Ratio: <b>0.150</b>                                 |
|  | <p><b>Flexural Strength (ACI 318-19, LRFD)</b></p> <p><math>S_m</math> - Section modulus</p> $S_m = \frac{\pi D^3}{32}$ $S_m = \frac{\pi \times (36 \text{ in})^3}{32}$ $S_m = 4580.4 \text{ in}^3$ <p><math>\lambda = 1</math> - Concrete modification factor (Normal concrete),<br/> Allowable flexural strength:<br/> <math>M_n</math> shall be the lesser of:<br/> <math>\phi M_{n,1}</math></p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 \text{ ksi})} \times 4580.442 \text{ in}^3$ $\phi M_{n,1} = 62.027 \text{ kipft}$ <p>14.5.2.1b <math>\phi M_{n,2}</math></p> $\phi M_{n,2} = \phi \times 0.85 \times f'_{ck} \times S_m$ $\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (4580.4 \text{ in}^3)$ $\phi M_{n,2} = 527.23 \text{ kipft}$ <p>Therefore,<br/> <math>\phi M_n</math> - Allowable flexural strength,</p> $\phi M_n = \text{MIN}[\phi M_{n,1}, \phi M_{n,2}]$ $\phi M_n = \text{MIN}[(62.027 \text{ kipft}), (527.23 \text{ kipft})]$ $\phi M_n = 62.027 \text{ kipft}$ <p><b>Considering x-direction:</b></p> <p><math>M_{max} = 42.148 \text{ kipft}</math> - Maximum moment in the x-direction,<br/> Ratio - Capacity</p> $\text{Ratio} = \frac{M_{max}}{\phi M_n}$ $\text{Ratio} = \frac{(42.148 \text{ kipft})}{(62.027 \text{ kipft})}$ $\text{Ratio} = 0.67951$ | <p>Status: <b>PASS</b><br/> Ratio: <b>0.680</b></p> |