

# Your Project Calculations



Project Name: SolarWindFX\_TOP15

S3D Model Link:

[https://platform.skyciv.com/structural?preload\\_name=SolarWindFX\\_TOP15&preload\\_path=Shared%20Enterprise%20Folder/MT\\_Solar\\_Projects/5\\_2023](https://platform.skyciv.com/structural?preload_name=SolarWindFX_TOP15&preload_path=Shared%20Enterprise%20Folder/MT_Solar_Projects/5_2023)

Public Model Link:

[https://platform.skyciv.com/structural-viewer?project\\_id=FluSGwgCjSFhlpLdvz2qiO5HLPc2mETcDMBpp3iIMmnTdx43zGzFPBjK8jopAxG](https://platform.skyciv.com/structural-viewer?project_id=FluSGwgCjSFhlpLdvz2qiO5HLPc2mETcDMBpp3iIMmnTdx43zGzFPBjK8jopAxG)

## Array Specification

|                                    |                              |
|------------------------------------|------------------------------|
| <b>Product:</b>                    | Beam                         |
| <b>Unique ID:</b>                  | 1P-0-8TOP-HD-72-L-5Hx3W-25BJ |
| <b>Duty Classification:</b>        | HD                           |
| <b>Module Width:</b>               | 41.50 in                     |
| <b>Module Length:</b>              | 82.13in                      |
| <b>Number of Rows:</b>             | 5                            |
| <b>Number of Columns:</b>          | 3                            |
| <b>Total Number of Modules:</b>    | 15                           |
| <b>Desired Tilt Angle:</b>         | 45                           |
| <b>Front Edge Clearance:</b>       | 3                            |
| <b>Total Array Height at Tilt:</b> | 15.30 ft                     |
| <b>Total Frame Length:</b>         | 19.50 ft                     |
| <b>Frame Weight:</b>               | 1159 lbs                     |
| <b>Array Dimensions N/S:</b>       | 17.50 ft                     |
| <b>Array Dimensions E/W:</b>       | 20.78 ft                     |
| <b>Rail Length:</b>                | 210.00 in                    |
| <b>Rail Spacing:</b>               | 3.42 ft                      |
| <b>Rail Check:</b>                 |                              |

## Support Specifications

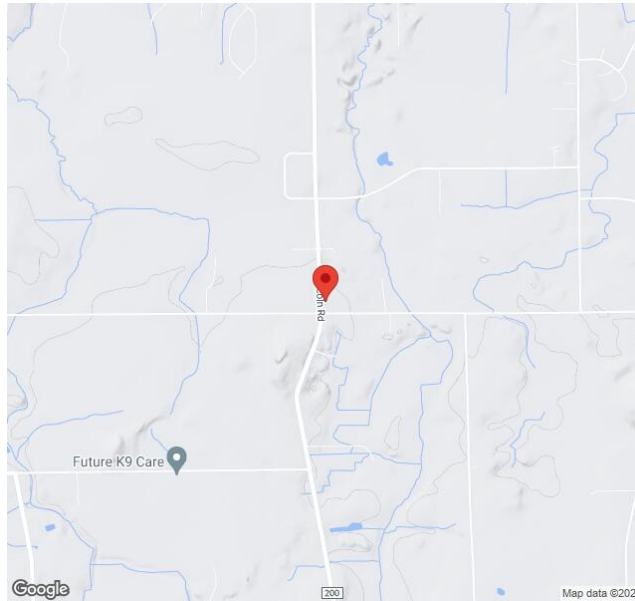
|                                 |                 |
|---------------------------------|-----------------|
| <b>Pole Size:</b>               | 8in Pipe Sch 40 |
| <b>Pole Length above Grade:</b> | 9.19 ft         |
| <b>Number of Poles:</b>         | 1               |
| <b>Pole Spacing:</b>            | 0               |

## Foundation Specifications

|  |                      |
|--|----------------------|
| <b>Foundation Type:</b>                | Square               |
| <b>Foundation Dimensions:</b>          | 36 x 36 in           |
| <b>Foundation Depth (below grade):</b> | Pile 1: 7.50 ft      |
| <b>Foundation Volume:</b>              | 2.500 y <sup>3</sup> |
| <b>Foundation Result:</b>              | PASSED               |
| <b>Mount Twist:</b>                    | 0.000009 kip         |

## Site Info

|                                   |   |
|-----------------------------------|---|
| <b>Risk Category:</b>             | I                                       |
| <b>Exposure:</b>                  | B                                       |
| <b>Soil Classification:</b>       | sand                                    |
| <b>Site Location:</b>             | 5612 Lincoln Rd, Ontario, NY 14519, USA |
| <b>Wind Speed:</b>                | 100 mph                                 |
| <b>Snow Load:</b>                 | 40 psf                                  |
| <b>Design Uplift Pressure:</b>    | Multiple pressures                      |
| <b>Design Downforce Pressure:</b> | Multiple pressures                      |
| <b>Design Snow Pressure:</b>      | 0.010996 ksf                            |



### Design Disclaimer

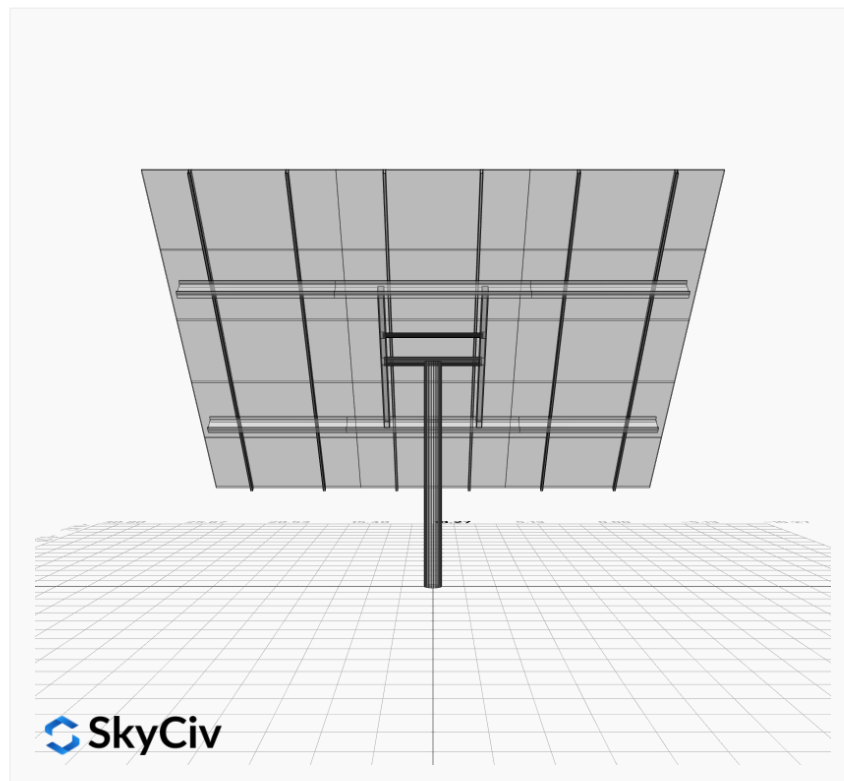
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

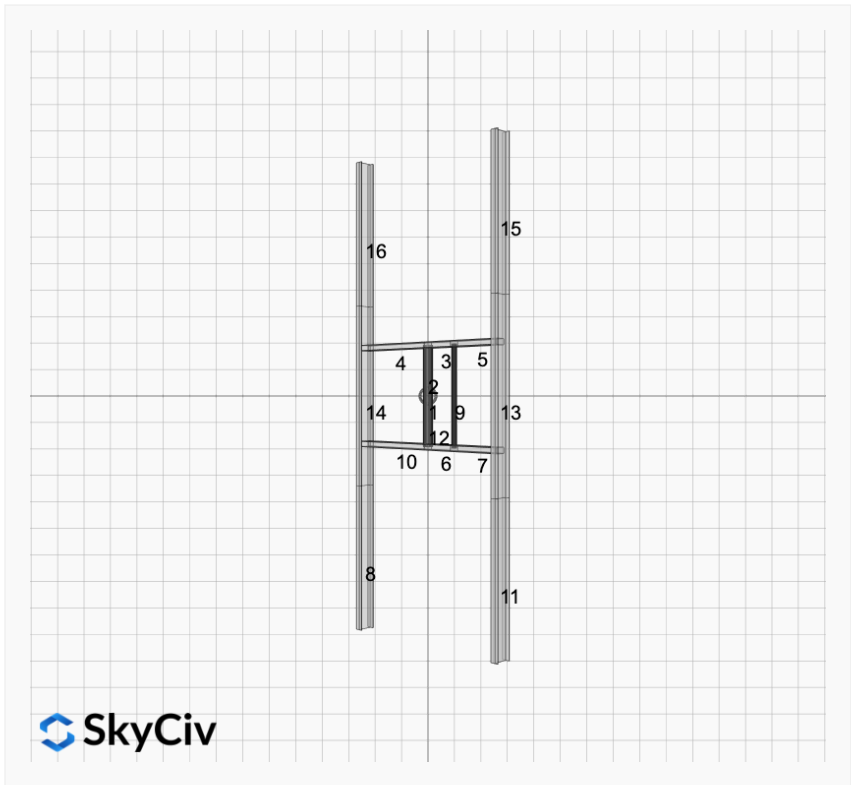
### AutoDesigner Input

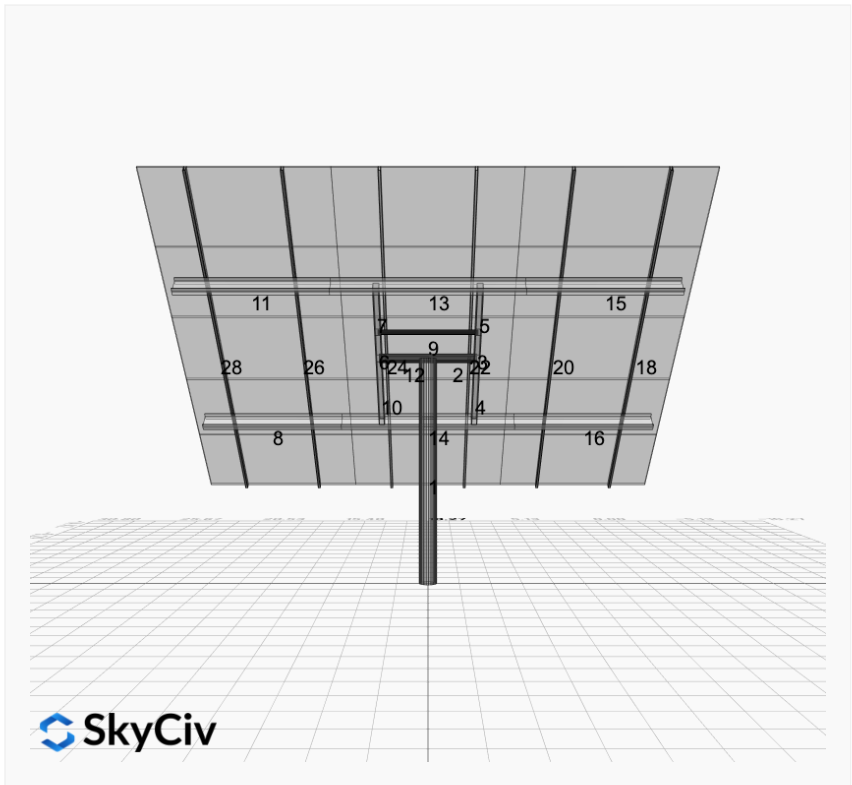
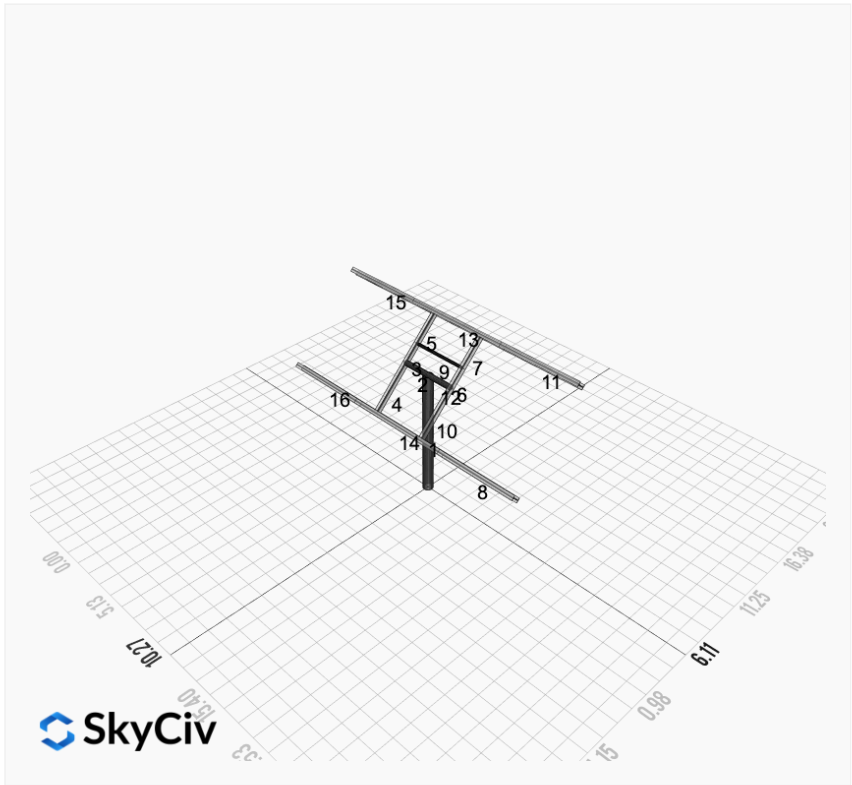
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```

### Design Notes:

- AISC Deflection checks are set to L/1 due to structure design intent







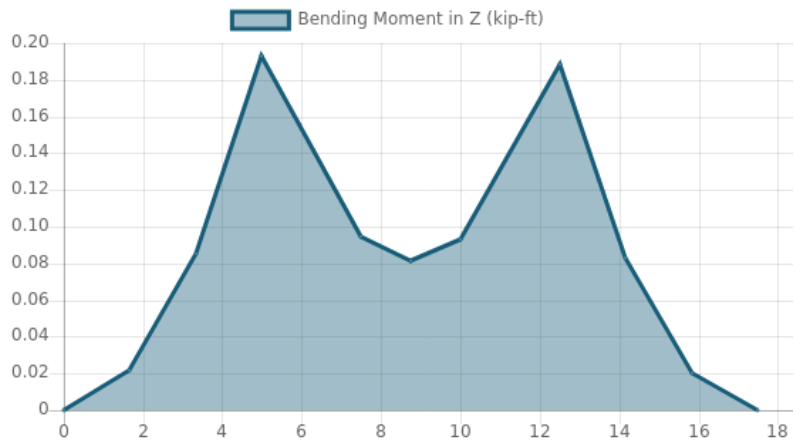
**Rail Design Check**

**Rail Length:** 17.5 ft  
**Additional Restraints Required:** None  
**Tributary Width:** 3.463749999999997 ft  
**Material:** Aluminium  
**Density:** 169 lb/ft<sup>3</sup>  
**Elasticity Modulus:** 10000 ksi  
**Fy:** 34.5 ksi  
**Fu:** 37 ksi  
**Snow (X):** 0.0269 kip/ft  
**Snow (Y):** -0.0269 kip/ft  
**Wind uplift Case A:** 0.0651 kip/ft  
**Wind uplift Case A:** 0.0651 kip/ft  
**Wind uplift Case B (X):** 0.0000 kip/ft  
**Wind uplift Case B (Y):** 0.0832 kip/ft

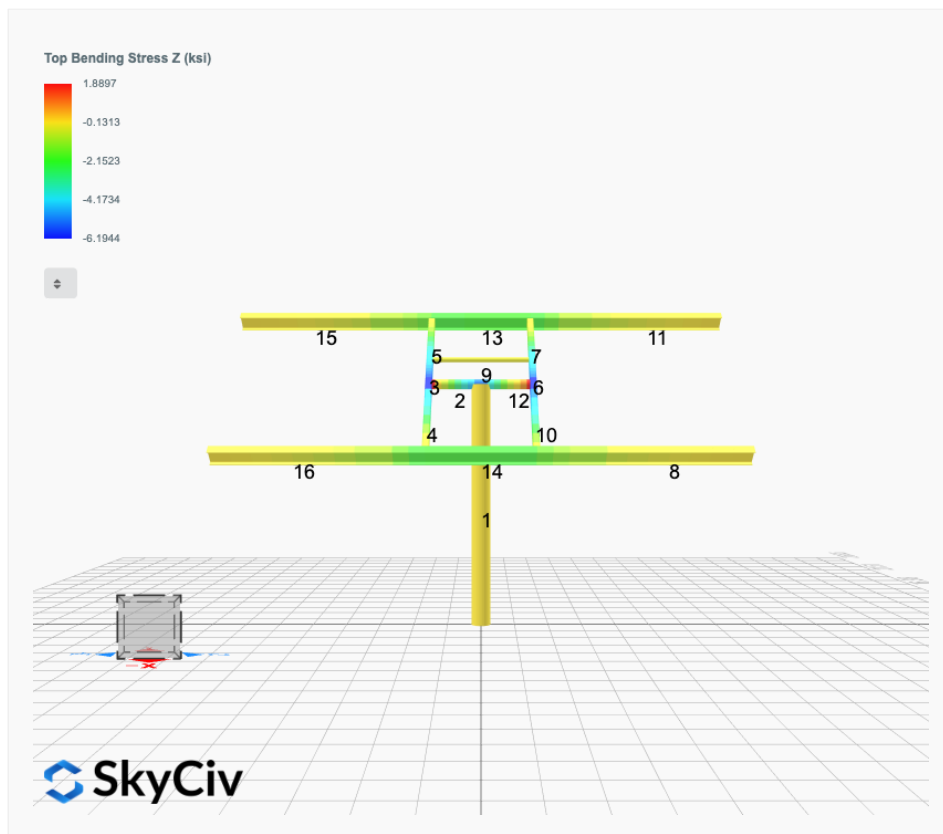
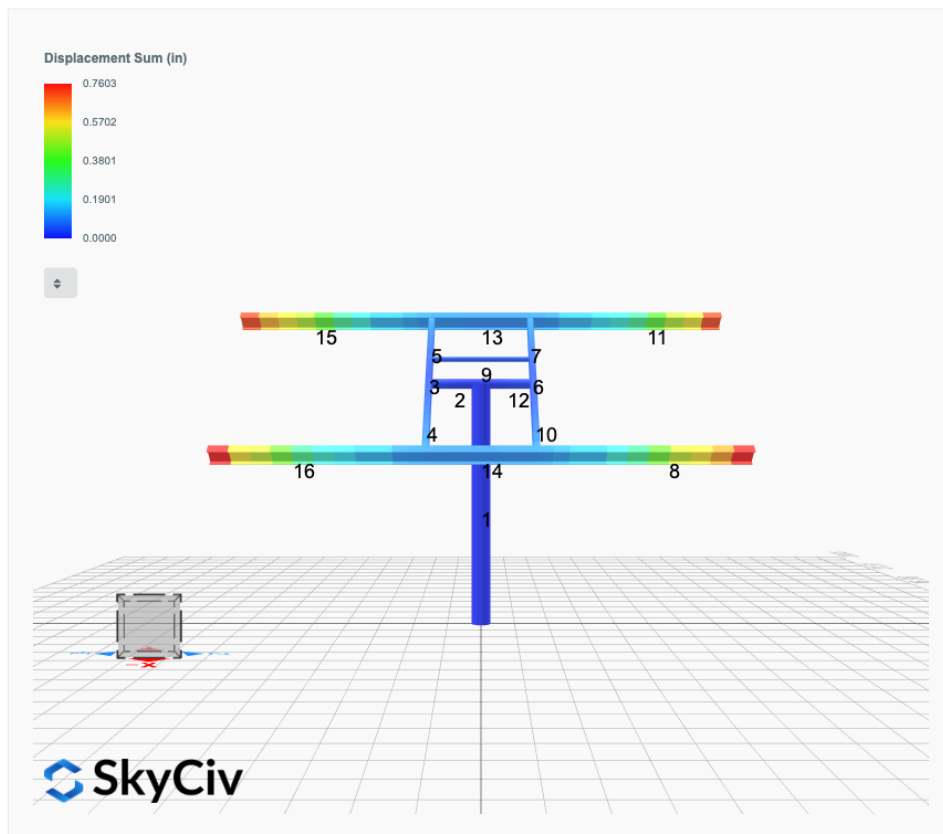


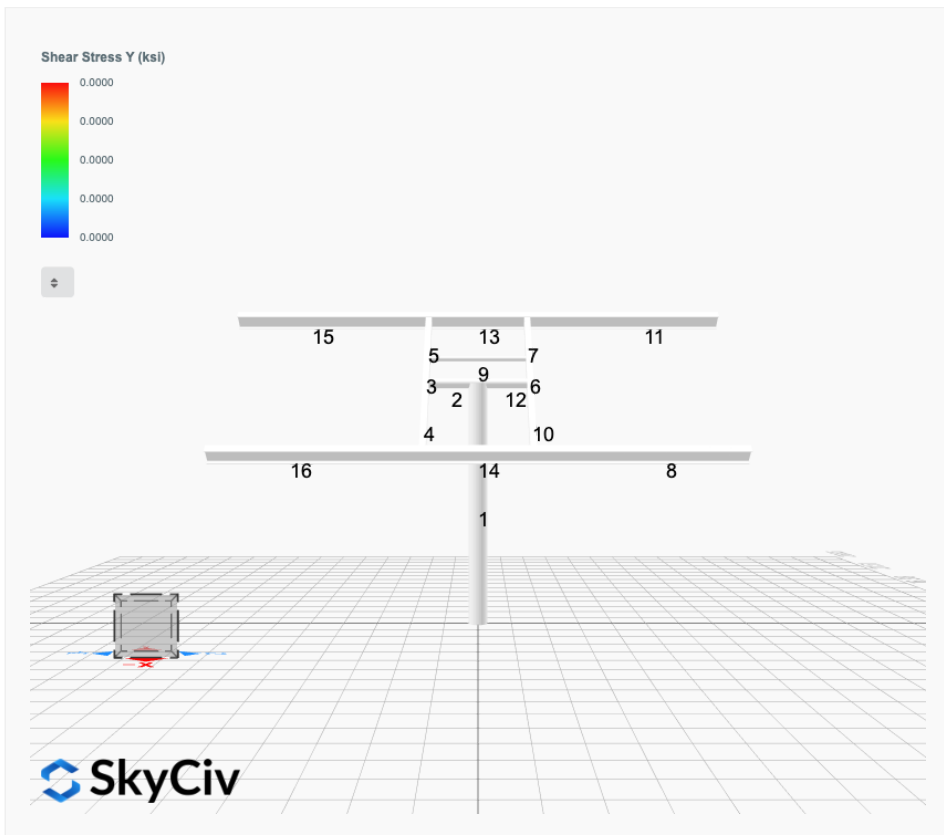
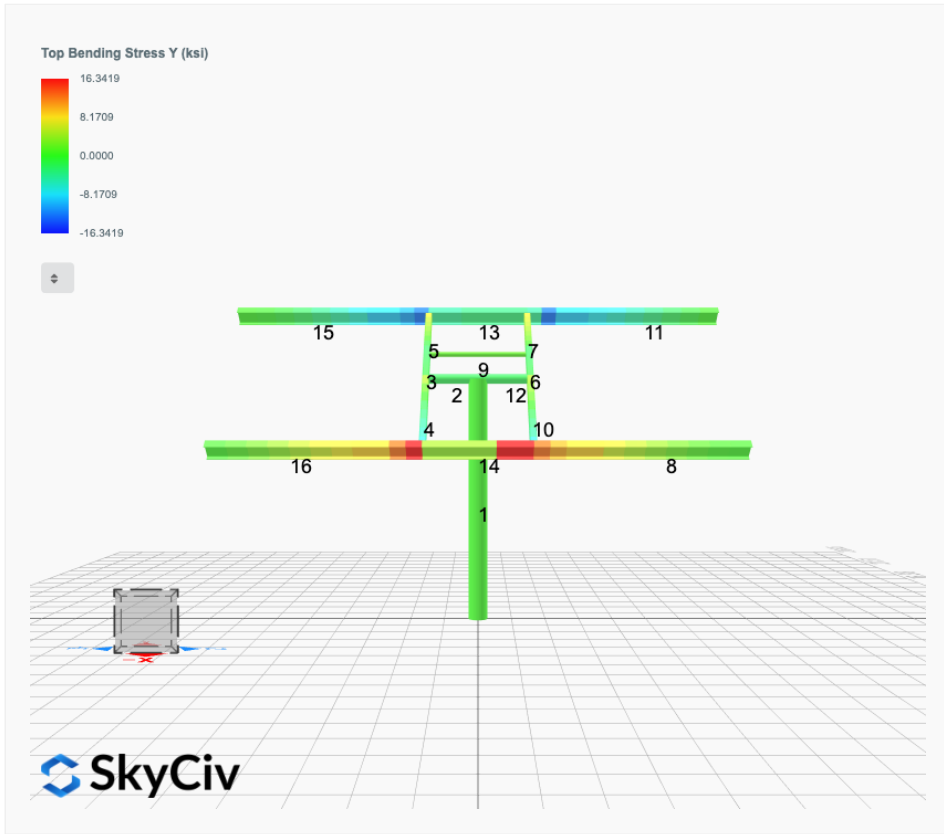
| Result Check        | Max Limit | Max Value   | Utility | Status |
|---------------------|-----------|-------------|---------|--------|
| Custom Stress Limit | 34.5      | 31.69679686 | 0.919   | PASS   |
| Material Yield      | 34.5      | 31.69679686 | 0.919   | PASS   |
| Material Strength   | 37        | 31.69679686 | 0.857   | PASS   |

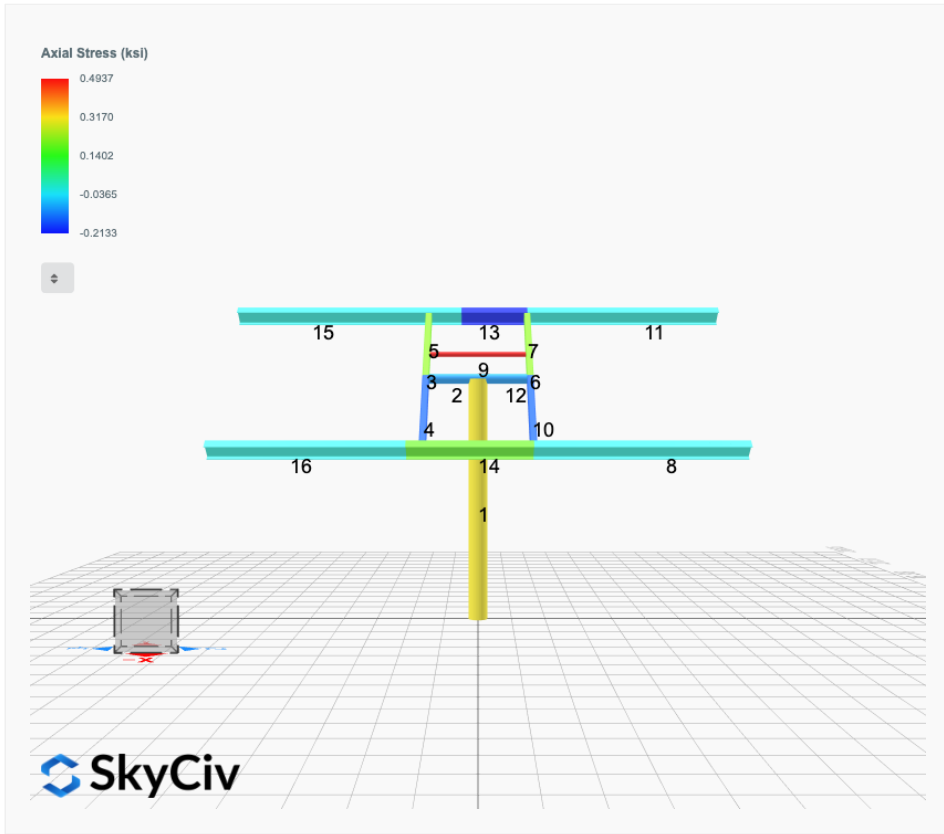
**Member 1, ULS: 1. 1.4D**



## 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  | 2.5020  | 0.0000  | 0.0000 | -0.0000 | 0.0239   |
| ULS: 2. D + L   | 0.0000  | 2.5020  | 0.0000  | 0.0000 | -0.0000 | 0.0239   |
| ULS: 3. D + (S or Lr or R)  | 0.0000  | 5.1554  | 0.0000  | 0.0000 | -0.0000 | 0.0330   |
| ULS: 3. D + (S or Lr or R)  | 0.0000  | 2.5020  | 0.0000  | 0.0000 | -0.0000 | 0.0239   |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R)  | 0.0000  | 4.4920  | 0.0000  | 0.0000 | -0.0000 | 0.0307   |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R)  | 0.0000  | 2.5020  | 0.0000  | 0.0000 | -0.0000 | 0.0239   |
| ULS: 5b. D + 0.7E   | 0.0000  | 2.5020  | 0.0000  | 0.0000 | -0.0000 | 0.0239   |
| ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S   | 0.0000  | 4.4920  | 0.0000  | 0.0000 | -0.0000 | 0.0307   |
| ULS: 8. 0.6D + 0.7E   | 0.0000  | 1.5012  | 0.0000  | 0.0000 | -0.0000 | 0.0143   |
| ULS: 5a. D + 0.6W_Wind downforce Case A only                                    | -3.7861 | 6.2881  | -0.0000 | 0.0000 | -0.0000 | 36.5424  |
| ULS: 5a. D + 0.6W_Wind downforce Case B only                                    | -3.7861 | 6.2881  | -0.0000 | 0.0000 | -0.0000 | 36.5424  |
| ULS: 5a. D + 0.6W_Wind uplift Case A only                                       | 2.7389  | -0.2369 | 0.0000  | 0.0000 | -0.0000 | -24.0766 |
| ULS: 5a. D + 0.6W_Wind uplift Case B only                                       | 2.4167  | 0.0853  | 0.0000  | 0.0000 | -0.0000 | -28.7644 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -2.8396 | 7.3316  | -0.0000 | 0.0000 | -0.0000 | 27.4196  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | -2.8396 | 7.3316  | -0.0000 | 0.0000 | -0.0000 | 27.4196  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only    | 2.0542  | 2.4378  | 0.0000  | 0.0000 | -0.0000 | -18.0446 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only    | 1.8125  | 2.6795  | 0.0000  | 0.0000 | -0.0000 | -21.5605 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -2.8396 | 5.3415  | -0.0000 | 0.0000 | -0.0000 | 27.4128  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | -2.8396 | 5.3415  | -0.0000 | 0.0000 | -0.0000 | 27.4128  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only    | 2.0542  | 0.4478  | 0.0000  | 0.0000 | -0.0000 | -18.0514 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only    | 1.8125  | 0.6894  | 0.0000  | 0.0000 | -0.0000 | -21.5673 |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case A only                                  | -3.7861 | 5.2873  | -0.0000 | 0.0000 | -0.0000 | 36.5328  |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case B only                                  | -3.7861 | 5.2873  | -0.0000 | 0.0000 | -0.0000 | 36.5328  |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case A only                                     | 2.7389  | -1.2377 | 0.0000  | 0.0000 | -0.0000 | -24.0861 |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case B only                                     | 2.4167  | -0.9155 | 0.0000  | 0.0000 | -0.0000 | -28.7739 |

### Worst Case Reactions LRFD

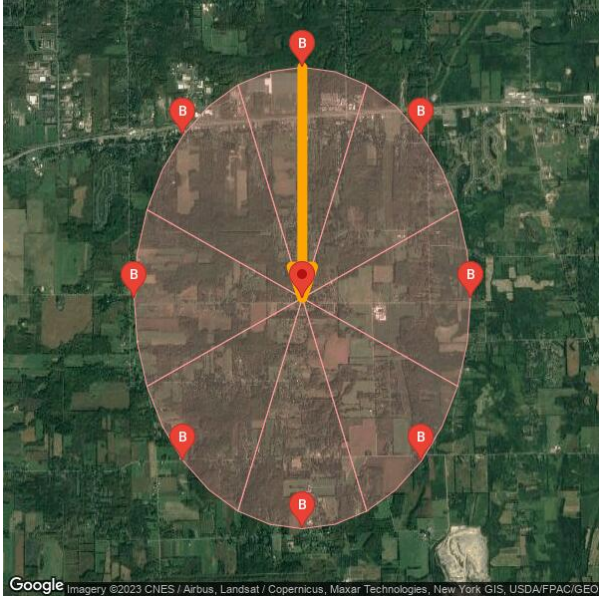
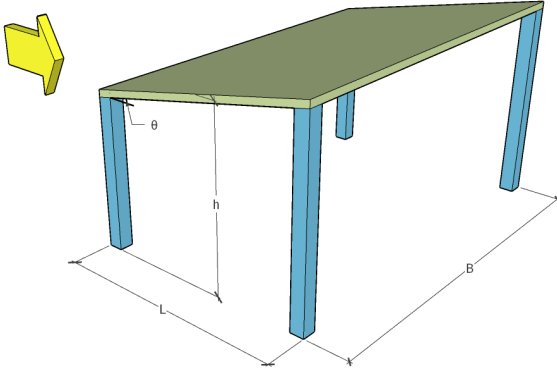
These calculations are taken directly from the FEA via SkyCiv and are used in the Concrete Checks of the Foundation Module.  
Note: Worst case values are assumed as downforce wind load cases.

| Result           | Value (kip, kip-ft) |
|------------------|---------------------|
| Axial            | 10.6393             |
| Shear X          | -6.3102             |
| Shear Z          | -0.0000             |
| Moment X         | -0.0000             |
| Moment Y (Twist) | 0.0000              |
| Moment Z         | 61.5044             |

### Worst Case Reactions ASD

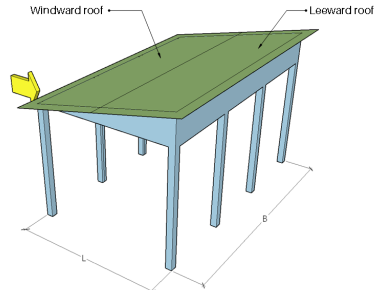
These results are taken from the worst case values in the above table and are used in the Soil Checks in the Foundation Module.  
Note: Worst case values are assumed as downforce wind load cases.

| Result           | Value (kip, kip-ft) |
|------------------|---------------------|
| Axial            | 7.3316              |
| Shear X          | -3.7861             |
| Shear Z          | -0.0000             |
| Moment X         | 0.0000              |
| Moment Y (Twist) | 0.0000              |
| Moment Z         | 36.5424             |

| REFERENCES                 | CALCULATIONS  | RESULTS                         |       |                      |          |                     |          |                       |         |              |                |                            |        |                |  |               |             |  |
|----------------------------|---|---------------------------------|-------|----------------------|----------|---------------------|----------|-----------------------|---------|--------------|----------------|----------------------------|--------|----------------|--|---------------|-------------|--|
|                            | <p style="text-align: center;"><b>Wind Load Calculations based on ASCE 7-16</b></p> <p><b>Design Information :</b><br/> Project Name : SolarWindFX_TOP15<br/> Client :<br/> Designer : MT SKYCIV AutoDesigner<br/> Company : MT Solar<br/> Units : Imperial<br/> Notes : Snow loads based on monoslope structure</p> <p><b>Project Data</b><br/> The structure is located in <b>5612 Lincoln Rd, Ontario, NY 14519</b> categorized as <b>Exposure B</b> (assumed to be homogeneous for the selected wind direction). The wind load calculation for the structure - Main Wind Force Resisting System (MWFRS) - is based on the Directional Procedure (Chapter 27) of ASCE 7. Moreover, the structure is classified as <b>Risk Category I</b>. The location is elevated at <b>494.79 ft</b> above mean sea level.</p>  <p style="text-align: center;"><b>Figure 1. Site location.</b></p> <table border="1"> <thead> <tr> <th>Parameter</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td>Building Length, <math>L</math></td> <td>12.23 ft</td> </tr> <tr> <td>Building Width, <math>B</math></td> <td>20.53 ft</td> </tr> <tr> <td>Mean Roof Height, <math>h</math></td> <td>9.19 ft</td> </tr> <tr> <td>Roof Profile</td> <td>Open Monoslope</td> </tr> <tr> <td>Roof Pitch Angle, <math>\theta</math></td> <td>45.00°</td> </tr> <tr> <td>Structure Type</td> <td>Main Wind Force Resisting System (MWFRS)</td> </tr> <tr> <td>Wind Blockage</td> <td>Empty Under</td> </tr> </tbody> </table>  <p style="text-align: center;"><b>Figure 2. Building parameters.</b></p> | Parameter                       | Value | Building Length, $L$ | 12.23 ft | Building Width, $B$ | 20.53 ft | Mean Roof Height, $h$ | 9.19 ft | Roof Profile | Open Monoslope | Roof Pitch Angle, $\theta$ | 45.00° | Structure Type | Main Wind Force Resisting System (MWFRS) | Wind Blockage | Empty Under |  |
| Parameter                  | Value   |                                 |       |                      |          |                     |          |                       |         |              |                |                            |        |                |  |               |             |  |
| Building Length, $L$       | 12.23 ft  |                                 |       |                      |          |                     |          |                       |         |              |                |                            |        |                |  |               |             |  |
| Building Width, $B$        | 20.53 ft  |                                 |       |                      |          |                     |          |                       |         |              |                |                            |        |                |  |               |             |  |
| Mean Roof Height, $h$      | 9.19 ft   |                                 |       |                      |          |                     |          |                       |         |              |                |                            |        |                |  |               |             |  |
| Roof Profile               | Open Monoslope  |                                 |       |                      |          |                     |          |                       |         |              |                |                            |        |                |  |               |             |  |
| Roof Pitch Angle, $\theta$ | 45.00°  |                                 |       |                      |          |                     |          |                       |         |              |                |                            |        |                |  |               |             |  |
| Structure Type             | Main Wind Force Resisting System (MWFRS)  |                                 |       |                      |          |                     |          |                       |         |              |                |                            |        |                |  |               |             |  |
| Wind Blockage              | Empty Under   |                                 |       |                      |          |                     |          |                       |         |              |                |                            |        |                |  |               |             |  |
| <p>Figure 26.5-1</p>       | <p><b>Basic Wind Speed, <math>V</math></b><br/> Wind speed for the address is <b>100 mph</b> for Risk Category I and was calculated using Triangular Interpolation Network (TIN) method from points with known wind speed values based on Figure 26.5-1 of ASCE 7.</p>  | <p><math>V = 100</math> mph</p> |       |                      |          |                     |          |                       |         |              |                |                            |        |                |  |               |             |  |
| <p>Table 207A.6-1</p>      | <p><b>Wind Directionality Factor, <math>K_d</math></b><br/> <math>K_d = 0.85</math> - Wind Directionality Factor<br/> For buildings</p>   | <p><math>K_d = 0.85</math></p>  |       |                      |          |                     |          |                       |         |              |                |                            |        |                |  |               |             |  |
| <p>Section 26.8.1</p>      | <p><b>Topographic Factor, <math>K_{zt}</math></b><br/> <math>K_{zt} = 1</math> - Topographic Factor<br/> For the selected wind source direction, either the terrain is relatively a flat surface or the structure is outside the local topographic zones.</p>   | <p><math>K_{zt} = 1</math></p>  |       |                      |          |                     |          |                       |         |              |                |                            |        |                |  |               |             |  |

|                         | <b>For calculating the hill-shape multiplier, the detected topography for the selected wind source direction is Flat.</b>   |   |                 |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
|-------------------------|---|---|-----------------|-------------------|---------------------------|-----------------|----------------|----------|--------------|----------------|---------|--------|--------|-------|----------|-------|---------|---------|-------|-------|-------|-----------------------------|--------|-------|--------------------------------|--------|-------|---------------------------|--------|-------|-------|-------|---------|--------|---|---|-------|-------|-------|-------|---------|--------|----|---|-------|-------|-------|-------|---------|--------|----|---|-------|-------|-------|-------|---------|--------|----|---|-------|-------|-------|-------|---------|--------|----|---|-------|-------|-------|-------|---------|--------|--|
| Section 26.9            | <p><b>Ground Elevation Factor, <math>K_e</math></b></p> <p><math>K_e</math> - Ground Elevation Factor</p> $K_e = e^{-0.0000362 E}$ $K_e = 0.98225$ <p>Where <math>E</math> = Site Elevation = 494.79 ft</p>   |   |                 |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| Section 26.9            | $K_e = 0.98225$ - Ground Elevation Factor   |   | $K_e = 0.98225$ |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| Section 26.10           | <p><b>Velocity Pressure Exposure Coefficient, <math>K_z</math></b></p> <p><math>K_z</math> - Velocity Pressure Exposure Coefficient</p> <p>For <math>z &lt; 15 ft</math></p> $K_z = 2.01 \times (15/z_g)^{2/\alpha}$  |   |                 |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| Section 26.10           | <p><math>K_z</math> - Velocity Pressure Exposure Coefficient</p> <p>For <math>15 ft \leq z \leq z_g</math></p> $K_z = 2.01 \times (z/z_g)^{2/\alpha}$   |   |                 |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
|                         |   | <table border="1"> <thead> <tr> <th>Level</th> <th>Elevation (ft)</th> <th><math>K_z</math></th> </tr> </thead> <tbody> <tr> <td>h</td> <td>9.187</td> <td>0.575</td> </tr> </tbody> </table>   | Level           | Elevation (ft)    | $K_z$                     | h               | 9.187          | 0.575    |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| Level                   | Elevation (ft)  | $K_z$   |                 |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| h                       | 9.187   | 0.575   |                 |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| Section 26.10.2         | <p><b>Velocity Pressure, <math>q_h</math></b></p> <p>For the selected wind source direction.</p> <p><math>q_h</math> - Velocity Pressure at h</p> $q_h = 0.00256 K_{z,h} K_{zt} K_d K_e V^2$ $q_h = 12.284 \text{ psf}$ <p>Where <math>K_{z,h} = 0.57472</math><br/> <math>K_{zt}</math> = Topographic Factor = 1<br/> <math>K_d</math> = Wind Directionality Factor = 0.85<br/> <math>V</math> = Basic Wind Speed = 100 mi/h<br/> <math>K_e</math> = Ground Elevation Factor = 0.98225</p> |   |                 |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| Section 26.8            | <p><b>Velocity Pressure for All Directions</b></p> <p><math>K_{zt}</math> - Topographic Factor</p> $K_{zt} = (1 + K_1 \times K_2 \times K_3)^2$   |   |                 |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| Section 26.10           | <p><math>K_z</math> - Velocity Pressure Exposure Coefficient</p> <p>For <math>15 ft \leq z \leq z_g</math></p> $K_z = 2.01 \times (z/z_g)^{2/\alpha}$   |   |                 |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| Section 26.10           | <p><math>K_z</math> - Velocity Pressure Exposure Coefficient</p> <p>For <math>z &lt; 15 ft</math></p> $K_z = 2.01 \times (15/z_g)^{2/\alpha}$   |   |                 |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
|                         |   | <table border="1"> <thead> <tr> <th>Direction</th> <th>Exposure Category</th> <th><math>K_z</math><br/>@ <math>h = 9.187 ft</math></th> <th><math>K_{zt}</math></th> <th><math>K_d</math></th> <th><math>K_d</math></th> <th><math>V</math><br/>(mph)</th> <th><math>q_h</math><br/>(psf)</th> </tr> </thead> <tbody> <tr><td>N</td><td>B</td><td>0.575</td><td>1.000</td><td>0.850</td><td>0.982</td><td>100.000</td><td>12.284</td></tr> <tr><td>S</td><td>B</td><td>0.575</td><td>1.000</td><td>0.850</td><td>0.982</td><td>100.000</td><td>12.284</td></tr> <tr><td>E</td><td>B</td><td>0.575</td><td>1.000</td><td>0.850</td><td>0.982</td><td>100.000</td><td>12.284</td></tr> <tr><td>W</td><td>B</td><td>0.575</td><td>1.000</td><td>0.850</td><td>0.982</td><td>100.000</td><td>12.284</td></tr> <tr><td>NE</td><td>B</td><td>0.575</td><td>1.000</td><td>0.850</td><td>0.982</td><td>100.000</td><td>12.284</td></tr> <tr><td>SE</td><td>B</td><td>0.575</td><td>1.000</td><td>0.850</td><td>0.982</td><td>100.000</td><td>12.284</td></tr> <tr><td>NW</td><td>B</td><td>0.575</td><td>1.000</td><td>0.850</td><td>0.982</td><td>100.000</td><td>12.284</td></tr> <tr><td>SW</td><td>B</td><td>0.575</td><td>1.000</td><td>0.850</td><td>0.982</td><td>100.000</td><td>12.284</td></tr> </tbody> </table> | Direction       | Exposure Category | $K_z$<br>@ $h = 9.187 ft$ | $K_{zt}$        | $K_d$          | $K_d$    | $V$<br>(mph) | $q_h$<br>(psf) | N       | B      | 0.575  | 1.000 | 0.850    | 0.982 | 100.000 | 12.284  | S     | B     | 0.575 | 1.000                       | 0.850  | 0.982 | 100.000                        | 12.284 | E     | B                         | 0.575  | 1.000 | 0.850 | 0.982 | 100.000 | 12.284 | W | B | 0.575 | 1.000 | 0.850 | 0.982 | 100.000 | 12.284 | NE | B | 0.575 | 1.000 | 0.850 | 0.982 | 100.000 | 12.284 | SE | B | 0.575 | 1.000 | 0.850 | 0.982 | 100.000 | 12.284 | NW | B | 0.575 | 1.000 | 0.850 | 0.982 | 100.000 | 12.284 | SW | B | 0.575 | 1.000 | 0.850 | 0.982 | 100.000 | 12.284 |  |
| Direction               | Exposure Category   | $K_z$<br>@ $h = 9.187 ft$   | $K_{zt}$        | $K_d$             | $K_d$                     | $V$<br>(mph)    | $q_h$<br>(psf) |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| N                       | B   | 0.575   | 1.000           | 0.850             | 0.982                     | 100.000         | 12.284         |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| S                       | B   | 0.575   | 1.000           | 0.850             | 0.982                     | 100.000         | 12.284         |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| E                       | B   | 0.575   | 1.000           | 0.850             | 0.982                     | 100.000         | 12.284         |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| W                       | B   | 0.575   | 1.000           | 0.850             | 0.982                     | 100.000         | 12.284         |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| NE                      | B   | 0.575   | 1.000           | 0.850             | 0.982                     | 100.000         | 12.284         |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| SE                      | B   | 0.575   | 1.000           | 0.850             | 0.982                     | 100.000         | 12.284         |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| NW                      | B   | 0.575   | 1.000           | 0.850             | 0.982                     | 100.000         | 12.284         |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| SW                      | B   | 0.575   | 1.000           | 0.850             | 0.982                     | 100.000         | 12.284         |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| Figure 27.3-4 to 27.3-7 | <p><b>Net Pressure Coefficients, <math>C_N</math></b></p> <p>The net pressure coefficients, <math>C_N</math>, are calculated using Figures 27.3-4 to 27.3-7 of ASCE 7-16 - Clear Wind Flow - as shown in Table below.</p>   |   |                 |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
|                         |   | <table border="1"> <thead> <tr> <th>Direction</th> <th>Surface</th> <th><math>C_N</math><br/>Case A</th> <th><math>C_N</math><br/>Case B</th> </tr> </thead> <tbody> <tr><td rowspan="2">0</td><td>Windward</td><td>-1.600</td><td>-2.300</td></tr> <tr><td>Leeward</td><td>-1.800</td><td>-0.700</td></tr> <tr><td rowspan="2">180</td><td>Windward</td><td>2.200</td><td>2.600</td></tr> <tr><td>Leeward</td><td>2.500</td><td>1.400</td></tr> <tr><td rowspan="3">90</td><td><math>\leq h</math> from windward edge</td><td>-0.800</td><td>0.800</td></tr> <tr><td><math>h</math> to <math>2h</math> from windward edge</td><td>-0.600</td><td>0.500</td></tr> <tr><td><math>&gt; 2h</math> from windward edge</td><td>-0.300</td><td>0.300</td></tr> </tbody> </table>  | Direction       | Surface           | $C_N$<br>Case A           | $C_N$<br>Case B | 0              | Windward | -1.600       | -2.300         | Leeward | -1.800 | -0.700 | 180   | Windward | 2.200 | 2.600   | Leeward | 2.500 | 1.400 | 90    | $\leq h$ from windward edge | -0.800 | 0.800 | $h$ to $2h$ from windward edge | -0.600 | 0.500 | $> 2h$ from windward edge | -0.300 | 0.300 |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| Direction               | Surface   | $C_N$<br>Case A   | $C_N$<br>Case B |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| 0                       | Windward  | -1.600  | -2.300          |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
|                         | Leeward   | -1.800  | -0.700          |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| 180                     | Windward  | 2.200   | 2.600           |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
|                         | Leeward   | 2.500   | 1.400           |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| 90                      | $\leq h$ from windward edge   | -0.800  | 0.800           |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
|                         | $h$ to $2h$ from windward edge  | -0.600  | 0.500           |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
|                         | $> 2h$ from windward edge   | -0.300  | 0.300           |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| Section 26.11           | <p><b>Gust Effect Factor, <math>G</math></b></p> <p><math>G = 0.85</math> - Gust Effect Factor</p> <p>The structure is assumed to be rigid.</p>   |   | $G = 0.85$      |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |
| Section 27.3.2          | <p><b>Design Wind Pressures (MWFRS)</b></p> <p><math>p</math> - Design Wind Pressure</p> <p>For open buildings</p> $p = q_h \times G \times C_N$ <p>For Wind Pressure - 0°</p>  |   |                 |                   |                           |                 |                |          |              |                |         |        |        |       |          |       |         |         |       |       |       |                             |        |       |                                |        |       |                           |        |       |       |       |         |        |   |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |    |   |       |       |       |       |         |        |  |

| Direction | Surface  | $p$<br>Case A<br>(psf) | $p$<br>Case B<br>(psf) |
|-----------|----------|------------------------|------------------------|
| 0         | Windward | -16.706                | -24.015                |
|           | Leeward  | -18.794                | -7.309                 |
| 180       | Windward | 22.971                 | 27.147                 |
|           | Leeward  | 26.103                 | 14.618                 |



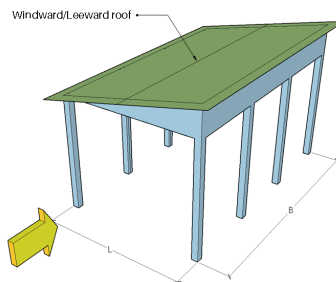
Wind along L - 0°

Service Wind Pressure - 0°/180°

| Direction | Surface  | $p$<br>Case A<br>(psf) | $p$<br>Case B<br>(psf) |
|-----------|----------|------------------------|------------------------|
| 0         | Windward | -10.024                | -14.409                |
|           | Leeward  | -11.277                | -4.385                 |
| 180       | Windward | 13.783                 | 16.288                 |
|           | Leeward  | 15.662                 | 8.771                  |

For Wind Pressure - 90°

| Direction | Surface                    | $p$<br>Case A<br>(psf) | $p$<br>Case B<br>(psf) |
|-----------|----------------------------|------------------------|------------------------|
| 90        | ≤ h from windward edge     | -8.353                 | 8.353                  |
|           | h to 2h from windward edge | -6.265                 | 5.221                  |
|           | > 2h from windward edge    | -3.132                 | 3.132                  |



Wind along B - 90°

Service Wind Pressure - 90°

| Direction | Surface                    | $p$<br>Case A<br>(psf) | $p$<br>Case B<br>(psf) |
|-----------|----------------------------|------------------------|------------------------|
| 90        | ≤ h from windward edge     | -5.012                 | 5.012                  |
|           | h to 2h from windward edge | -3.759                 | 3.132                  |
|           | > 2h from windward edge    | -1.879                 | 1.879                  |

Section 27.3.2  
Section 28.3.5

In addition to the roof pressures for 90°, an additional horizontal wind load on open building should be calculated for wind pressures parallel to the ridge in accordance with Section 28.3.5. We will assume  $K_S = 1.0$  and should be adjusted and be reduced based on the actual solidity ratio  $\phi$  and number of frames  $n$  - See Figure 28.3-2.

Section 27.3.2  
Section 28.3.5

$p$  - Horizontal Wind Loads on Open or Partially Enclosed Buildings

For wind pressure parallel to the ridge (90°)

$$p = q_h \times [(GC_{pf})_{windward} - (GC_{pf})_{leeward}] \times K_B \times K_S$$

Section 27.3.2  
Section 28.3.5

$K_B$  - Frame Width Factor

For  $L < 100ft$ ,  $K_B = 1.8 - 0.01L$ . Otherwise,  $K_B = 0.8$ .

$$K_B = 1.8 - 0.01 * L \leq 0.8$$

$$K_B = 1.6777$$

Where  $L$  = Building Length = 12.227 ft

Section 28.3.5  $K_S$  - Shielding Factor

$$K_S = 0.6 + 0.073 \times (n - 1) + (1.25 \times \phi^{1.8})$$

Section 28.3.5  $K_S = 1$  - Shielding Factor

Assumed to be equal to 1.0 and should be adjusted based on the actual wall solidity ratio  $\phi$  and number of frames  $n$ .

Figure 28.3-1  
Section 28.3.5  $(GC_{pf})_{windward} = 0.4$

Using Zone 5 from Figure 28.3-1

Figure 28.3-1  
Section 28.3.5  $(GC_{pf})_{leeward} = -0.29$

Using Zone 6 from Figure 28.3-1

Section 27.3.2  
Section 28.3.5  $p$  - Horizontal Wind Loads on Open or Partially Enclosed Buildings

For wind pressure parallel to the ridge (90°)

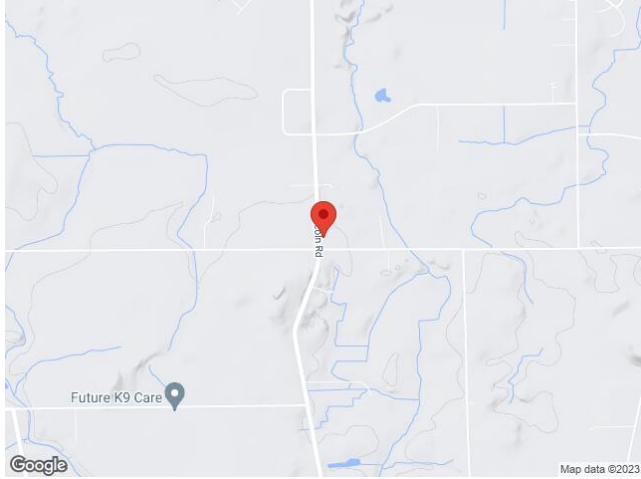
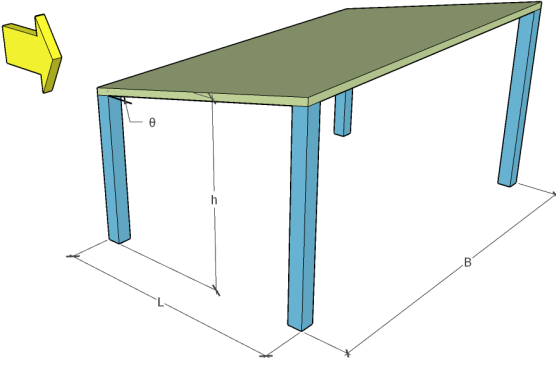
$$p = q_h [(GC_{pf})_{windward} - (GC_{pf})_{leeward}] K_B K_S$$

$$p = 14.22 \text{ psf}$$

$$K_S = 1$$

$$(GC_{pf})_{windward} = 0.4$$

$$(GC_{pf})_{leeward} = -0.29$$

| REFERENCES                   | CALCULATIONS   | RESULTS           |       |                      |           |                     |           |                       |          |              |                |                            |         |  |
|------------------------------|--|-------------------|-------|----------------------|-----------|---------------------|-----------|-----------------------|----------|--------------|----------------|----------------------------|---------|--|
|                              | <p style="text-align: center;"><b>Snow Load Detailed Calculations based on ASCE 7-16</b></p> <p><b>Design Information :</b></p> <p>Project Name : SolarWindFX_TOP15<br/> Client :<br/> Designer : MT_SKYCIV AutoDesigner<br/> Company : MT Solar<br/> Units : Imperial<br/> Notes : Snow loads based on monoslope structure</p> <p><b>Project Data</b></p> <p>The structure is located in <b>5612 Lincoln Rd, Ontario, NY 14519</b> categorized as <b>Risk Category I</b>. The snow load calculation for the structure is based on the Snow Loads (Chapter 7) of ASCE 7. The location is elevated at <b>495 ft</b> above mean sea level.</p>  <p style="text-align: center;"><b>Figure 1. Site location.</b></p> <p>Additional details of the structure are shown in Table below and illustrated in Figure 2:</p> <table border="1"> <thead> <tr> <th>Parameter</th> <th>Value</th> </tr> </thead> <tbody> <tr> <td>Building Length, <math>L</math></td> <td>12.227 ft</td> </tr> <tr> <td>Building Width, <math>B</math></td> <td>20.532 ft</td> </tr> <tr> <td>Mean Roof Height, <math>h</math></td> <td>9.187 ft</td> </tr> <tr> <td>Roof Profile</td> <td>Open Monoslope</td> </tr> <tr> <td>Roof Pitch Angle, <math>\theta</math></td> <td>45.000°</td> </tr> </tbody> </table>  <p style="text-align: center;"><b>Figure 2. Building parameters.</b></p> | Parameter         | Value | Building Length, $L$ | 12.227 ft | Building Width, $B$ | 20.532 ft | Mean Roof Height, $h$ | 9.187 ft | Roof Profile | Open Monoslope | Roof Pitch Angle, $\theta$ | 45.000° |  |
| Parameter                    | Value  |                   |       |                      |           |                     |           |                       |          |              |                |                            |         |  |
| Building Length, $L$         | 12.227 ft  |                   |       |                      |           |                     |           |                       |          |              |                |                            |         |  |
| Building Width, $B$          | 20.532 ft  |                   |       |                      |           |                     |           |                       |          |              |                |                            |         |  |
| Mean Roof Height, $h$        | 9.187 ft   |                   |       |                      |           |                     |           |                       |          |              |                |                            |         |  |
| Roof Profile                 | Open Monoslope   |                   |       |                      |           |                     |           |                       |          |              |                |                            |         |  |
| Roof Pitch Angle, $\theta$   | 45.000°  |                   |       |                      |           |                     |           |                       |          |              |                |                            |         |  |
| <p>Section 7.2 of ASCE 7</p> | <p><b>Ground Snow Load, <math>p_g</math></b></p> <p>The ground snow load, <math>p_g</math>, for the site location is <b>40 psf</b> at elevation 494.79 ft above mean sea level based on Section 7.2 of ASCE 7</p>  | <p>2 - 40 psf</p> |       |                      |           |                     |           |                       |          |              |                |                            |         |  |

|                                      | ASCE 7   | $P_g = 70 \text{ psf}$       |
|--------------------------------------|--|------------------------------|
| Table 7-2 Section 7.3.1 of ASCE 7    | <p><b>Exposure Factor, <math>C_e</math></b></p> <p>The exposure factor, <math>C_e</math>, for the structure is equal 0.90 as the terrain is categorized as <b>Exposure B</b> with exposure condition specified as <b>Fully Exposed</b> based on Table 7-2 Section 7.3.1 of ASCE 7.</p> | $C_e = 0.90$                 |
| Table 7-3 Section 7.3.2 of ASCE 7    | <p><b>Thermal Factor, <math>C_t</math></b></p> <p>Since the thermal condition of the structure is categorized as "<b>Unheated and open air structures</b>," the corresponding thermal factor, <math>C_t</math>, is equal 1.20 based on Table 7-3 Section 7.3.2 of ASCE 7.</p>          | $C_t = 1.20$                 |
| Table 1.5-2 of Chapter 1 ASCE 7      | <p><b>Importance Factor, <math>I_s</math></b></p> <p>Since the structure is classified Risk Category I, the Importance Factor, <math>I_s</math>, is equal to <b>0.8</b>.</p>   | $I_s = 0.80$                 |
| Equation 7.3-1 of Section 7.3 ASCE 7 | <p><b>Flat Roof Snow Load, <math>p_f</math></b></p> <p>The flat roof snow load, <math>p_f</math>, (psf) is calculated using the Equation 7.3-1:</p> $p_f = 0.7C_eC_tI_s p_g$ $p_f = 0.7(0.90)(1.20)(0.80)(40.00) = 24.19 \text{ psf}$  | $p_f = 24.19 \text{ psf}$    |
| Section 7.10 ASCE 7                  | <p><b>Rain-on-snow Surcharge Load, <math>p_r</math></b></p> <p>The rain-on-snow surcharge load, <math>p_r</math>, is equal to 0.00 psf since <math>p_g &gt; 20 \text{ psf}</math>.</p>   | $p_r = 0.00 \text{ psf}$     |
| Equation 7.7-1 of ASCE 7             | <p><b>Snow Density, <math>\gamma</math></b></p> <p>The snow density, <math>\gamma</math>, is calculated using Equation 7.7-1 of ASCE 7 as:</p> $\gamma = 0.13p_g + 14 \leq 30 = 0.13(40.00) + 14 \leq 30$ $\gamma = 19.20 \text{ pcf}$   | $\gamma = 19.20 \text{ pcf}$ |
| Section 7.4 ASCE 7                   | <p><b>Roof Slope Factor (Balanced), <math>C_s</math></b></p> <p>Since the roof is classified as cold roof (<math>C_t &gt; 1.0</math>), the corresponding roof slope factor, <math>C_s</math>, is equal to 0.455 based on Figure 7.2c where <math>\theta = 45.00^\circ</math>.</p>      | $C_s = 0.455$                |
| Equation 7.4-1 of Section 7.4 ASCE 7 | <p><b>Sloped Roof Snow Load (Balanced), <math>p_s</math></b></p> <p>The sloped roof snow load, <math>p_s</math>, (psf) is calculated using the Equation 7.4-1:</p> $p_s = C_s p_f$ $p_s = (0.455)(24.19) = 11.00 \text{ psf}$  | $p_s = 11.00 \text{ psf}$    |

## Project Details

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

User Name: sales@mtsolar.us  
 Project Name: SolarWindFX\_TOP15  
 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 <sub>y</sub> (ksi) | F <sub>u</sub> (ksi) |
| 1                | 29000   | 50                   | 65                   |

| Section Dimensions |  |  |  |  |  |  |  |
|--------------------|--|--|--|--|--|--|--|
|                    |  |  |  |  |  |  |  |

| ID | Name            | d (in) | t <sub>w</sub> (in) |  |  |  |  |
|----|-----------------|--------|---------------------|--|--|--|--|
| 2  | 2in Pipe Sch 80 | 2.38   | 0.22                |  |  |  |  |
| 5  | 4in Pipe Sch 80 | 4.50   | 0.34                |  |  |  |  |
| 9  | 8in Pipe Sch 40 | 8.63   | 0.32                |  |  |  |  |

| ID | Name        | d (in) | b (in) | t <sub>w</sub> (in) | t <sub>b</sub> (in) | r (in) |  |
|----|-------------|--------|--------|---------------------|---------------------|--------|--|
| 16 | HSS5x3x3/16 | 5.00   | 3.00   | 0.17                | 0.17                | 0.17   |  |

| ID | Name  | d (in) | t <sub>w</sub> (in) | b <sub>t</sub> (in) | b <sub>b</sub> (in) | t <sub>t</sub> (in) | t <sub>b</sub> (in) | r (in) |
|----|-------|--------|---------------------|---------------------|---------------------|---------------------|---------------------|--------|
| 19 | W8x10 | 7.89   | 0.17                | 3.94                | 3.94                | 0.20                | 0.20                | 0.30   |

| Section Properties |                 |                      |                      |                                    |                                    |                                   |                                    |                                    |
|--------------------|-----------------|----------------------|----------------------|------------------------------------|------------------------------------|-----------------------------------|------------------------------------|------------------------------------|
| ID                 | Name            | A (in <sup>2</sup> ) | J (in <sup>4</sup> ) | I <sub>yp</sub> (in <sup>4</sup> ) | I <sub>zp</sub> (in <sup>4</sup> ) | I <sub>w</sub> (in <sup>6</sup> ) | S <sub>yp</sub> (in <sup>3</sup> ) | S <sub>zp</sub> (in <sup>3</sup> ) |
| 2                  | 2in Pipe Sch 80 | 1.48                 | 1.74                 | 0.87                               | 0.87                               | 0.00                              | 1.02                               | 1.02                               |
| 5                  | 4in Pipe Sch 80 | 4.41                 | 19.22                | 9.61                               | 9.61                               | 0.00                              | 5.85                               | 5.85                               |



|    |        |        |       |       |       |       |
|----|--------|--------|-------|-------|-------|-------|
| 10 | 116.10 | 111.33 | 15.79 | 11.10 | 42.08 | 23.28 |
| 11 | 133.20 | 20.65  | 32.87 | 6.12  | 40.24 | 43.62 |
| 12 | 198.33 | 196.72 | 21.95 | 21.95 | 59.50 | 59.50 |
| 13 | 133.20 | 104.94 | 23.37 | 6.12  | 40.24 | 43.62 |
| 14 | 133.20 | 104.94 | 22.92 | 6.12  | 40.24 | 43.62 |
| 15 | 133.20 | 20.65  | 32.87 | 6.12  | 40.24 | 43.62 |
| 16 | 133.20 | 20.65  | 32.87 | 6.12  | 40.24 | 43.62 |

## Design Ratio

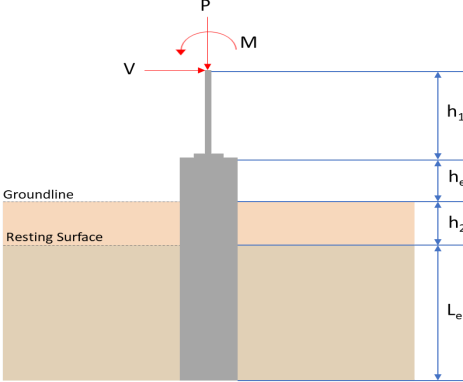
| Member ID | P     | M <sub>z</sub> | M <sub>y</sub> | V <sub>y</sub> | V <sub>z</sub> | (P,M <sub>z</sub> ,M <sub>y</sub> ) | Worst LC | KL/r         | δ            | Status |
|-----------|-------|----------------|----------------|----------------|----------------|-------------------------------------|----------|--------------|--------------|--------|
| 1         | 0.044 | 0.738          | 0.000          | 0.056          | 0.000          | 0.761                               | #13      | 0.394        | Not Required | Pass   |
| 2         | 0.007 | 0.398          | 0.293          | 0.087          | 0.053          | 0.693                               | #13      | 0.035        | Not Required | Pass   |
| 3         | 0.011 | 0.731          | 0.065          | 0.073          | 0.009          | 0.756                               | #13      | 0.045        | Not Required | Pass   |
| 4         | 0.010 | 0.660          | 0.252          | 0.066          | 0.051          | 0.746                               | #13      | 0.080        | Not Required | Pass   |
| 5         | 0.010 | 0.454          | 0.264          | 0.073          | 0.068          | 0.495                               | #13      | 0.074        | Not Required | Pass   |
| 6         | 0.011 | 0.731          | 0.065          | 0.073          | 0.009          | 0.756                               | #13      | 0.045        | Not Required | Pass   |
| 7         | 0.010 | 0.454          | 0.264          | 0.073          | 0.068          | 0.495                               | #13      | 0.074        | Not Required | Pass   |
| 8         | 0.000 | 0.155          | 0.356          | 0.042          | 0.017          | 0.481                               | #21      | Not Required | Not Required | Pass   |
| 9         | 0.031 | 0.058          | 0.068          | 0.001          | 0.000          | 0.133                               | #13      | 0.204        | Not Required | Pass   |
| 10        | 0.010 | 0.660          | 0.252          | 0.066          | 0.051          | 0.746                               | #13      | 0.080        | Not Required | Pass   |
| 11        | 0.000 | 0.171          | 0.356          | 0.046          | 0.017          | 0.489                               | #21      | Not Required | Not Required | Pass   |
| 12        | 0.007 | 0.398          | 0.293          | 0.087          | 0.053          | 0.693                               | #13      | 0.035        | Not Required | Pass   |
| 13        | 0.012 | 0.411          | 0.594          | 0.060          | 0.022          | 0.906                               | #21      | 0.190        | Not Required | Pass   |
| 14        | 0.011 | 0.381          | 0.594          | 0.054          | 0.022          | 0.887                               | #21      | 0.190        | Not Required | Pass   |
| 15        | 0.000 | 0.171          | 0.356          | 0.046          | 0.017          | 0.489                               | #21      | Not Required | Not Required | Pass   |
| 16        | 0.000 | 0.155          | 0.356          | 0.042          | 0.017          | 0.481                               | #21      | Not Required | Not Required | Pass   |

## Definitions

|                                     |   |
|-------------------------------------|---|
| $\Phi_t$                            | Safety factor for tensile                                 |
| $\Phi_c$                            | Safety factor for compression                             |
| $\Phi_b$                            | Safety factor for flexure                                 |
| $\Phi_v$                            | Safety factor for shear                                   |
| E                                   | Modulus of elasticity                                     |
| F <sub>y</sub>                      | Specified minimum yield stress                            |
| F <sub>u</sub>                      | Specified minimum tensile strength                        |
| A                                   | Cross-sectional area                                      |
| J                                   | Torsional constant  |
| I <sub>yp</sub>                     | Moment of inertia about the Y axes                        |
| I <sub>zp</sub>                     | Moment of inertia about the Z axes                        |
| I <sub>w</sub>                      | Warping constant  |
| S <sub>yp</sub>                     | Plastic section modulus about the Y axis                  |
| S <sub>zp</sub>                     | Plastic section modulus about the Z axis                  |
| KL                                  | Effective length  |
| C <sub>b</sub>                      | Buckling modification factor (from all load combinations) |
| L <sub>b</sub>                      | Length between braced points                              |
| LST                                 | Limited slenderness for tension                           |
| LSC                                 | Limited slenderness for compression                       |
| LD                                  | Limited deflection  |
| P <sub>n</sub>                      | Nominal axial strength (tension/compression)              |
| M <sub>n</sub>                      | Nominal flexural strength (about Z/Y axis)                |
| V <sub>n</sub>                      | Nominal shear strength (along Z/Y axis)                   |
| P                                   | Design ratio in case of axial force                       |
| M <sub>z</sub>                      | Design ratio in case of bending about Z axis              |
| M <sub>y</sub>                      | Design ratio in case of bending about Y axis              |
| V <sub>y</sub>                      | Design ratio in case of shear along Y axis                |
| V <sub>z</sub>                      | Design ratio in case of shear along Z axis                |
| (P,M <sub>z</sub> ,M <sub>y</sub> ) | Design ratio in case of axial force and bending action    |
| KL/r                                | Design ratio in case of section slenderness               |
| δ                                   | Design ratio in case of member deflection                 |
| OK                                  | Capacity is provided                                      |

ON  
NG

Capacity is provided  
Capacity is not provided

| REFERENCES     | CALCULATIONS   | RESULTS                                    |   |  |   |   |   |          |         |                |     |      |           |       |        |             |        |        |             |       |       |               |       |       |               |        |        |  |
|----------------|--|--|---|--|---|---|---|----------|---------|----------------|-----|------|-----------|-------|--------|-------------|--------|--------|-------------|-------|-------|---------------|-------|-------|---------------|--------|--------|--|
|                | <p><b>SkyCiv Foundation Design</b><br/>Pile Foundation</p> <p><b>Design Information :</b><br/>Design code : IBC 2021 (International Building Code)<br/>Unit System : Imperial</p>  |  |   |  |   |   |   |          |         |                |     |      |           |       |        |             |        |        |             |       |       |               |       |       |               |        |        |  |
|                | <p><b>Pile Input</b></p>  <p><b>Geometry</b><br/>Pile shape: rectangular<br/><math>b = 36</math> in - Pile width<br/><math>D = 36</math> in - Pile depth<br/><math>L = 7.5</math> ft - Total pile length<br/><math>h_1 = 0</math> ft - Lateral load height from the top of the pile,<br/><math>h_2 = 0</math> ft - Depth to resting surface<br/><math>h_e = 0</math> ft - Length of pile above the ground</p> <p><b>Tabulation of Soil Parameters</b></p> <table border="1"> <thead> <tr> <th>Layer</th> <th>Label</th> <th>Allowable Bearing Pressure (<math>q_a</math>) (psf)</th> <th>Allowable Lateral Pressure (<math>R</math>) (psf/ft)</th> </tr> </thead> <tbody> <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> </tbody> </table> <p><b>Tabulation of Loads</b></p> <table border="1"> <thead> <tr> <th>Load Component</th> <th>ASD</th> <th>LRFD</th> </tr> </thead> <tbody> <tr> <td><math>P</math> (kip)</td> <td>7.332</td> <td>10.639</td> </tr> <tr> <td><math>V_x</math> (kip)</td> <td>-3.786</td> <td>-6.310</td> </tr> <tr> <td><math>V_z</math> (kip)</td> <td>0.000</td> <td>0.000</td> </tr> <tr> <td><math>M_x</math> (kipft)</td> <td>0.000</td> <td>0.000</td> </tr> <tr> <td><math>M_z</math> (kipft)</td> <td>36.542</td> <td>61.504</td> </tr> </tbody> </table> <p><b>Material Properties</b><br/><math>f'_{ck} = 3</math> ksi - Concrete strength,</p> | Layer                                      | Label                                       | Allowable Bearing Pressure ( $q_a$ ) (psf) | Allowable Lateral Pressure ( $R$ ) (psf/ft) | 1 | Sand, silty sand, clayey sand, silty gravel & clayey gravel | 2000.000 | 150.000 | Load Component | ASD | LRFD | $P$ (kip) | 7.332 | 10.639 | $V_x$ (kip) | -3.786 | -6.310 | $V_z$ (kip) | 0.000 | 0.000 | $M_x$ (kipft) | 0.000 | 0.000 | $M_z$ (kipft) | 36.542 | 61.504 |  |
| Layer          | Label  | Allowable Bearing Pressure ( $q_a$ ) (psf) | Allowable Lateral Pressure ( $R$ ) (psf/ft) |  |   |   |   |          |         |                |     |      |           |       |        |             |        |        |             |       |       |               |       |       |               |        |        |  |
| 1              | Sand, silty sand, clayey sand, silty gravel & clayey gravel  | 2000.000                                   | 150.000                                     |  |   |   |   |          |         |                |     |      |           |       |        |             |        |        |             |       |       |               |       |       |               |        |        |  |
| Load Component | ASD  | LRFD                                       |   |  |   |   |   |          |         |                |     |      |           |       |        |             |        |        |             |       |       |               |       |       |               |        |        |  |
| $P$ (kip)      | 7.332  | 10.639                                     |   |  |   |   |   |          |         |                |     |      |           |       |        |             |        |        |             |       |       |               |       |       |               |        |        |  |
| $V_x$ (kip)    | -3.786   | -6.310                                     |   |  |   |   |   |          |         |                |     |      |           |       |        |             |        |        |             |       |       |               |       |       |               |        |        |  |
| $V_z$ (kip)    | 0.000  | 0.000                                      |   |  |   |   |   |          |         |                |     |      |           |       |        |             |        |        |             |       |       |               |       |       |               |        |        |  |
| $M_x$ (kipft)  | 0.000  | 0.000                                      |   |  |   |   |   |          |         |                |     |      |           |       |        |             |        |        |             |       |       |               |       |       |               |        |        |  |
| $M_z$ (kipft)  | 36.542   | 61.504                                     |   |  |   |   |   |          |         |                |     |      |           |       |        |             |        |        |             |       |       |               |       |       |               |        |        |  |
|                | <p><b>Required depth to resist lateral loads (ASD)</b><br/><math>H</math> - Point of application of the lateral load</p> $H = h_1 + h_2 + h_e$ $H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})$ $H = 0 \text{ ft}$ <p><b>Considering x-direction:</b><br/><math>H_o</math> - Lateral force per length of pile,</p> $H_o = \frac{V_x}{1.57 D}$ $H_o = \frac{(-3.786 \text{ kip})}{1.57 \times (36 \text{ in})}$ $H_o = -0.80382 \text{ kip/ft}$ <p><math>M_o</math> - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$   |  |   |  |   |   |   |          |         |                |     |      |           |       |        |             |        |        |             |       |       |               |       |       |               |        |        |  |

|          |   |   |
|----------|---|---|
|          | $M_o = \frac{(36.542 \text{ kipft}) + ((-3.786 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (36 \text{ in})}$ $M_o = 7.7584 \text{ kipft/ft}$ <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} = 6.6823 \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> $L_{e,req} = \text{MAX}[L_{e,x}, L_{e,z}]$ $L_{e,req} = \text{MAX}[(6.6823 \text{ ft}), (0 \text{ ft})]$ $L_{e,req} = 6.682 \text{ ft}$ <p><math>L_e</math> - Actual embedded length of pile,</p> $L_e = L - h_e - h_2$ $L_e = (7.5 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 7.5 \text{ ft}$ <p><b>Ratio</b> - Embedded depth</p> $\text{Ratio} = \frac{L_{e,req}}{L_e}$ $\text{Ratio} = \frac{(6.682 \text{ ft})}{(7.5 \text{ ft})}$ $\text{Ratio} = 0.89093$ | <p>Status: <b>PASS</b><br/> Ratio: <b>0.890</b></p> |
|          | <p><b>End-bearing Capacity (ASD)</b></p> <p>A - Pile cross-section area</p> $A = b D$ $A = (36 \text{ in}) \times (36 \text{ in})$ $A = 9 \text{ ft}^2$ <p>q - End-bearing pressure</p> $q = \frac{P_v}{A}$ $q = \frac{(7.332 \text{ kip})}{(9 \text{ ft}^2)}$ $q = 0.81467 \text{ kip/ft}^2$ <p><b>Check bearing capacity ratio:</b></p> <p><b>Ratio</b> - Capacity</p> $\text{Ratio} = \frac{q}{q_o}$ $\text{Ratio} = \frac{(0.81467 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $\text{Ratio} = 0.40733$   | <p>Status: <b>PASS</b><br/> Ratio: <b>0.410</b></p> |
| Czerniak | <p><b>Lateral Soil Pressure (ASD):</b></p> <p><math>L/D</math> - Length to least lateral dimension ratio,</p> $L/D = \frac{L}{D}$ $L/D = \frac{(7.5 \text{ ft})}{(36 \text{ in})}$  |   |

$$L/D = 2.5$$

Since  $L/D \leq 10$ ,

Pile is short.

**Considering x-direction:**

$H_o = -0.80382$  kip/ft - Lateral force per length of pile,

$M_o = 7.7584$  kipft/ft - Overturning moment per length of pile,

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

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

$$a = \frac{(4 \times (7.7584 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (-0.80382 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (7.7584 \text{ kipft/ft})) + (4 \times (-0.80382 \text{ kip/ft}) \times (7.5 \text{ ft}))}$$

$$a = 5.2133 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (7.7584 \text{ kipft/ft})) + (3 \times (-0.80382 \text{ kip/ft}) \times (7.5 \text{ ft}))]^2}{(7.5 \text{ ft})^2 \times [(3 \times (7.7584 \text{ kipft/ft})) + (2 \times (-0.80382 \text{ kip/ft}) \times (7.5 \text{ ft}))]}$$

$$p = 0.19925 \text{ kip/ft}^2$$

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

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

$$s = \frac{6 \times [(2 \times (7.7584 \text{ kipft/ft})) + ((-0.80382 \text{ kip/ft}) \times (7.5 \text{ ft}))]}{(7.5 \text{ ft})^2}$$

$$s = 1.0121 \text{ kip/ft}^2$$

**Check lateral soil pressure capacity:**

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(5.2133 \text{ ft})}{2}$$

$$p_a = 0.391 \text{ kip/ft}^2$$

*Ratio* - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.19925 \text{ kip/ft}^2)}{(0.391 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.5096$$

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

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (7.5 \text{ ft})$$

$$p_s = 1.125 \text{ kip/ft}^2$$

*Ratio* - Lateral soil capacity

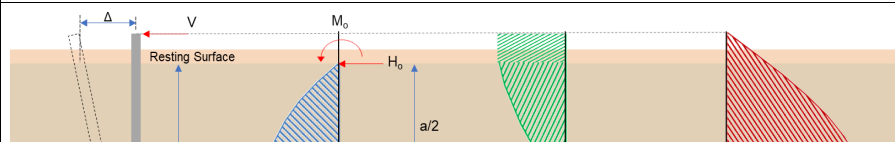
$$\text{Ratio} = \frac{s}{p_s}$$

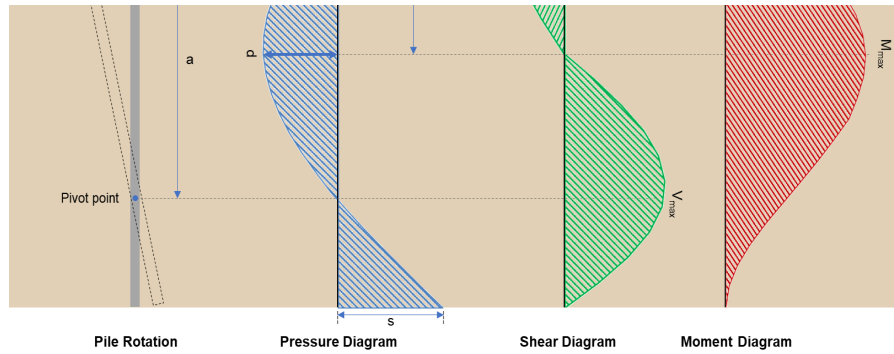
$$\text{Ratio} = \frac{(1.0121 \text{ kip/ft}^2)}{(1.125 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.89961$$

Status: **PASS**  
Ratio: **0.510**

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





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

$H_o$  - Lateral force per length of pile,

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

$$H_o = \frac{(-6.31 \text{ kip})}{1.57 \times (36 \text{ in})}$$

$$H_o = -1.3397 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

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

$$M_o = \frac{(61.504 \text{ kipft}) + ((-6.31 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (36 \text{ in})}$$

$$M_o = 13.058 \text{ kipft/ft}$$

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

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

$$E = \frac{(13.058 \text{ kipft/ft})}{(-1.3397 \text{ kip/ft})}$$

$$E = 9.7471 \text{ ft}$$

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

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

$$a = \frac{(4 \times (13.058 \text{ kipft/ft}) \times (7.5 \text{ ft})) + (3 \times (-1.3397 \text{ kip/ft}) \times (7.5 \text{ ft})^2)}{(6 \times (13.058 \text{ kipft/ft})) + (4 \times (-1.3397 \text{ kip/ft}) \times (7.5 \text{ ft}))}$$

$$a = 5.2119 \text{ ft}$$

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

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

$$V_{max} = ((-1.3397 \text{ kip/ft}) \times (36 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (9.7471 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left( \frac{(5.2119 \text{ ft})}{(7.5 \text{ ft})} \right)^2 \right] + \left[ 4 \times \left( \frac{3 \times (9.7471 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left( \frac{(5.2119 \text{ ft})}{(7.5 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 11.893 \text{ kip}$$

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

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

$$M_{max} = ((-1.3397 \text{ kip/ft}) \times (36 \text{ in}) \times (7.5 \text{ ft})) \times \left[ \left( \frac{(9.7471 \text{ ft})}{(7.5 \text{ ft})} + \frac{(5.2119 \text{ ft})}{2 \times (7.5 \text{ ft})} \right) - \left[ \left( \frac{4 \times (9.7471 \text{ ft})}{(7.5 \text{ ft})} + 3 \right) \times \left( \frac{(5.2119 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^3 \right] + \left[ \left( \frac{3 \times (9.7471 \text{ ft})}{(7.5 \text{ ft})} + 2 \right) \times \left( \frac{(5.2119 \text{ ft})}{2 \times (7.5 \text{ ft})} \right)^4 \right] \right]$$

$$M_{max} = 41.873 \text{ kipft}$$

### Minimum Reinforcement Check (LRFD)

#### Parameters:

$f'_{ck} = 3 \text{ ksi}$  - Concrete strength,  
 $f_{yk} = 60 \text{ ksi}$  - Longitudinal reinforcement strength,  
 $\phi = 0.65$  - Reduction factor for axial strength,  
 $\alpha = 0.8$  - Alpha factor for axial strength,  
 $A_g = 1296 \text{ in}^2$  - Gross area of concrete,

Table 22.4.2.1

#### Longitudinal reinforcement:

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

22.4.2.2, 10.6.1.1

$A_{st,required}$

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

$$A_{st,required} = \text{Min} \left[ \frac{\frac{(10.639 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (3 \text{ ksi}) \times (1296 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (3 \text{ ksi}))}, (0.08 \times (1296 \text{ in}^2)) \right]$$

$$A_{st,required} = -57.169 \text{ in}^2$$

$A_{min}$  - Governing minimum reinforcement area,

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

$$A_{min} = \text{Max} [(-57.169 \text{ in}^2), (0.0018 \times (1296 \text{ in}^2))]$$

$$A_{min} = 2.3328 \text{ in}^2$$

$n_{rebar}$  - Required number of reinforcement,

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

$$n_{rebar} = \frac{(2.3328 \text{ in}^2)}{(0.3068 \text{ in}^2)}$$

$$n_{rebar} = 8$$

$A_{st}$  - Actual total reinforcement area,

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

$$A_{st} = (8) \times \frac{\pi \times (0.625 \text{ in})^2}{4}$$

$$A_{st} = 2.4544 \text{ in}^2$$

Ratio - Capacity

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

$$\text{Ratio} = \frac{(2.3328 \text{ in}^2)}{(2.4544 \text{ in}^2)}$$

$$\text{Ratio} = 0.95047$$

Status: **PASS**  
Ratio: **0.950**

25.2.3

$s_{rebar}$  - Minimum spacing of reinforcement,

$$s_{rebar} = \text{Max} [1.5, (1.5 d_{bar})]$$

$$s_{rebar} = \text{Max} [1.5, (1.5 \times (0.625 \text{ in}))]$$

$$s_{rebar} = 1.5 \text{ in}$$

#### Ties:

25.7.2.2 Since longitudinal reinforcement is  $\leq$  No. 10: Use #3(0.375 in)

25.7.2.1  $s_{ties}$  - Maximum spacing of ties,

$$s_{ties} = \text{Min} [(16 d_{bar}), (48 d_{ties}), \text{Min} (D, b)]$$

$$s_{ties} = \text{Min} [(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), \text{Min} ((36 \text{ in}), (36 \text{ in}))]$$

$$s_{ties} = 10 \text{ in}$$

#### Summary:

Main reinforcement: **8 - #5 (0.625 in)**

**Axial Compression Strength (ACI 318-19, LRFD)**22.4.2.2  $\phi P_N$  - Allowable axial compressive strength

$$\phi P_N = \phi 0.80 [(0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st})]$$

$$\phi P_N = (0.65) \times 0.80 \times [(0.85 \times (3 \text{ ksi}) \times [(1296 \text{ in}^2) - (2.4544 \text{ in}^2)]) + ((60 \text{ ksi}) \times (2.4544 \text{ in}^2))]$$

$$\phi P_N = 1791.8 \text{ kip}$$

Ratio - Capacity

$$\text{Ratio} = \frac{P}{\phi P_N}$$

$$\text{Ratio} = \frac{(10.639 \text{ kip})}{(1791.8 \text{ kip})}$$

$$\text{Ratio} = 0.0059375$$

Status: **PASS**  
Ratio: **0.010****Shear Strength (ACI 318-19, LRFD)****Parameters:** $b_w = 36 \text{ in}$  - Effective width,22.5.2.2  $d$  - Effective depth

$$d = 0.80 D$$

$$d = 0.80 \times (36 \text{ in})$$

$$d = 28.8 \text{ in}$$

22.5.5.1.3  $\lambda_s$  - size effect modification factor

$$\lambda_s = \text{MIN} \left[ \sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$$

$$\lambda_s = \text{MIN} \left[ \sqrt{\frac{2}{1 + \frac{(28.8 \text{ in})}{10}}}, 1 \right]$$

$$\lambda_s = 0.71796$$

The following variables were converted to be consistent with empirical formula  $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$ ,22.5.5.1.1  $V_{c,max}$  - Max shear strength of concrete

$$V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$$

$$V_{c,max} = 5 \times (0.71796) \times \sqrt{(3000 \text{ psi})} \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{c,max} = 203.86 \text{ kip}$$

The following variables were converted to be consistent with empirical formula  $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$ ,  $P = 10.639 \text{ kip} \rightarrow 10639 \text{ lbf}$ ,22.5.5.1.1(a)  $V_{c,a}$  - Shear strength of concrete (a)

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

$$V_{c,a} = \left[ 2 \times (0.71796) \times \sqrt{(3000 \text{ psi})} + \frac{(10639 \text{ lbf})}{6 \times (1296 \text{ in}^2)} \right] \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{c,a} = 82.961 \text{ kip}$$

The following variables were converted to be consistent with empirical formula  $f'_{ck} = 3 \text{ ksi} \rightarrow 3000 \text{ psi}$ ,22.5.5.1.2  $V_{c,b}$  - Shear strength of concrete (b)

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

$$V_{c,b} = \left[ 2 \times (0.71796) \times \sqrt{(3000 \text{ psi})} + (0.05 \times (3000 \text{ psi})) \right] \times (36 \text{ in}) \times (28.8 \text{ in})$$

$$V_{c,b} = 237.06 \text{ kip}$$

 $V_c$  - Governing shear strength of concrete

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

$$V_c = \text{Min}[(203.86 \text{ kip}), (82.961 \text{ kip}), (237.06 \text{ kip})]$$

$$V_c = 82.961 \text{ kip}$$

|                  |   |   |
|------------------|---|---|
| <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>.</p> <p><math>V_{s,a}</math> - Shear strength of steel (a)</p> $V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$ $V_{s,a} = 8 \times \sqrt{(3000 \text{ psi})} \times (36 \text{ in}) \times (28.8 \text{ in})$ $V_{s,a} = 454.3 \text{ kip}$ <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> $V_{s,b} = \frac{2 A_v f_{yw} d}{s_{ties}}$ $V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (28.8 \text{ in})}{(10 \text{ in})}$ $V_{s,b} = 38.17 \text{ kip}$ <p><math>V_s</math> - Governing shear strength of steel</p> $V_s = \text{MIN}[V_{s,a}, V_{s,b}]$ $V_s = \text{MIN}[(454.3 \text{ kip}), (38.17 \text{ kip})]$ $V_s = 38.17 \text{ kip}$ <p>22.5.1.1 <math>\phi V_n</math> - Allowable shear strength</p> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((82.961 \text{ kip}) + (38.17 \text{ kip}))$ $\phi V_n = 78.735 \text{ kip}$ <p><b>Considering x-direction:</b></p> <p><math>V_{max} = 11.893 \text{ kip}</math> - Maximum shear force in the x-direction,<br/> <b>Ratio</b> - Capacity</p> $\text{Ratio} = \frac{V_{max}}{\phi V_n}$ $\text{Ratio} = \frac{(11.893 \text{ kip})}{(78.735 \text{ kip})}$ $\text{Ratio} = 0.15105$ | <p>Status: <b>PASS</b><br/> Ratio: <b>0.150</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> $S_m = \frac{b D^2}{6}$ $S_m = \frac{(36 \text{ in}) \times (36 \text{ in})^2}{6}$ $S_m = 7776 \text{ in}^3$ <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> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(3 \text{ ksi})} \times 7776.000 \text{ in}^3$ $\phi M_{n,1} = 115.350 \text{ kipft}$ <p><math>\phi M_{n,2}</math></p> $\phi M_{n,2} = \phi \times 0.85 \times f'_c \times S_m$  |   |

$\phi M_{n,x} = \phi M_{n,y}$

$$\phi M_{n,2} = (0.65) \times 0.85 \times (3 \text{ ksi}) \times (7776 \text{ in}^3)$$

$$\phi M_{n,2} = 1074.1 \text{ kipft}$$

Therefore,  
 $\phi M_n$  - Allowable flexural strength,

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

$$\phi M_n = \text{MIN}[(115.35 \text{ kipft}), (1074.1 \text{ kipft})]$$

$$\phi M_n = 115.35 \text{ kipft}$$

**Considering x-direction:**

$M_{max} = 41.873 \text{ kipft}$  - Maximum moment in the x-direction,

*Ratio* - Capacity

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

$$\text{Ratio} = \frac{(41.873 \text{ kipft})}{(115.35 \text{ kipft})}$$

$$\text{Ratio} = 0.36301$$

Status: **PASS**  
Ratio: **0.360**