

# Your Project Calculations



Project Name: Dupuis

S3D Model Link:

[https://platform.skyciv.com/structural?preload\\_name=Dupuis&preload\\_path=Shared%20Enterprise%20Folder/MT\\_Solar\\_Projects/3\\_2024](https://platform.skyciv.com/structural?preload_name=Dupuis&preload_path=Shared%20Enterprise%20Folder/MT_Solar_Projects/3_2024)

Public Model Link:

[https://platform.skyciv.com/structural-viewer?project\\_id=tkSJPa8x0IAAv5IglVG5s7tcKGzK05YU8GmRdDhJBILH8mL77n32E6zoul0dhs1](https://platform.skyciv.com/structural-viewer?project_id=tkSJPa8x0IAAv5IglVG5s7tcKGzK05YU8GmRdDhJBILH8mL77n32E6zoul0dhs1)

## Array Specification

|                             |                              |
|-----------------------------|------------------------------|
| Product:                    | Beam                         |
| Unique ID:                  | 1P-0-6TOP-SD-24-L-4Hx2W-6BIC |
| Duty Classification:        | SD                           |
| Module Width:               | 41.00 in                     |
| Module Length:              | 75.20in                      |
| Number of Rows:             | 4                            |
| Number of Columns:          | 2                            |
| Total Number of Modules:    | 8                            |
| Desired Tilt Angle:         | 50                           |
| Front Edge Clearance:       | 3                            |
| Total Array Height at Tilt: | 13.53 ft                     |
| Total Frame Length:         | 11.50 ft                     |
| Frame Weight:               | 516 lbs                      |
| Array Dimensions N/S:       | 13.83 ft                     |
| Array Dimensions E/W:       | 12.70 ft                     |
| Rail Length:                | 166.00 in                    |
| Rail Spacing:               | 3.13 ft                      |
| Rail Check:                 | Not Checked                  |

## Support Specifications

|                          |                 |
|--------------------------|-----------------|
| Pole Size:               | 6in Pipe Sch 40 |
| Pole Length above Grade: | 8.30 ft         |
| Number of Poles:         | 1               |
| Pole Spacing:            | 0               |

## Foundation Specifications

|                                 |                      |
|---------------------------------|----------------------|
| Foundation Type:                | Round                |
| Foundation Dimensions:          | Ø36 in               |
| Foundation Depth (below grade): | Pile 1: 6.25 ft      |
| Foundation Volume:              | 1.636 y <sup>3</sup> |
| Foundation Result:              | PASSED               |
| Mount Twist:                    | 0.000001 kip         |

## Site Info

|                            |                    |
|----------------------------|--------------------|
| Risk Category:             | I                  |
| Exposure:                  | B                  |
| Soil Classification:       | sand               |
| Site Location:             | Buckfield, ME, USA |
| Wind Speed:                | 102 mph            |
| Snow Load:                 | 90 psf             |
| Design Uplift Pressure:    | 0.013133 ksf       |
| Design Downforce Pressure: | -0.013133 ksf      |
| Design Snow Pressure:      | 0.019793 ksf       |



### Design Disclaimer

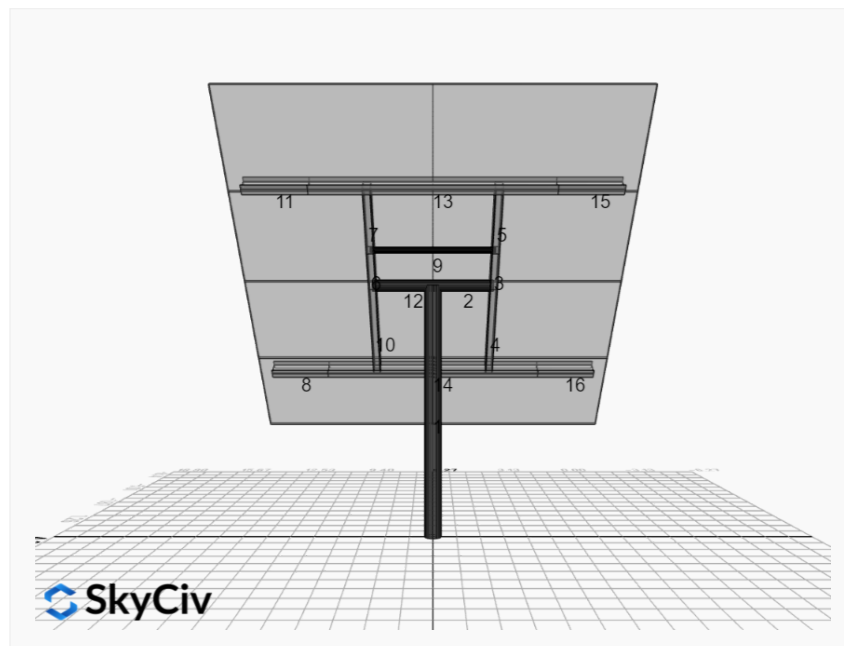
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

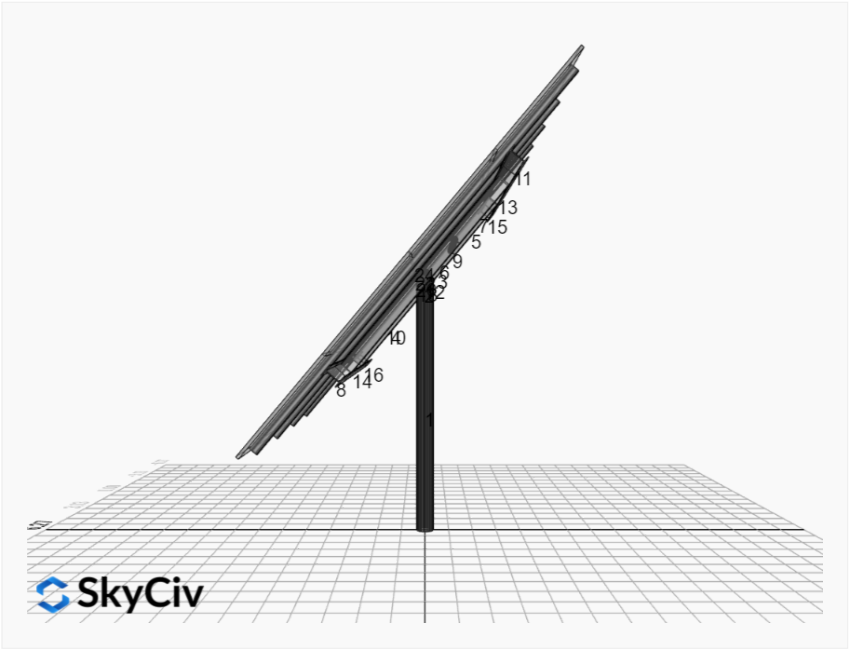
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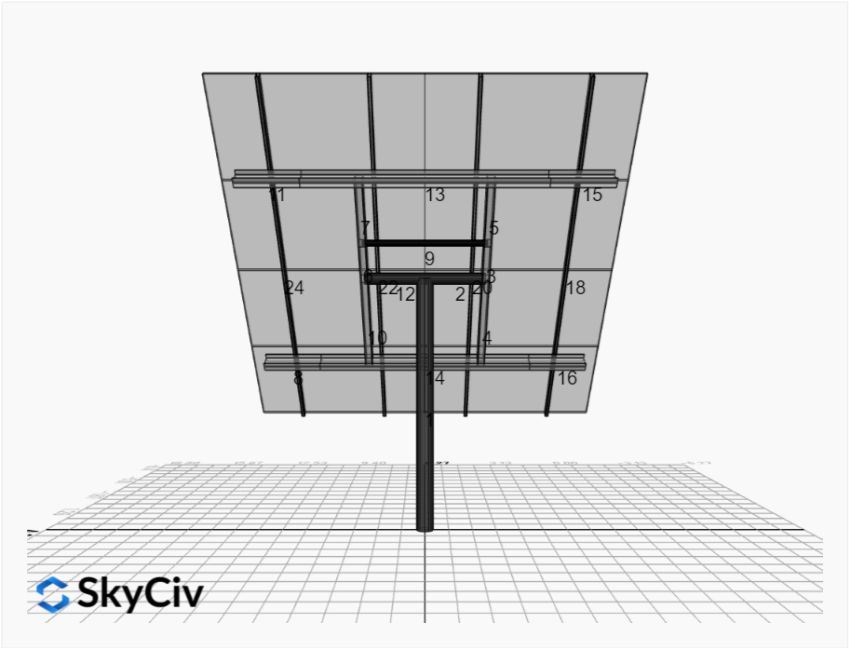
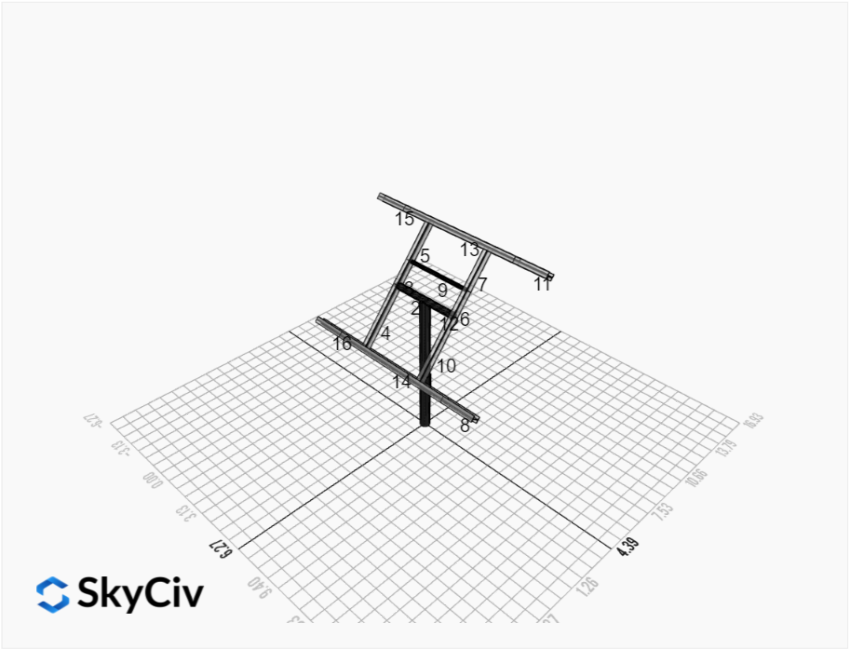
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### Design Notes:

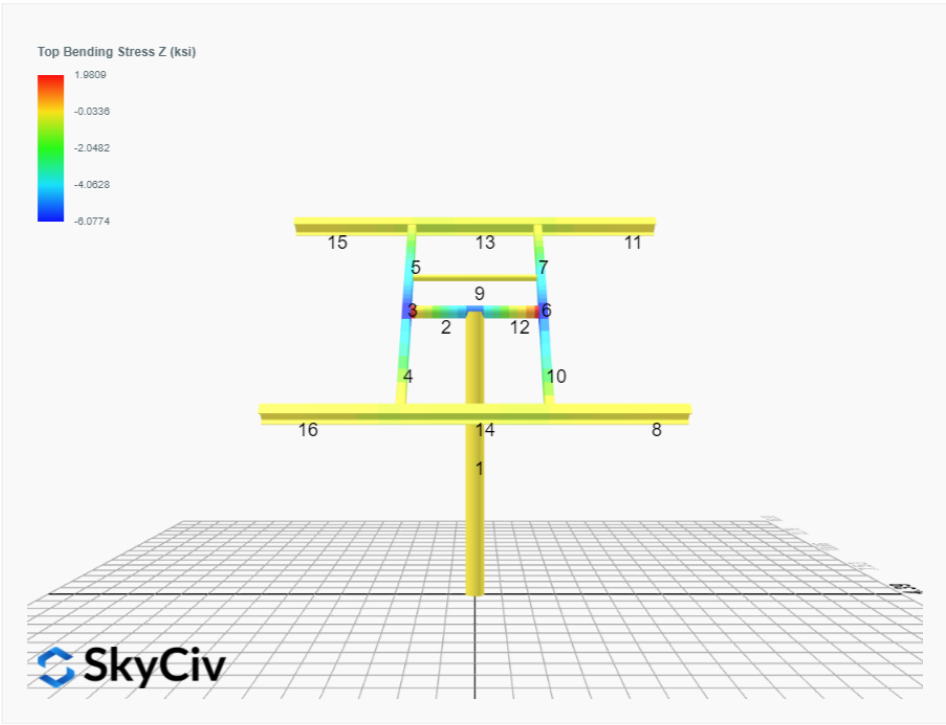
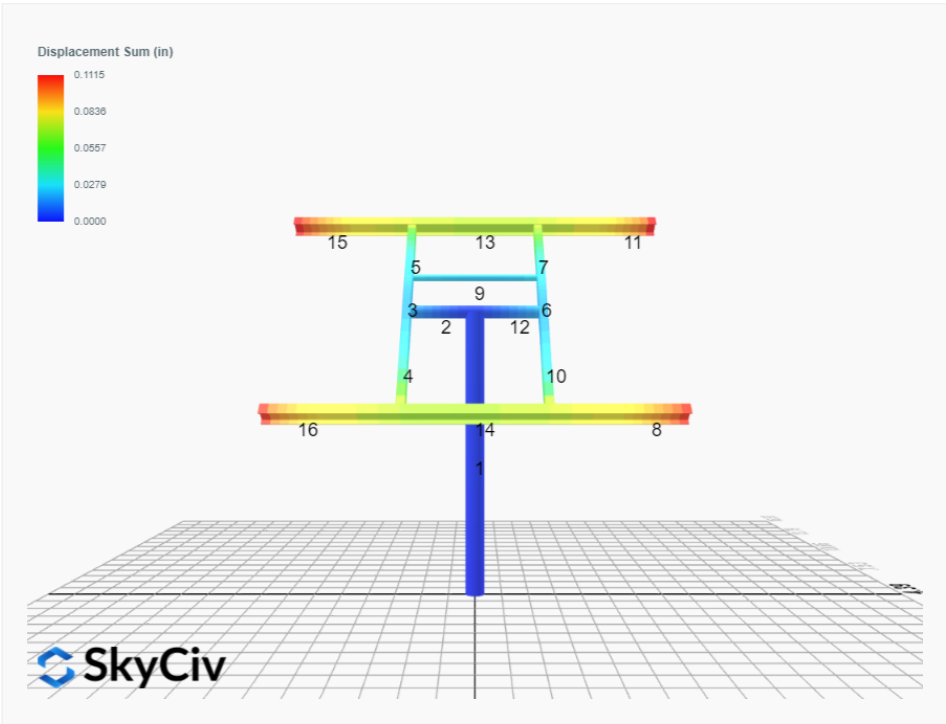
- AISC Deflection checks are set to L/1 due to structure design intent
- Foundation Soil Parameters used in this Autodesigned are all estimates, proper geotechnical reports are required to confirm soil profiles
- Wind speeds, snow loads and other site specific results are based on ASCE 7 2016
- Steel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

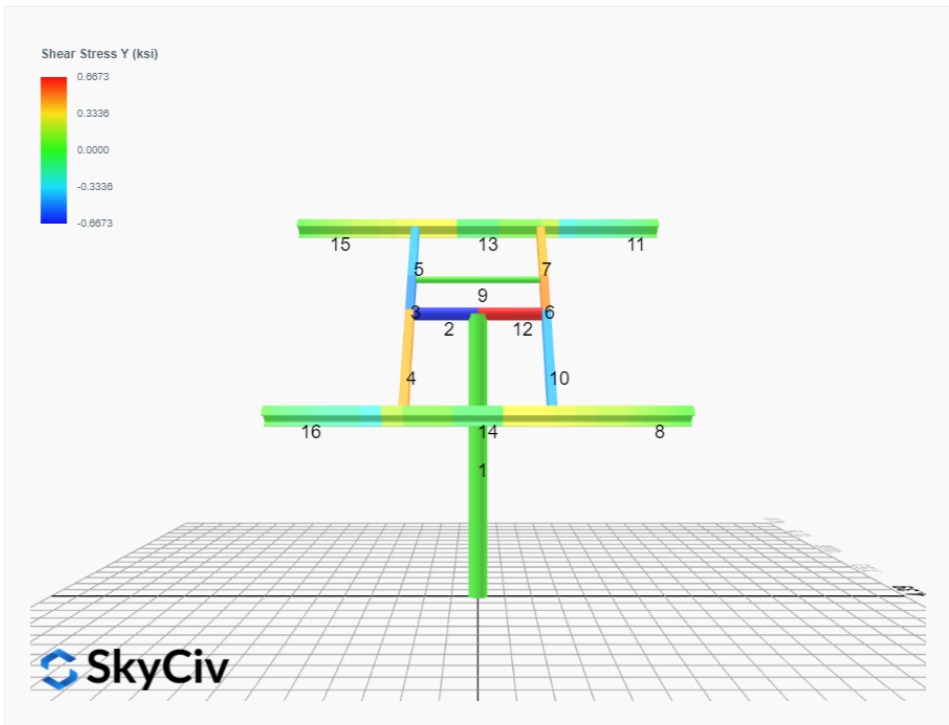
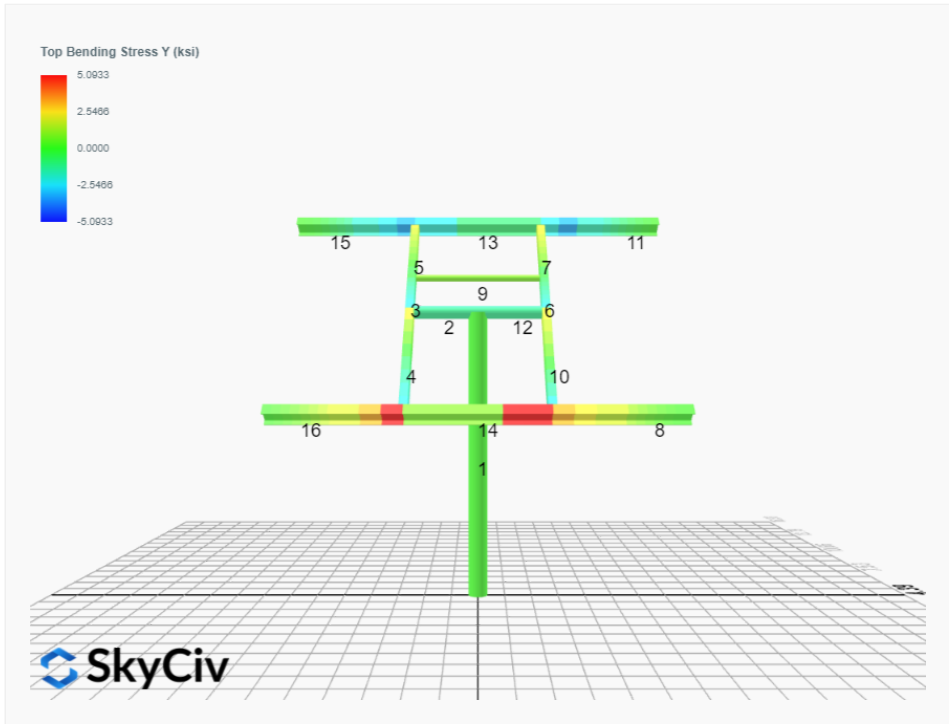






FEM Results (Envelope Worst Case for each member)







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

### ASD Load Combination Results

| Name                                                                            | Fx      | Fy      | Fz     | Mx     | My      | Mz      |
|---------------------------------------------------------------------------------|---------|---------|--------|--------|---------|---------|
| ULS: 1. D                                                                       | 0.0000  | 1.3383  | 0.0000 | 0.0000 | -0.0000 | 0.0147  |
| ULS: 2. D + L                                                                   | 0.0000  | 1.3383  | 0.0000 | 0.0000 | -0.0000 | 0.0147  |
| ULS: 3. D + (S or Lr or R)                                                      | 0.0000  | 3.3623  | 0.0000 | 0.0000 | -0.0000 | 0.0221  |
| ULS: 3. D + (S or Lr or R)                                                      | 0.0000  | 1.3383  | 0.0000 | 0.0000 | -0.0000 | 0.0147  |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R)                                          | 0.0000  | 2.8563  | 0.0000 | 0.0000 | -0.0000 | 0.0202  |
| ULS: 4. D + 0.75L + 0.75(S or Lr or R)                                          | 0.0000  | 1.3383  | 0.0000 | 0.0000 | -0.0000 | 0.0147  |
| ULS: 5b. D + 0.7E                                                               | 0.0000  | 1.3383  | 0.0000 | 0.0000 | -0.0000 | 0.0147  |
| ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S                                         | 0.0000  | 2.8563  | 0.0000 | 0.0000 | -0.0000 | 0.0202  |
| ULS: 8. 0.6D + 0.7E                                                             | 0.0000  | 0.8030  | 0.0000 | 0.0000 | -0.0000 | 0.0088  |
| ULS: 5a. D + 0.6W_Wind downforce Case A only                                    | -1.0604 | 2.2281  | 0.0000 | 0.0000 | -0.0000 | 8.8680  |
| ULS: 5a. D + 0.6W_Wind downforce Case B only                                    | 0.0000  | 1.3383  | 0.0000 | 0.0000 | -0.0000 | 0.0147  |
| ULS: 5a. D + 0.6W_Wind uplift Case A only                                       | 1.0604  | 0.4484  | 0.0000 | 0.0000 | -0.0000 | -8.7329 |
| ULS: 5a. D + 0.6W_Wind uplift Case B only                                       | 0.0000  | 1.3383  | 0.0000 | 0.0000 | -0.0000 | 0.0147  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -0.7953 | 3.5236  | 0.0000 | 0.0000 | -0.0000 | 6.6602  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | 0.0000  | 2.8563  | 0.0000 | 0.0000 | -0.0000 | 0.0202  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only    | 0.7953  | 2.1889  | 0.0000 | 0.0000 | -0.0000 | -6.5404 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only    | 0.0000  | 2.8563  | 0.0000 | 0.0000 | -0.0000 | 0.0202  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only | -0.7953 | 2.0056  | 0.0000 | 0.0000 | -0.0000 | 6.6546  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only | 0.0000  | 1.3383  | 0.0000 | 0.0000 | -0.0000 | 0.0147  |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only    | 0.7953  | 0.6709  | 0.0000 | 0.0000 | -0.0000 | -6.5460 |
| ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only    | 0.0000  | 1.3383  | 0.0000 | 0.0000 | -0.0000 | 0.0147  |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case A only                                  | -1.0604 | 1.6928  | 0.0000 | 0.0000 | -0.0000 | 8.8621  |
| ULS: 7. 0.6D + 0.6W_Wind downforce Case B only                                  | 0.0000  | 0.8030  | 0.0000 | 0.0000 | -0.0000 | 0.0088  |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case A only                                     | 1.0604  | -0.0869 | 0.0000 | 0.0000 | -0.0000 | -8.7387 |
| ULS: 7. 0.6D + 0.6W_Wind uplift Case B only                                     | 0.0000  | 0.8030  | 0.0000 | 0.0000 | -0.0000 | 0.0088  |

### Worst Case Reactions LRFD

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

| Result           | Value (kip, kip-ft) |
|------------------|---------------------|
| Axial            | 5.5858              |
| Shear X          | -1.7674             |
| Shear Z          | 0.0000              |
| Moment X         | 0.0000              |
| Moment Y (Twist) | 0.0000              |
| Moment Z         | 14.9568             |

### Worst Case Reactions ASD

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

| Result           | Value (kip, kip-ft) |
|------------------|---------------------|
| Axial            | 3.5236              |
| Shear X          | -1.0604             |
| Shear Z          | 0.0000              |
| Moment X         | 0.0000              |
| Moment Y (Twist) | 0.0000              |
| Moment Z         | 8.8680              |

## Project Details

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

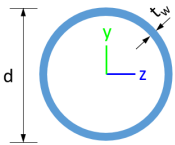
User Name: sales@mtsolar.us  
Unit System: imperial



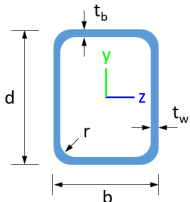
## Design Input Information

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

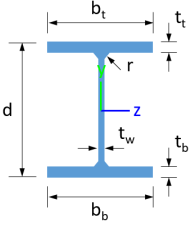
| Design Materials |         |             |             |
|------------------|---------|-------------|-------------|
| ID               | E (ksi) | $F_y$ (ksi) | $F_u$ (ksi) |
| 1                | 29000   | 50          | 65          |

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

| ID | Name            | d (in) | $t_w$ (in) |  |  |  |  |  |
|----|-----------------|--------|------------|--|--|--|--|--|
| 1  | 2in Pipe Sch 40 | 2.38   | 0.15       |  |  |  |  |  |
| 4  | 4in Pipe Sch 40 | 4.50   | 0.24       |  |  |  |  |  |
| 7  | 6in Pipe Sch 40 | 6.63   | 0.28       |  |  |  |  |  |

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

| ID | Name       | d (in) | b (in) | $t_w$ (in) | $t_b$ (in) | r (in) |  |  |
|----|------------|--------|--------|------------|------------|--------|--|--|
| 15 | HSS5x3x1/8 | 5.00   | 3.00   | 0.12       | 0.12       | 0.12   |  |  |

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

| ID | Name | d (in) | $t_w$ (in) | $b_f$ (in) | $b_b$ (in) | $t_f$ (in) | $t_b$ (in) | r (in) |
|----|------|--------|------------|------------|------------|------------|------------|--------|
| 18 | W6x9 | 5.90   | 0.17       | 3.94       | 3.94       | 0.21       | 0.21       | 0.25   |

| Section Properties |                 |                      |                      |                             |                             |                          |                             |                             |
|--------------------|-----------------|----------------------|----------------------|-----------------------------|-----------------------------|--------------------------|-----------------------------|-----------------------------|
| ID                 | Name            | A (in <sup>2</sup> ) | J (in <sup>4</sup> ) | $I_{yp}$ (in <sup>4</sup> ) | $I_{zp}$ (in <sup>4</sup> ) | $I_w$ (in <sup>6</sup> ) | $S_{yp}$ (in <sup>3</sup> ) | $S_{zp}$ (in <sup>3</sup> ) |
| 1                  | 2in Pipe Sch 40 | 1.07                 | 1.33                 | 0.67                        | 0.67                        | 0.00                     | 0.76                        | 0.76                        |
| 4                  | 4in Pipe Sch 40 | 3.17                 | 14.47                | 7.23                        | 7.23                        | 0.00                     | 4.31                        | 4.31                        |
| 7                  | 6in Pipe Sch 40 | 5.58                 | 56.28                | 28.14                       | 28.14                       | 0.00                     | 11.28                       | 11.28                       |

|    |            |      |      |      |       |       |      |      |
|----|------------|------|------|------|-------|-------|------|------|
| 15 | HSS5x3x1/8 | 1.77 | 6.02 | 2.75 | 6.03  | 0.51  | 2.07 | 2.93 |
| 18 | W6x9       | 2.68 | 0.04 | 2.20 | 16.40 | 17.70 | 1.72 | 6.23 |

| Member Properties |            |                       |                       |                     |                                                                                                                                   |             |             |        |  |
|-------------------|------------|-----------------------|-----------------------|---------------------|-----------------------------------------------------------------------------------------------------------------------------------|-------------|-------------|--------|--|
| Member ID         | Section ID | K <sub>z</sub> L (ft) | K <sub>y</sub> L (ft) | L <sub>b</sub> (ft) | C <sub>b</sub>                                                                                                                    | L<br>S<br>T | L<br>S<br>C | L<br>D |  |
| 1                 | 7          | 17.43                 | 17.43                 | 8.30                | -                                                                                                                                 | 300         | 200         | 1      |  |
| 2                 | 4          | 1.30                  | 1.30                  | 2.00                | -                                                                                                                                 | 300         | 200         | 1      |  |
| 3                 | 15         | 0.92                  | 0.92                  | 1.42                | 1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.17,1.19,1.18,1.18,1.18,1.18,1.19,1.15,1.19,1.18,1.19,1.17,1.19      | 300         | 200         | 1      |  |
| 4                 | 15         | 2.44                  | 2.44                  | 3.75                | 1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.68,1.65,1.68,1.67,1.69,1.66,1.69,1.67,1.67,1.68,1.67,1.68,1.69,1.62,1.69,1.67,1.69,1.66,1.69 | 300         | 200         | 1      |  |
| 5                 | 15         | 1.52                  | 1.52                  | 2.33                | 1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.65,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.67,1.67,1.67,1.68,1.64,1.68,1.67,1.68,1.66,1.68 | 300         | 200         | 1      |  |
| 6                 | 15         | 0.92                  | 0.92                  | 1.42                | 1.19,1.18,1.19,1.18,1.19,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.17,1.19,1.18,1.18,1.18,1.18,1.18,1.19,1.15,1.19,1.18,1.19,1.17,1.19 | 300         | 200         | 1      |  |
| 7                 | 15         | 1.52                  | 1.52                  | 2.33                | 1.68,1.67,1.68,1.67,1.68,1.68,1.67,1.67,1.65,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.67,1.67,1.67,1.68,1.64,1.68,1.67,1.68,1.66,1.68 | 300         | 200         | 1      |  |
| 8                 | 18         | 4.20                  | 4.20                  | 2.00                | 2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33           | 300         | 200         | 1      |  |
| 9                 | 1          | 2.60                  | 2.60                  | 4.00                | -                                                                                                                                 | 300         | 200         | 1      |  |
| 10                | 15         | 2.44                  | 2.44                  | 3.75                | 1.69,1.68,1.69,1.67,1.68,1.69,1.67,1.68,1.65,1.68,1.67,1.69,1.66,1.69,1.67,1.67,1.68,1.67,1.68,1.69,1.62,1.69,1.67,1.69,1.66,1.69 | 300         | 200         | 1      |  |
| 11                | 18         | 4.20                  | 4.20                  | 2.00                | 2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33           | 300         | 200         | 1      |  |
| 12                | 4          | 1.30                  | 1.30                  | 2.00                | -                                                                                                                                 | 300         | 200         | 1      |  |
| 13                | 18         | 4.88                  | 4.00                  | 7.50                | 1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09           | 300         | 200         | 1      |  |
| 14                | 18         | 4.88                  | 4.00                  | 7.50                | 1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09,1.09           | 300         | 200         | 1      |  |
| 15                | 18         | 4.20                  | 4.20                  | 2.00                | 2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33           | 300         | 200         | 1      |  |
| 16                | 18         | 4.20                  | 4.20                  | 2.00                | 2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33,2.33           | 300         | 200         | 1      |  |

## Member Design Capacity

| Member ID | $\Phi_c P_n$ (kip) | $\Phi_t P_n$ (kip) | $\Phi_b M_{zn}$ (k-ft) | $\Phi_b M_{yn}$ (k-ft) | $\Phi_v V_{yn}$ (kip) | $\Phi_v V_{zn}$ (kip) |
|-----------|--------------------|--------------------|------------------------|------------------------|-----------------------|-----------------------|
| 1         | 251.16             | 133.21             | 42.30                  | 42.30                  | 75.35                 | 75.35                 |
| 2         | 142.83             | 141.72             | 16.17                  | 16.17                  | 42.85                 | 42.85                 |
| 3         | 79.65              | 74.02              | 10.99                  | 4.60                   | 29.14                 | 16.61                 |
| 4         | 79.65              | 72.01              | 10.99                  | 4.60                   | 29.14                 | 16.61                 |
| 5         | 79.65              | 73.44              | 10.99                  | 4.60                   | 29.14                 | 16.61                 |
| 6         | 79.65              | 74.02              | 10.99                  | 4.60                   | 29.14                 | 16.61                 |
| 7         | 79.65              | 73.44              | 10.99                  | 4.60                   | 29.14                 | 16.61                 |
| 8         | 120.60             | 96.18              | 23.36                  | 6.45                   | 30.09                 | 45.74                 |
| 9         | 48.35              | 43.11              | 2.85                   | 2.85                   | 14.51                 | 14.51                 |
| 10        | 79.65              | 72.01              | 10.99                  | 4.60                   | 29.14                 | 16.61                 |

|    |        |        |       |       |       |       |
|----|--------|--------|-------|-------|-------|-------|
| 11 | 120.60 | 96.18  | 23.36 | 6.45  | 30.09 | 45.74 |
| 12 | 142.83 | 141.72 | 16.17 | 16.17 | 42.85 | 42.85 |
| 13 | 120.60 | 98.23  | 19.16 | 6.45  | 30.09 | 45.74 |
| 14 | 120.60 | 98.23  | 19.11 | 6.45  | 30.09 | 45.74 |
| 15 | 120.60 | 96.18  | 23.36 | 6.45  | 30.09 | 45.74 |
| 16 | 120.60 | 96.18  | 23.36 | 6.45  | 30.09 | 45.74 |

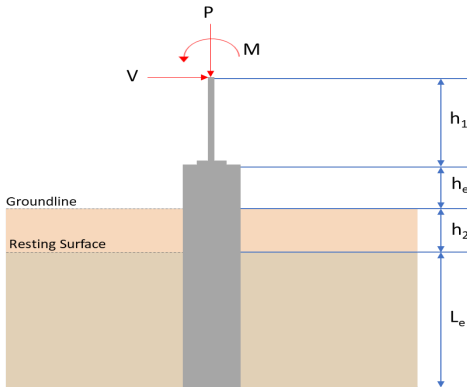
## Design Ratio

| Member ID | P     | M <sub>z</sub> | M <sub>y</sub> | V <sub>y</sub> | V <sub>z</sub> | (P,M <sub>z</sub> ,M <sub>y</sub> ) | Worst LC | KL/r         | δ            | Status |
|-----------|-------|----------------|----------------|----------------|----------------|-------------------------------------|----------|--------------|--------------|--------|
| 1         | 0.042 | 0.354          | 0.000          | 0.023          | 0.000          | 0.369                               | #13      | 0.466        | Not Required | Pass   |
| 2         | 0.001 | 0.252          | 0.117          | 0.063          | 0.021          | 0.338                               | #21      | 0.052        | Not Required | Pass   |
| 3         | 0.012 | 0.351          | 0.152          | 0.035          | 0.027          | 0.508                               | #21      | 0.044        | Not Required | Pass   |
| 4         | 0.011 | 0.347          | 0.145          | 0.035          | 0.021          | 0.486                               | #21      | 0.078        | Not Required | Pass   |
| 5         | 0.012 | 0.217          | 0.143          | 0.035          | 0.019          | 0.241                               | #21      | 0.073        | Not Required | Pass   |
| 6         | 0.012 | 0.351          | 0.152          | 0.035          | 0.027          | 0.508                               | #21      | 0.044        | Not Required | Pass   |
| 7         | 0.012 | 0.217          | 0.143          | 0.035          | 0.019          | 0.241                               | #21      | 0.073        | Not Required | Pass   |
| 8         | 0.000 | 0.015          | 0.046          | 0.012          | 0.007          | 0.061                               | #21      | Not Required | Not Required | Pass   |
| 9         | 0.003 | 0.019          | 0.031          | 0.001          | 0.000          | 0.051                               | #21      | 0.132        | Not Required | Pass   |
| 10        | 0.011 | 0.347          | 0.145          | 0.035          | 0.021          | 0.486                               | #21      | 0.078        | Not Required | Pass   |
| 11        | 0.000 | 0.015          | 0.046          | 0.012          | 0.007          | 0.061                               | #21      | Not Required | Not Required | Pass   |
| 12        | 0.001 | 0.252          | 0.117          | 0.063          | 0.021          | 0.338                               | #21      | 0.052        | Not Required | Pass   |
| 13        | 0.003 | 0.072          | 0.163          | 0.022          | 0.012          | 0.227                               | #21      | 0.177        | Not Required | Pass   |
| 14        | 0.003 | 0.074          | 0.163          | 0.022          | 0.012          | 0.227                               | #21      | 0.177        | Not Required | Pass   |
| 15        | 0.000 | 0.015          | 0.046          | 0.012          | 0.007          | 0.061                               | #21      | Not Required | Not Required | Pass   |
| 16        | 0.000 | 0.015          | 0.046          | 0.012          | 0.007          | 0.061                               | #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                                      |
| NG                                  | Capacity is not provided                                  |

no capacity is not provided

| REFERENCES     | CALCULATIONS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | RESULTS                                  |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |       |        |  |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|--------------------------------------------|------------------------------------------|--------------------------------------------|---|-------------------------------------------------------------|----------|---------|----------------|-----|------|---------|-------|-------|----------|--------|--------|----------|-------|-------|------------|-------|-------|------------|-------|--------|--|
|                | <div><div>SkyCiv Foundation Design</div><div>Pile Foundation</div><div>Design Information :</div><div>Design code : IBC 2021 (International Building Code)</div><div>Unit System : Imperial</div></div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                          |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |       |        |  |
|                | <div><div>Pile Input</div><div></div><div><div>Geometry</div><div>Pile shape: round</div><div>D = 36 in - Pile diameter</div><div>L = 6.25 ft - Total pile length</div><div>h1 = 0 ft - Lateral load height from the top of the pile,</div><div>h2 = 0 ft - Depth to resisting surface</div><div>he = 0 ft - Length of pile above the ground</div></div><div><div>Tabulation of Soil Parameters</div><table><tr><th>Layer</th><th>Label</th><th>Allowable Bearing Pressure (qa)<br/>(psf)</th><th>Allowable Lateral Pressure (R)<br/>(psf/ft)</th></tr><tr><td>1</td><td>Sand, silty sand, clayey sand, silty gravel &amp; clayey gravel</td><td>2000.000</td><td>150.000</td></tr></table></div><div><div>Tabulation of Loads</div><table><tr><th>Load Component</th><th>ASD</th><th>LRFD</th></tr><tr><td>P (kip)</td><td>3.524</td><td>5.586</td></tr><tr><td>Vx (kip)</td><td>-1.060</td><td>-1.767</td></tr><tr><td>Vz (kip)</td><td>0.000</td><td>0.000</td></tr><tr><td>Mx (kipft)</td><td>0.000</td><td>0.000</td></tr><tr><td>Mz (kipft)</td><td>8.868</td><td>14.957</td></tr></table></div><div><div>Material Properties</div><div>f'ck = 2.5 ksi - Concrete strength,</div></div></div> | Layer                                    | Label                                      | Allowable Bearing Pressure (qa)<br>(psf) | Allowable Lateral Pressure (R)<br>(psf/ft) | 1 | Sand, silty sand, clayey sand, silty gravel & clayey gravel | 2000.000 | 150.000 | Load Component | ASD | LRFD | P (kip) | 3.524 | 5.586 | Vx (kip) | -1.060 | -1.767 | Vz (kip) | 0.000 | 0.000 | Mx (kipft) | 0.000 | 0.000 | Mz (kipft) | 8.868 | 14.957 |  |
| Layer          | Label                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Allowable Bearing Pressure (qa)<br>(psf) | Allowable Lateral Pressure (R)<br>(psf/ft) |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |       |        |  |
| 1              | Sand, silty sand, clayey sand, silty gravel & clayey gravel                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 2000.000                                 | 150.000                                    |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |       |        |  |
| Load Component | ASD                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | LRFD                                     |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |       |        |  |
| P (kip)        | 3.524                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 5.586                                    |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |       |        |  |
| Vx (kip)       | -1.060                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | -1.767                                   |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |       |        |  |
| Vz (kip)       | 0.000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0.000                                    |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |       |        |  |
| Mx (kipft)     | 0.000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0.000                                    |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |       |        |  |
| Mz (kipft)     | 8.868                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 14.957                                   |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |       |        |  |
|                | <div><div>Required depth to resist lateral loads (ASD)</div><div>H - Point of application of the lateral load</div><div><div><div><div><math>H = h_1 + h_2 + h_e</math></div><div><math>H = (0\text{ ft}) + (0\text{ ft}) + (0\text{ ft})</math></div><div><math>H = 0\text{ ft}</math></div></div></div></div><div><div>Considering x-direction:</div><div>Ho - Lateral force per length of pile,</div><div><div><div><math>H_o = \frac{V_x}{D}</math></div><div><math>H_o = \frac{(-1.06\text{ kip})}{(36\text{ in})}</math></div><div><math>H_o = -0.35333\text{ kip/ft}</math></div></div></div><div><div>Mo - Moment per length of pile,</div><div><div><math>M_o = \frac{M_z + (V_x H)}{D}</math></div></div></div></div></div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                          |                                            |                                          |                                            |   |                                                             |          |         |                |     |      |         |       |       |          |        |        |          |       |       |            |       |       |            |       |        |  |

|          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                            |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
|          | $M_o = \frac{(8.868 \text{ kipft}) + ((-1.06 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$ $M_o = 2.956 \text{ kipft/ft}$ <p>Required depth of embedment in earth:</p> $L_x^3 - \left(14.14 \times \frac{H_o \times L_x}{R}\right) - \left(18.85 \times \frac{M_o}{R}\right) = 0$ <p>Solving the cubic equation:<br/> <math>L_{e,x} = 5.6726 \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> $L_{e,req} = \text{MAX}[L_{e,x}, L_{e,z}]$ $L_{e,req} = \text{MAX}[(5.6726 \text{ ft}), (0 \text{ ft})]$ $L_{e,req} = 5.673 \text{ ft}$ <p><math>L_e</math> - Actual embedded length of pile,</p> $L_e = L - h_e - h_2$ $L_e = (6.25 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 6.25 \text{ ft}$ <p>Ratio - Embedded depth</p> $\text{Ratio} = \frac{L_{e,req}}{L_e}$ $\text{Ratio} = \frac{(5.673 \text{ ft})}{(6.25 \text{ ft})}$ $\text{Ratio} = 0.90768$ | Status: <b>PASS</b><br>Ratio: <b>0.910</b> |
|          | <p><b>End-bearing Capacity (ASD)</b><br/> <math>A</math> - Pile cross-section area</p> $A = \pi \left(\frac{D}{2}\right)^2$ $A = \pi \times \left(\frac{(36 \text{ in})}{2}\right)^2$ $A = 7.0686 \text{ ft}^2$ <p><math>q</math> - End-bearing pressure</p> $q = \frac{P_o}{A}$ $q = \frac{(3.524 \text{ kip})}{(7.0686 \text{ ft}^2)}$ $q = 0.49854 \text{ kip/ft}^2$ <p><b>Check bearing capacity ratio:</b><br/> Ratio - Capacity</p> $\text{Ratio} = \frac{q}{q_a}$ $\text{Ratio} = \frac{(0.49854 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $\text{Ratio} = 0.24927$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Status: <b>PASS</b><br>Ratio: <b>0.250</b> |
| Czerniak | <p><b>Lateral Soil Pressure (ASD):</b><br/> <math>L/D</math> - Length to least lateral dimension ratio,</p> $L/D = \frac{L}{D}$ $L/D = \frac{(6.25 \text{ ft})}{(36 \text{ in})}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                            |

$$L/D = 2.0833$$

Since  $L/D \leq 10$ ,

Pile is short.

**Considering x-direction:**

$H_o = -0.35333$  kip/ft - Lateral force per length of pile,

$M_o = 2.956$  kipft/ft - Overturning moment per length of pile,

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

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

$$a = \frac{(4 \times (2.956 \text{ kipft/ft}) \times (6.25 \text{ ft})) + (3 \times (-0.35333 \text{ kip/ft}) \times (6.25 \text{ ft})^2)}{(6 \times (2.956 \text{ kipft/ft})) + (4 \times (-0.35333 \text{ kip/ft}) \times (6.25 \text{ ft}))}$$

$$a = 4.3398 \text{ ft}$$

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

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

$$p = \frac{1.178 \times [(4 \times (2.956 \text{ kipft/ft})) + (3 \times (-0.35333 \text{ kip/ft}) \times (6.25 \text{ ft}))]^2}{(6.25 \text{ ft})^3 \times [(3 \times (2.956 \text{ kipft/ft})) + (2 \times (-0.35333 \text{ kip/ft}) \times (6.25 \text{ ft}))]}$$

$$p = 0.18312 \text{ kip/ft}^2$$

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

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

$$s = \frac{9.425 \times [(2 \times (2.956 \text{ kipft/ft})) + ((-0.35333 \text{ kip/ft}) \times (6.25 \text{ ft}))]}{(6.25 \text{ ft})^2}$$

$$s = 0.89362 \text{ kip/ft}^2$$

**Check lateral soil pressure capacity:**

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(4.3398 \text{ ft})}{2}$$

$$p_a = 0.32549 \text{ kip/ft}^2$$

*Ratio* - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.18312 \text{ kip/ft}^2)}{(0.32549 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.5626$$

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

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (6.25 \text{ ft})$$

$$p_s = 0.9375 \text{ kip/ft}^2$$

*Ratio* - Lateral soil capacity

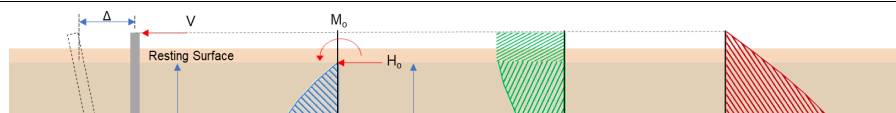
$$\text{Ratio} = \frac{s}{p_s}$$

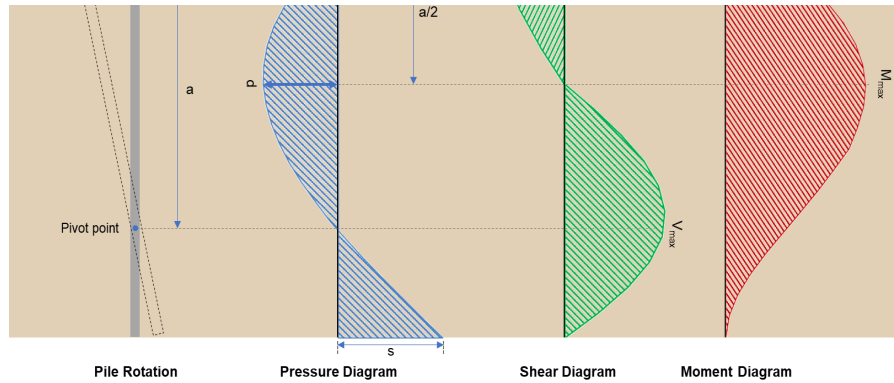
$$\text{Ratio} = \frac{(0.89362 \text{ kip/ft}^2)}{(0.9375 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.9532$$

Status: **PASS**  
Ratio: **0.560**

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





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

$H_o$  - Lateral force per length of pile,

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

$$H_o = \frac{(-1.767 \text{ kip})}{(36 \text{ in})}$$

$$H_o = -0.589 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

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

$$M_o = \frac{(14.957 \text{ kipft}) + ((-1.767 \text{ kip}) \times (0 \text{ ft}))}{(36 \text{ in})}$$

$$M_o = 4.9857 \text{ kipft/ft}$$

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

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

$$E = \frac{(4.9857 \text{ kipft/ft})}{(-0.589 \text{ kip/ft})}$$

$$E = 8.4646 \text{ ft}$$

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

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

$$a = \frac{(4 \times (4.9857 \text{ kipft/ft}) \times (6.25 \text{ ft})) + (3 \times (-0.589 \text{ kip/ft}) \times (6.25 \text{ ft})^2)}{(6 \times (4.9857 \text{ kipft/ft})) + (4 \times (-0.589 \text{ kip/ft}) \times (6.25 \text{ ft}))}$$

$$a = 4.3385 \text{ ft}$$

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

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

$$V_{max} = ((-0.589 \text{ kip/ft}) \times (36 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (8.4646 \text{ ft})}{(6.25 \text{ ft})} + 3 \right) \times \left( \frac{(4.3385 \text{ ft})}{(6.25 \text{ ft})} \right)^2 \right] + \left[ 4 \times \left( \frac{3 \times (8.4646 \text{ ft})}{(6.25 \text{ ft})} + 2 \right) \times \left( \frac{(4.3385 \text{ ft})}{(6.25 \text{ ft})} \right)^3 \right] \right]$$

$$V_{max} = 5.3998 \text{ kip}$$

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

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

$$M_{max} = ((-0.589 \text{ kip/ft}) \times (36 \text{ in}) \times (6.25 \text{ ft})) \times \left[ \left( \frac{(8.4646 \text{ ft})}{(6.25 \text{ ft})} + \frac{(4.3385 \text{ ft})}{2 \times (6.25 \text{ ft})} \right) - \left[ \left( \frac{4 \times (8.4646 \text{ ft})}{(6.25 \text{ ft})} + 3 \right) \times \left( \frac{(4.3385 \text{ ft})}{2 \times (6.25 \text{ ft})} \right)^3 \right] + \left[ \left( \frac{3 \times (8.4646 \text{ ft})}{(6.25 \text{ ft})} + 2 \right) \times \left( \frac{(4.3385 \text{ ft})}{2 \times (6.25 \text{ ft})} \right)^4 \right] \right]$$

|                |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                     |
|----------------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
|                |                    | $M_{max} = 15.875 \text{ kipft}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                     |
| Table 22.4.2.1 | 22.4.2.2, 10.6.1.1 | <p><b>Minimum Reinforcement Check (LRFD)</b></p> <p><b>Parameters:</b></p> <p><math>f'_{ck} = 2.5 \text{ ksi}</math> - Concrete strength,<br/> <math>f_{yk} = 60 \text{ ksi}</math> - Longitudinal reinforcement strength,<br/> <math>\phi = 0.65</math> - Reduction factor for axial strength,<br/> <math>\alpha = 0.85</math> - Alpha factor for axial strength,<br/> <math>A_g = 1017.9 \text{ in}^2</math> - Gross area of concrete,</p> <p><b>Longitudinal reinforcement:</b></p> <p>Required reinforcement due to axial load, <math>A_{st,required}</math></p> $A_{st,required} = \text{Min} \left[ \frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = \text{Min} \left[ \frac{\frac{(5.586 \text{ kip})}{(0.65) \times (0.85)} - (0.85 \times (2.5 \text{ ksi}) \times (1017.9 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (1017.9 \text{ in}^2)) \right]$ $A_{st,required} = -37.199 \text{ in}^2$ <p><math>A_{min}</math> - Governing minimum reinforcement area,</p> $A_{min} = \text{Max} [A_{st,required}, (0.0018 A_g)]$ $A_{min} = \text{Max} [(-37.199 \text{ in}^2), (0.0018 \times (1017.9 \text{ in}^2))]$ $A_{min} = 1.8322 \text{ in}^2$ <p><math>n_{rebar}</math> - Required number of reinforcement,</p> $n_{rebar} = \frac{A_{min}}{A_{rebar}}$ $n_{rebar} = \frac{(1.8322 \text{ in}^2)}{(0.3068 \text{ in}^2)}$ $n_{rebar} = 6$ <p><math>A_{st}</math> - Actual total reinforcement area,</p> $A_{st} = n_{rebar} \frac{\pi d_{bar}^2}{4}$ $A_{st} = (6) \times \frac{\pi \times (0.625 \text{ in})^2}{4}$ $A_{st} = 1.8408 \text{ in}^2$ <p><b>Ratio - Capacity</b></p> $\text{Ratio} = \frac{A_{min}}{A_{st}}$ $\text{Ratio} = \frac{(1.8322 \text{ in}^2)}{(1.8408 \text{ in}^2)}$ $\text{Ratio} = 0.99533$ <p>25.7.2.3 <math>s_{rebar}</math> - Minimum spacing of reinforcement,</p> $s_{rebar} = \text{Max} [1.5, (1.5 d_{bar})]$ $s_{rebar} = \text{Max} [1.5, (1.5 \times (0.625 \text{ in}))]$ $s_{rebar} = 1.5 \text{ in}$ <p><b>Ties:</b></p> <p>25.7.2.2 Since longitudinal reinforcement is <math>\leq \text{No. 10}\varnothing</math>: Use #3(0.375 in)</p> <p>25.7.2.1 <math>s_{ties}</math> - Maximum center-to-center spacing of ties,</p> $s_{ties} = \text{Min} [(16 d_{bar}), (48 d_{ties}), D]$ $s_{ties} = \text{Min} [(16 \times (0.625 \text{ in})), (48 \times (0.375 \text{ in})), (36 \text{ in})]$ $s_{ties} = 10 \text{ in}$ <p><b>Summary:</b></p> | <p>Status: <b>PASS</b><br/> Ratio: <b>1.000</b></p> |

|               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                    |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|
|               | <p>Main reinforcement: <b>6 - #5 (0.625 in)</b><br/>Ties: <b>#3(0.375 in) - 10 in</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                    |
| 22.4.2.2      | <p><b>Axial Compression Strength (ACI 318-19, LRFD)</b></p> <p><math>\phi P_N</math> - Allowable axial compressive strength</p> $\phi P_N = \phi 0.85 \left[ (0.85 f'_{ck} [A_g - A_{st}]) + (f_{yk} A_{st}) \right]$ $\phi P_N = (0.65) \times 0.85 \times \left[ (0.85 \times (2.5 \text{ ksi}) \times [(1017.9 \text{ in}^2) - (1.8408 \text{ in}^2)]) + ((60 \text{ ksi}) \times (1.8408 \text{ in}^2)) \right]$ $\phi P_N = 1253.9 \text{ kip}$ <p>Ratio - Capacity</p> $Ratio = \frac{P}{\phi P_N}$ $Ratio = \frac{(5.586 \text{ kip})}{(1253.9 \text{ kip})}$ $Ratio = 0.0044549$                                                                                                    | <p>Status: <b>PASS</b><br/>Ratio: <b>0.000</b></p> |
| 22.5.2.2      | <p><b>Shear Strength (ACI 318-19, LRFD)</b></p> <p><b>Parameters:</b></p> <p><math>b_w = 36 \text{ in}</math> - Effective width,<br/><math>d</math> - Effective depth</p> $d = 0.80 D$ $d = 0.80 \times (36 \text{ in})$ $d = 28.8 \text{ in}$                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                    |
| 22.5.5.1.3    | <p><math>\lambda_s</math> - size effect modification factor</p> $\lambda_s = MIN \left[ \sqrt{\frac{2}{1 + \frac{d}{10}}}, 1 \right]$ $\lambda_s = MIN \left[ \sqrt{\frac{2}{1 + \frac{(28.8 \text{ in})}{10}}}, 1 \right]$ $\lambda_s = 0.71796$                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                    |
| 22.5.5.1.1    | <p>The following variables were converted to be consistent with empirical formula <math>f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}</math> ,<br/><math>V_{c,max}</math> - Max shear strength of concrete</p> $V_{c,max} = 5 \lambda_s \sqrt{f'_{ck}} b_w d$ $V_{c,max} = 5 \times (0.71796) \times \sqrt{(2500 \text{ psi})} \times (36 \text{ in}) \times (28.8 \text{ in})$ $V_{c,max} = 186.09 \text{ kip}$                                                                                                                                                                                                                                                                   |                                                    |
| 22.5.5.1.1(a) | <p>The following variables were converted to be consistent with empirical formula <math>f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}</math> , <math>P = 5.586 \text{ kip} \rightarrow 5586 \text{ lbf}</math> ,<br/><math>V_{c,a}</math> - Shear strength of concrete (a)</p> $V_{c,a} = \left[ 2 \lambda_s \sqrt{f'_{ck}} + \frac{P}{6 A_g} \right] b_w d$ $V_{c,a} = \left[ 2 \times (0.71796) \times \sqrt{(2500 \text{ psi})} + \frac{(5586 \text{ lbf})}{6 \times (1017.9 \text{ in}^2)} \right] \times (36 \text{ in}) \times (28.8 \text{ in})$ $V_{c,a} = 75.386 \text{ kip}$                                                                                             |                                                    |
| 22.5.5.1.2    | <p>The following variables were converted to be consistent with empirical formula <math>f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}</math> ,<br/><math>V_{c,b}</math> - Shear strength of concrete (b)</p> $V_{c,b} = \left[ 2 \lambda_s \sqrt{f'_{ck}} + (0.05 f'_{ck}) \right] b_w d$ $V_{c,b} = \left[ 2 \times (0.71796) \times \sqrt{(2500 \text{ psi})} + (0.05 \times (2500 \text{ psi})) \right] \times (36 \text{ in}) \times (28.8 \text{ in})$ $V_{c,b} = 204.04 \text{ kip}$ <p><math>V_c</math> - Governing shear strength of concrete</p> $V_c = Min [V_{c,max}, V_{c,a}, V_{c,b}]$ $V_c = Min [(186.09 \text{ kip}), (75.386 \text{ kip}), (204.04 \text{ kip})]$ |                                                    |

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <p>22.5.1.2</p>  | <p style="text-align: center;"><math>V_c = 75.386 \text{ kip}</math></p> <p>The following variables were converted to be consistent with empirical formula <math>f'_{ck} = 2.5 \text{ ksi} \rightarrow 2500 \text{ psi}</math> ,</p> <p><math>V_{s,a}</math> - Shear strength of steel (a)</p> $V_{s,a} = 8 \sqrt{f'_{ck}} b_w d$ $V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (36 \text{ in}) \times (28.8 \text{ in})$ $V_{s,a} = 414.72 \text{ kip}$ <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> $V_s = MIN[V_{s,a}, V_{s,b}]$ $V_s = MIN[(414.72 \text{ kip}), (38.17 \text{ kip})]$ $V_s = 38.17 \text{ kip}$ <p>22.5.1.1 <math>\phi V_n</math> - Allowable shear strength</p> $\phi V_n = \phi (V_c + V_s)$ $\phi V_n = (0.65) \times ((75.386 \text{ kip}) + (38.17 \text{ kip}))$ $\phi V_n = 73.812 \text{ kip}$ <p><b>Considering x-direction:</b></p> <p><math>V_{max} = 5.3998 \text{ kip}</math> - Maximum shear force in the x-direction,<br/> <math>Ratio</math> - Capacity</p> $Ratio = \frac{V_{max}}{\phi V_n}$ $Ratio = \frac{(5.3998 \text{ kip})}{(73.812 \text{ kip})}$ $Ratio = 0.073157$ <p style="text-align: right;">Status: <b>PASS</b><br/> Ratio: <b>0.070</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> $S_m = \frac{\pi D^3}{32}$ $S_m = \frac{\pi \times (36 \text{ in})^3}{32}$ $S_m = 4580.4 \text{ in}^3$ <p><math>\lambda = 1</math> - Concrete modification factor (Normal concrete),<br/> Allowable flexural strength:<br/> <math>M_n</math> shall be the lesser of:</p> <p><math>\phi M_{n,1}</math></p> $\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$ $\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{(2.5 \text{ ksi})} \times 4580.442 \text{ in}^3$ $\phi M_{n,1} = 62.027 \text{ kipft}$ <p><math>\phi M_{n,2}</math></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |  |

$$\phi M_{n,2} = \phi 0.85 f'_{ck} S_m$$

$$\phi M_{n,2} = (0.65) \times 0.85 \times (2.5 \text{ ksi}) \times (4580.4 \text{ in}^3)$$

$$\phi M_{n,2} = 527.23 \text{ kipft}$$

Therefore,

$\phi M_n$  - Allowable flexural strength,

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

$$\phi M_n = \text{MIN}[(62.027 \text{ kipft}), (527.23 \text{ kipft})]$$

$$\phi M_n = 62.027 \text{ kipft}$$

**Considering x-direction:**

$M_{max} = 15.875 \text{ kipft}$  - Maximum moment in the x-direction,

*Ratio* - Capacity

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

$$\text{Ratio} = \frac{(15.875 \text{ kipft})}{(62.027 \text{ kipft})}$$

$$\text{Ratio} = 0.25594$$

Status: **PASS**  
Ratio: **0.260**