

## Project Details



**Project Name:** Garvey

**Date:** Fri Jul 26 2024

**Location:** County Rd 75, Colorado 81050, USA

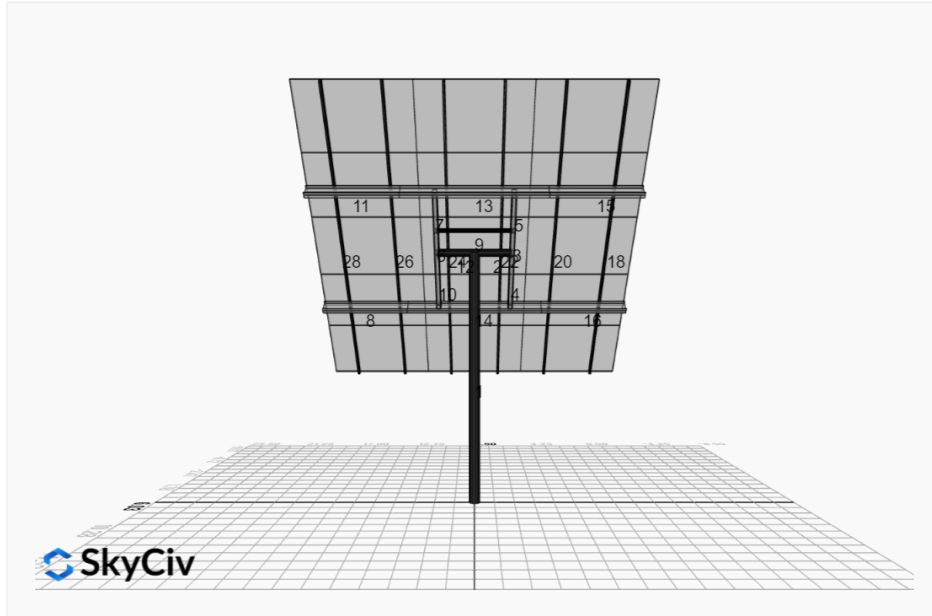
**Number of Modules:** 15

**Unique ID:** 1P-0-6TOP-HD-57-L-5Hx3W-IL76

**Number of Poles:** 1

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

**Date Sold:** \_\_\_\_\_



<b>Array Dimensions N/S</b>	18.96 ft
<b>Array Dimensions E/W</b>	17.25 ft
<b>Winter Tilt Angle</b>	50
<b>Front Edge Clearance</b>	6 ft

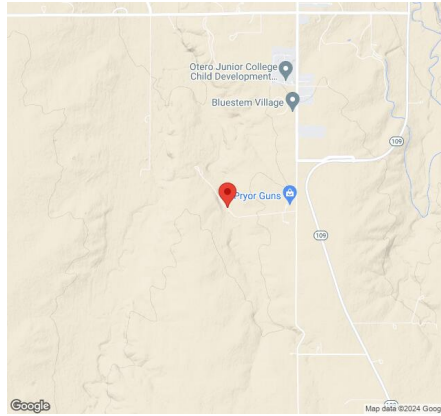
### MT Solar Bill of Materials (1P-0-6TOP-HD-57-L-5Hx3W-IL76)

Part	Short Description	BOM Qty
MTS-PC-6	6IN Pole Cap Assembly	1
MTS-HF-HD	H-Frame Assembly-HD	1
MTS-HD-Wing-57	57IN HD Wing	4
MTS-CLAMP-ANGLE-4PK	Angle Clamp	3

### Rail Bill of Materials

Part	Qty
Rails (225in)	6
Rail Attachment	24
Module Mid Clamp	24
Module End Clamp	12
Ground Lug	3

## Site Details:



**Site Address:** County Rd 75, Colorado 81050, USA

### Array Specification

<b>Duty Classification:</b>	HD
<b>Module Width:</b>	45.00 in
<b>Module Length:</b>	68.00in
<b>Number of Rows:</b>	5
<b>Number of Columns:</b>	3
<b>Total Number of Modules:</b>	15
<b>Winter Tilt Angle:</b>	50
<b>Front Edge Clearance:</b>	6
<b>Total Array Height at Tilt:</b>	20.44 ft
<b>Total Frame Length:</b>	17.00 ft
<b>Frame Weight:</b>	1250 lbs
<b>Array Dimensions N/S:</b>	18.96 ft
<b>Array Dimensions E/W:</b>	17.25 ft
<b>Rail Length:</b>	227.50 in
<b>Rail Spacing:</b>	2.83 ft

### Support Specifications

<b>Pole Size:</b>	6in Pipe Sch 80
<b>Pole Length above Grade:</b>	13.26 ft
<b>Number of Poles:</b>	1
<b>Pole Spacing:</b>	0

### Foundation Specifications

<b>Foundation Type:</b>	Square
<b>Foundation Dimensions:</b>	48 x 48 in
<b>Foundation Depth (below grade):</b>	Pile 1: 6.75 ft
<b>Foundation Volume:</b>	4.000 y <sup>3</sup>

### Site Info

<b>Risk Category:</b>	I
<b>Exposure:</b>	C
<b>Soil Classification:</b>	sand
<b>Site Location:</b>	County Rd 75, Colorado 81050, USA
<b>Wind Speed:</b>	90 mph
<b>Snow Load:</b>	95 psf

### **Design Disclaimer**

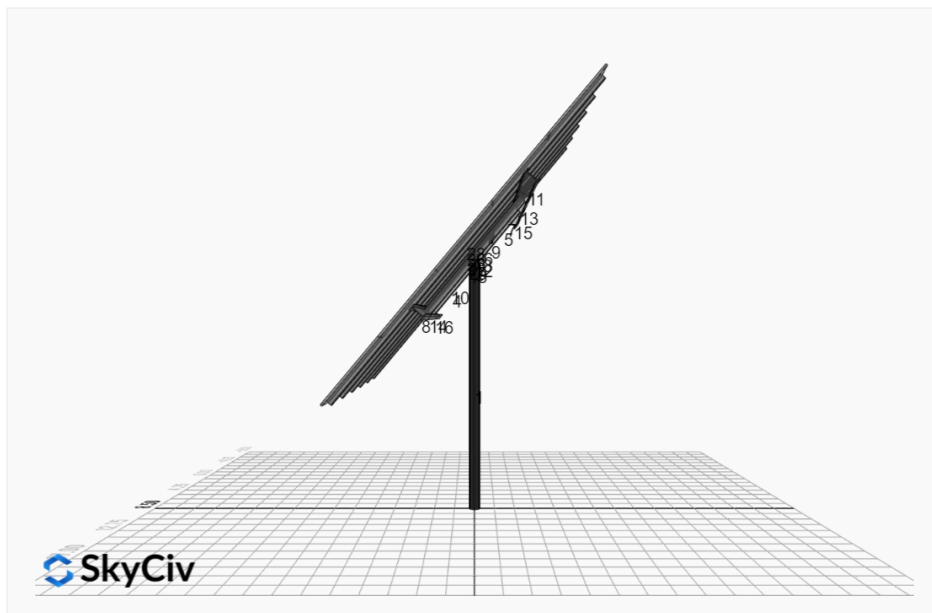
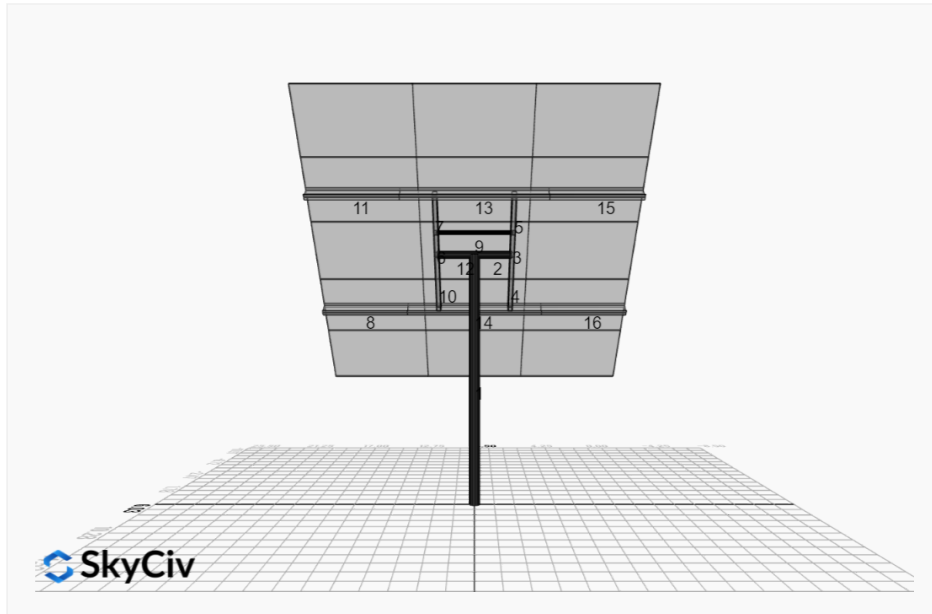
This software should be used for preliminary designs and should not be used as a final design unless reviewed, verified and designed by a qualified structural engineer.

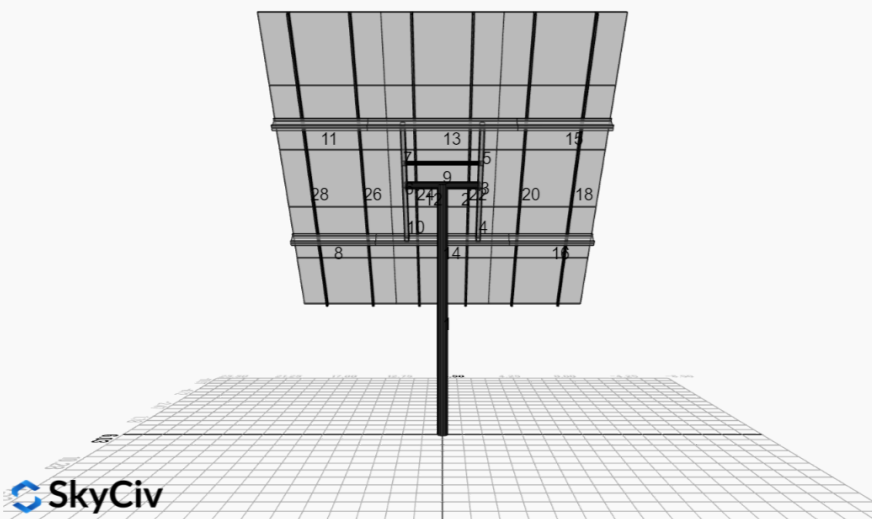
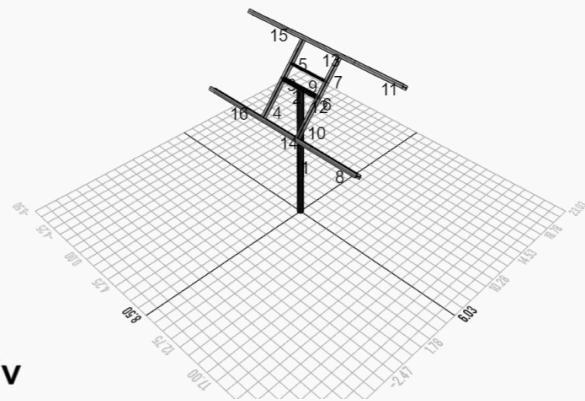
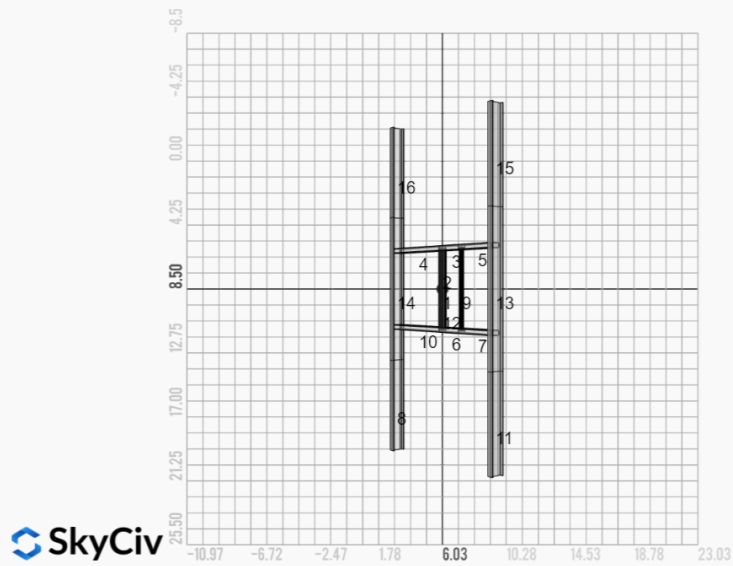
## AutoDesigner Input

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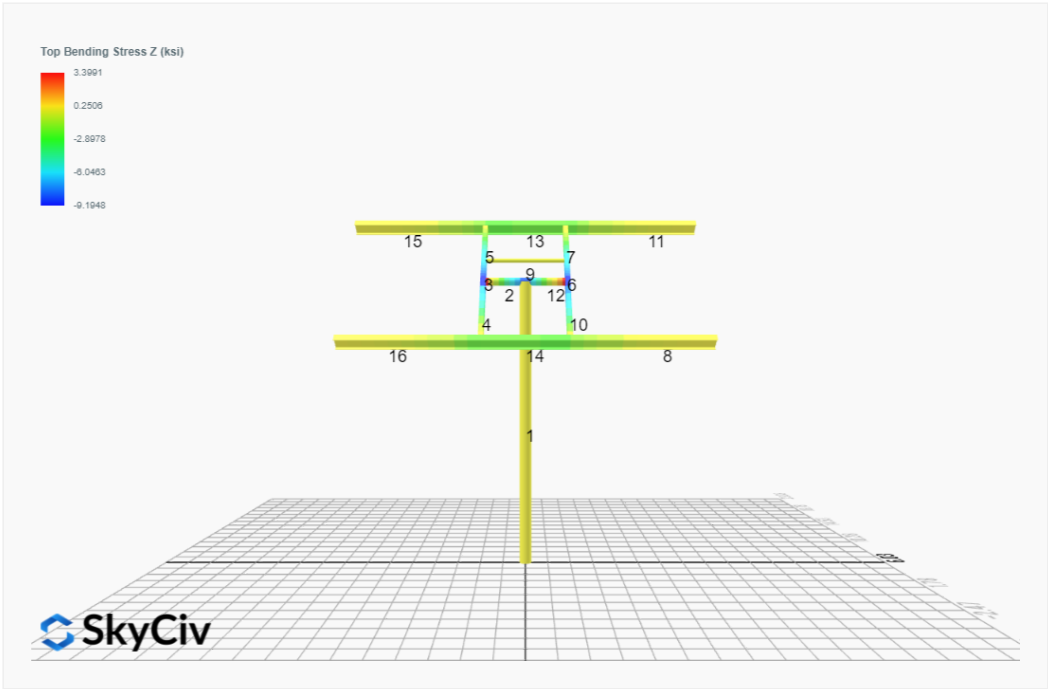
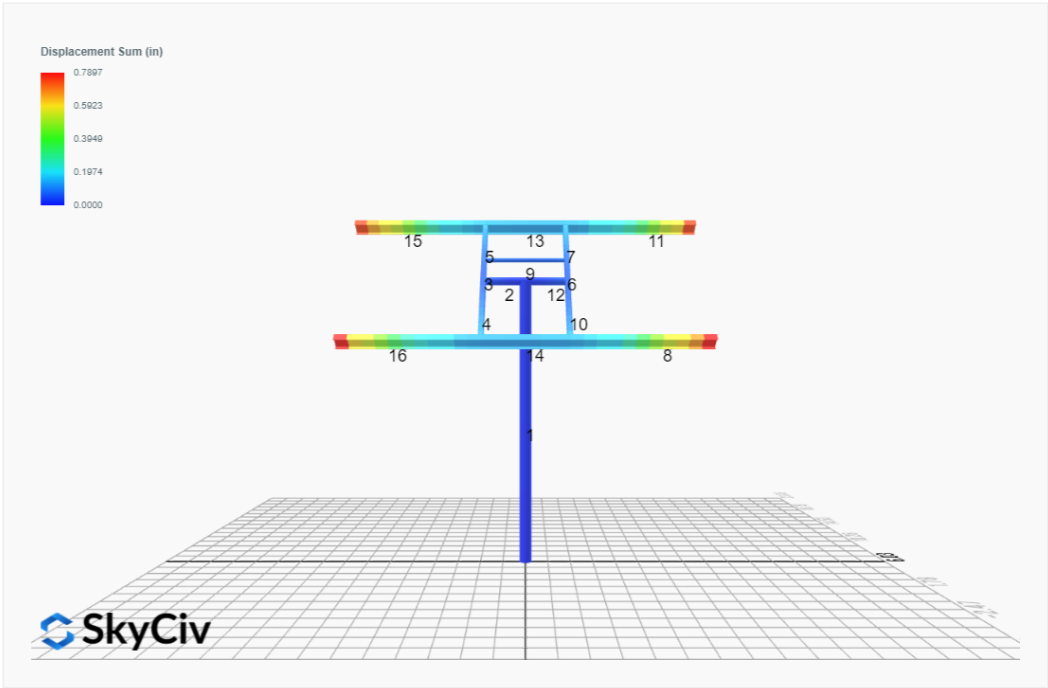
## Design Notes:

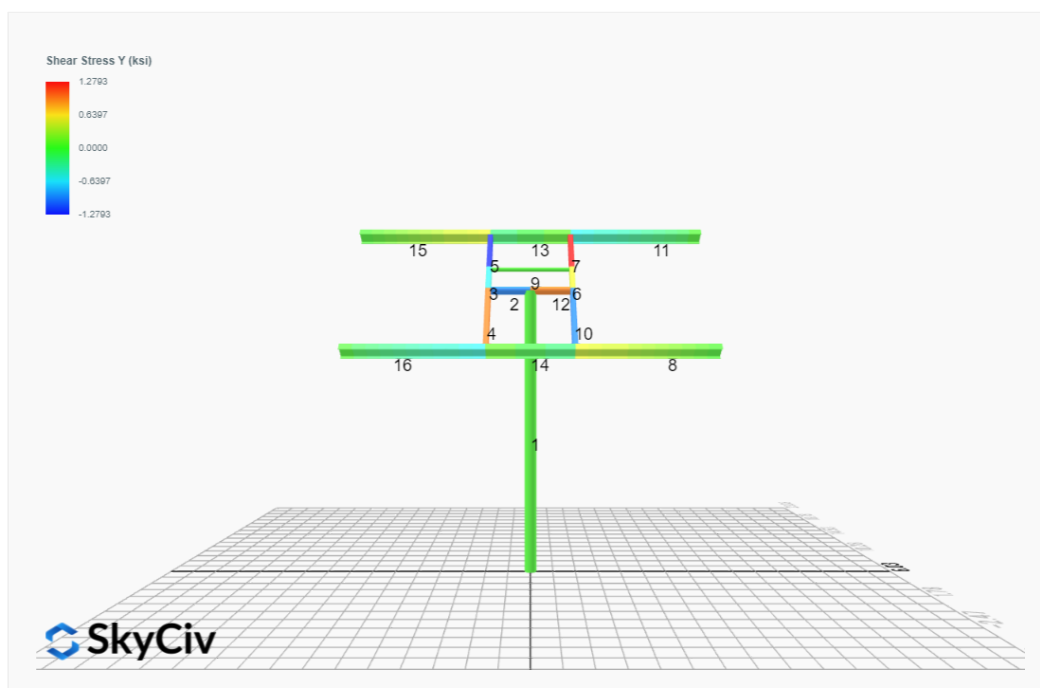
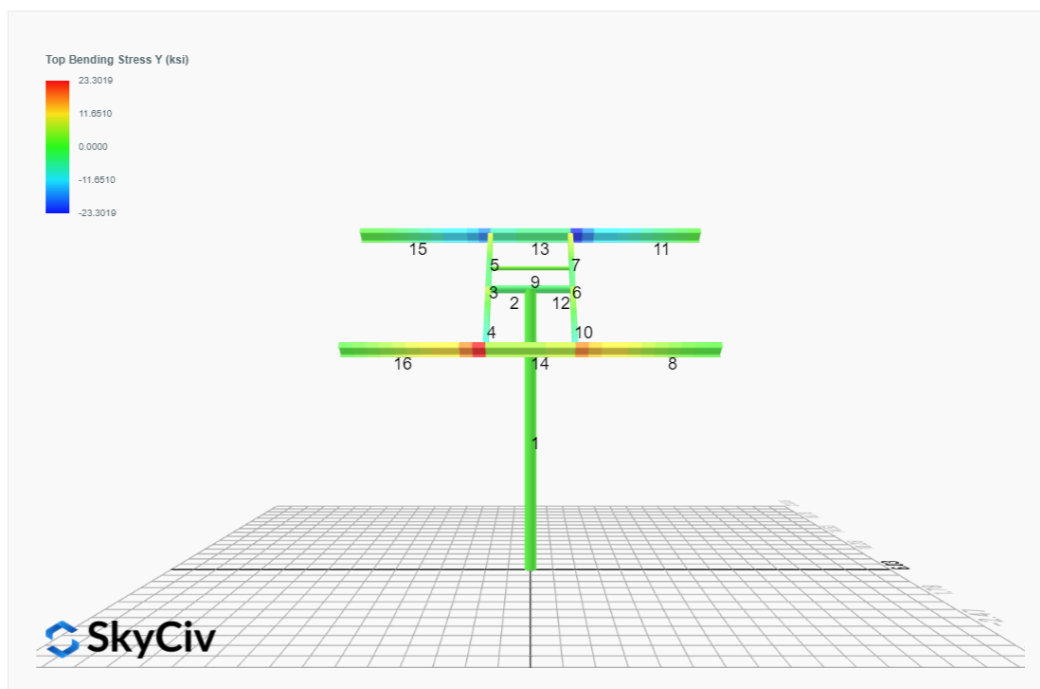
- AISC Deflection checks are set to L/1 due to structure design intent
- Foundation Soil Parameters used in this Autodesign are all estimates, proper geotechnical reports are required to confirm soil profiles
- Wind speeds, snow loads and other site specific results are based on ASCE 7 2016
- Steel frame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

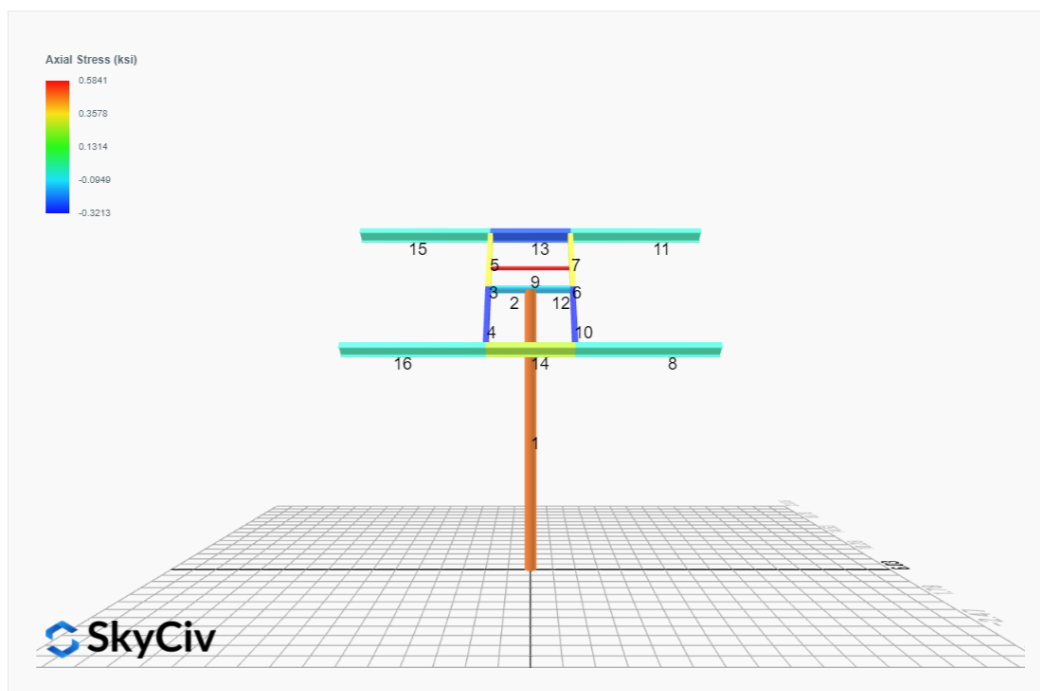




# FEM Results (Envelope Worst Case for each member)









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

### ASD Load Combination Results

Name	Fx	Fy	Fz	Mx	My	Mz
ULS: 1. D	0.0000	2.4216	0.0000	0.0000	-0.0000	0.0215
ULS: 2. D + L	0.0000	2.4216	0.0000	0.0000	-0.0000	0.0215
ULS: 3. D + (S or Lr or R)	0.0000	6.7500	0.0000	0.0000	-0.0000	0.0463
ULS: 3. D + (S or Lr or R)	0.0000	2.4216	0.0000	0.0000	-0.0000	0.0215
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	5.6679	0.0000	0.0000	-0.0000	0.0401
ULS: 4. D + 0.75L + 0.75(S or Lr or R)	0.0000	2.4216	0.0000	0.0000	-0.0000	0.0215
ULS: 5b. D + 0.7E	0.0000	2.4216	0.0000	0.0000	-0.0000	0.0215
ULS: 6b. D + 0.75L + 0.75(0.7)E + 0.75S	0.0000	5.6679	0.0000	0.0000	-0.0000	0.0401
ULS: 8. 0.6D + 0.7E	0.0000	1.4530	0.0000	0.0000	-0.0000	0.0129
ULS: 5a. D + 0.6W_Wind downforce Case A only	-2.1853	4.2554	0.0000	0.0000	-0.0000	29.6562
ULS: 5a. D + 0.6W_Wind downforce Case B only	0.0000	2.4216	0.0000	0.0000	-0.0000	0.0215
ULS: 5a. D + 0.6W_Wind uplift Case A only	2.1853	0.5879	0.0000	0.0000	-0.0000	-28.3387
ULS: 5a. D + 0.6W_Wind uplift Case B only	0.0000	2.4216	0.0000	0.0000	-0.0000	0.0215
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.6390	7.0432	0.0000	0.0000	-0.0000	22.2661
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0000	5.6679	0.0000	0.0000	-0.0000	0.0401
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.6390	4.2926	0.0000	0.0000	-0.0000	-21.2301
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0000	5.6679	0.0000	0.0000	-0.0000	0.0401
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case A only	-1.6390	3.7969	0.0000	0.0000	-0.0000	22.2475
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind downforce Case B only	0.0000	2.4216	0.0000	0.0000	-0.0000	0.0215
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case A only	1.6390	1.0464	0.0000	0.0000	-0.0000	-21.2487
ULS: 6a. D + 0.75L + 0.75(0.6)W + 0.75(S or Lr or R)_Wind uplift Case B only	0.0000	2.4216	0.0000	0.0000	-0.0000	0.0215
ULS: 7. 0.6D + 0.6W_Wind downforce Case A only	-2.1853	3.2867	0.0000	0.0000	-0.0000	29.6475
ULS: 7. 0.6D + 0.6W_Wind downforce Case B only	0.0000	1.4530	0.0000	0.0000	-0.0000	0.0129
ULS: 7. 0.6D + 0.6W_Wind uplift Case A only	2.1853	-0.3807	0.0000	0.0000	-0.0000	-28.3473
ULS: 7. 0.6D + 0.6W_Wind uplift Case B only	0.0000	1.4530	0.0000	0.0000	-0.0000	0.0129

### 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	11.3594
Shear X	-3.6422
Shear Z	0.0000
Moment X	0.0000
Moment Y (Twist)	0.0000
Moment Z	51.4346

### 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	7.0432
Shear X	-2.1853
Shear Z	0.0000
Moment X	0.0000
Moment Y (Twist)	0.0000
Moment Z	29.6562

Project Details

Design Code: AISC 360-16 LRFD  
Provision: LRFD  
Country: United States  
  
User Name: sales@mtsolar.us  
Project Name: Garvey  
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					
8	6in Pipe Sch 80	6.63	0.43					
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>vo</sub> (in <sup>4</sup> )	I <sub>zo</sub> (in <sup>4</sup> )	I <sub>w</sub> (in <sup>6</sup> )	S <sub>vo</sub> (in <sup>3</sup> )	S <sub>zo</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
8	6in Pipe Sch 80	8.40	80.98	40.49	40.49	0.00	16.60	16.60
16	HSS5x3x3/16	2.58	8.64	3.85	8.53	0.73	2.96	4.21
19	W8x10	2.96	0.04	2.09	30.80	30.90	1.66	8.87

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>	LS T	LS C	L D	
1	8	27.85	27.85	13.26	-	300	200	1	
2	5	1.30	1.30	2.00	-	300	200	1	
3	16	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.17,1.19,1.18,1.18,1.18,1.18,1.19,1.17,1.19,1.18,1.19,1.19	300	200	1	
4	16	2.44	2.44	3.75	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.68,1.67,1.67,1.68,1.64,1.68,1.67,1.68,1.66,1.68	300	200	1	
5	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.67,1.67,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68	300	200	1	
6	16	0.92	0.92	1.42	1.19,1.18,1.19,1.18,1.18,1.19,1.18,1.18,1.17,1.18,1.18,1.19,1.17,1.19,1.18,1.18,1.18,1.18,1.18,1.19,1.17,1.19,1.18,1.19,1.19	300	200	1	
7	16	1.52	1.52	2.33	1.68,1.67,1.68,1.67,1.67,1.68,1.67,1.67,1.66,1.67,1.67,1.68,1.66,1.68,1.67,1.67,1.67,1.67,1.67,1.68,1.65,1.68,1.67,1.68,1.66,1.68	300	200	1	
8	19	9.97	9.97	4.75	2.33,2.33	300	200	1	
9	2	2.60	2.60	4.00	-	300	200	1	
10	16	2.44	2.44	3.75	1.68,1.68,1.68,1.67,1.68,1.68,1.67,1.68,1.66,1.68,1.67,1.68,1.66,1.68,1.67,1.67,1.68,1.67,1.67,1.68,1.64,1.68,1.67,1.68,1.66,1.68	300	200	1	
11	19	9.97	9.97	4.75	2.33,2.33	300	200	1	
12	5	1.30	1.30	2.00	-	300	200	1	
13	19	4.88	4.00	7.50	1.03,1.03	300	200	1	
14	19	4.88	4.00	7.50	1.03,1.03	300	200	1	
15	19	9.97	9.97	4.75	2.33,2.33	300	200	1	
16	19	9.97	9.97	4.75	2.33,2.33	300	200	1	

## Member Design Capacity

Member ID	$\Phi_t P_n$ (kip)	$\Phi_c P_n$ (kip)	$\Phi_b M_{zn}$ (k-ft)	$\Phi_b M_{yn}$ (k-ft)	$\Phi_v V_{yn}$ (kip)	$\Phi_v V_{zn}$ (kip)
1	378.22	81.91	62.23	62.23	113.47	113.47
2	198.33	196.72	21.95	21.95	59.50	59.50
3	116.10	115.41	15.79	11.10	42.08	23.28
4	116.10	111.33	15.79	11.10	42.08	23.28
5	116.10	114.23	15.79	11.10	42.08	23.28
6	116.10	115.41	15.79	11.10	42.08	23.28
7	116.10	114.23	15.79	11.10	42.08	23.28
8	133.20	32.95	32.87	6.12	40.24	43.62
9	66.48	58.89	3.82	3.82	19.94	19.94
10	116.10	111.33	15.79	11.10	42.08	23.28
11	133.20	32.95	32.87	6.12	40.24	43.62
12	198.33	196.72	21.95	21.95	59.50	59.50
13	133.20	85.85	23.60	6.12	40.24	43.62

14	133.20	85.85	23.59	6.12	40.24	43.62
15	133.20	32.95	32.87	6.12	40.24	43.62
16	133.20	32.95	32.87	6.12	40.24	43.62

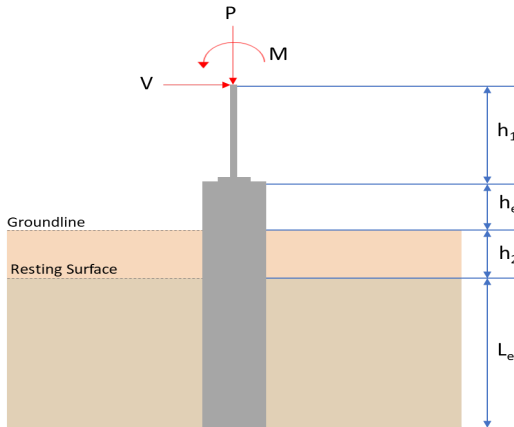
## Design Ratio

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	0.139	0.826	0.000	0.032	0.000	0.876	#13	0.761	Not Required	Pass
2	0.007	0.370	0.181	0.092	0.031	0.513	#21	0.035	Not Required	Pass
3	0.015	0.505	0.076	0.050	0.002	0.589	#21	0.045	Not Required	Pass
4	0.015	0.499	0.297	0.050	0.061	0.693	#21	0.080	Not Required	Pass
5	0.015	0.313	0.308	0.049	0.079	0.398	#21	0.074	Not Required	Pass
6	0.015	0.505	0.076	0.050	0.002	0.589	#21	0.045	Not Required	Pass
7	0.015	0.313	0.308	0.049	0.079	0.398	#21	0.074	Not Required	Pass
8	0.000	0.083	0.379	0.029	0.022	0.462	#21	Not Required	Not Required	Pass
9	0.030	0.029	0.056	0.001	0.000	0.095	#21	0.204	Not Required	Pass
10	0.015	0.499	0.297	0.050	0.061	0.693	#21	0.080	Not Required	Pass
11	0.000	0.083	0.379	0.029	0.022	0.462	#21	Not Required	Not Required	Pass
12	0.007	0.370	0.181	0.092	0.031	0.513	#21	0.035	Not Required	Pass
13	0.014	0.228	0.709	0.039	0.031	0.926	#21	0.190	Not Required	Pass
14	0.017	0.231	0.709	0.039	0.031	0.927	#21	0.190	Not Required	Pass
15	0.000	0.083	0.379	0.029	0.022	0.462	#21	Not Required	Not Required	Pass
16	0.000	0.083	0.379	0.029	0.022	0.462	#21	Not Required	Not Required	Pass

## Definitions

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



REFERENCES	CALCULATIONS	RESULTS																										
	<div>SkyCiv Foundation Design</div> <div>Pile Foundation</div> <div>Design Information :</div> <div>Design code : IBC 2021 (International Building Code)</div> <div>Unit System : Imperial</div>																											
	<div>Pile Input</div> <div></div> <div>Geometry</div> <div>Pile shape: rectangular</div> <div>b = 48 in - Pile width</div> <div>D = 48 in - Pile depth</div> <div>L = 6.75 ft - Total pile length</div> <div>h1 = 0 ft - Lateral load height from the top of the pile,</div> <div>h2 = 0 ft - Depth to resisting surface</div> <div>he = 0 ft - Length of pile above the ground</div> <div>Tabulation of Soil Parameters</div> <table><tr><th>Layer</th><th>Label</th><th>Allowable Bearing Pressure (qa) (psf)</th><th>Allowable Lateral Pressure (R) (psf/ft)</th></tr><tr><td>1</td><td>Sand, silty sand, clayey sand, silty gravel &amp; clayey gravel</td><td>2000.000</td><td>150.000</td></tr></table> <div>Tabulation of Loads</div> <table><tr><th>Load Component</th><th>ASD</th><th>LRFD</th></tr><tr><td>P (kip)</td><td>7.043</td><td>11.359</td></tr><tr><td>Vx (kip)</td><td>-2.185</td><td>-3.642</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>29.656</td><td>51.435</td></tr></table> <div>Material Properties</div> <div>f'ck = 2.5 ksi - Concrete strength,</div>	Layer	Label	Allowable Bearing Pressure (qa) (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)	7.043	11.359	Vx (kip)	-2.185	-3.642	Vz (kip)	0.000	0.000	Mx (kipft)	0.000	0.000	Mz (kipft)	29.656	51.435	
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	<div>Required depth to resist lateral loads (ASD)</div> <div>H - Point of application of the lateral load</div> <div><math display="block">H = h_1 + h_2 + h_e</math></div> <div><math display="block">H = (0 \text{ ft}) + (0 \text{ ft}) + (0 \text{ ft})</math></div> <div><math display="block">H = 0 \text{ ft}</math></div> <div>Considering x-direction:</div> <div>Ho - Lateral force per length of pile,</div> <div><math display="block">H_o = \frac{V_x}{1.57 \; D}</math></div> <div><math display="block">H_o = \frac{(-2.185 \text{ kip})}{1.57 \times (48 \text{ in})}</math></div> <div><math display="block">H_o = -0.34793 \text{ kip/ft}</math></div>																											

	<p><math>M_o</math> - Moment per length of pile,</p> $M_o = \frac{M_z + (V_x H)}{1.57 D}$ $M_o = \frac{(29.656 \text{ kipft}) + ((-2.185 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$ $M_o = 4.7223 \text{ kipft/ft}$ <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:  <math>L_{e,x} = 6.2729 \text{ ft}</math> - Required depth in x-direction,</p> <p><b>Considering z-direction:</b>  <math>L_{e,z} = 0 \text{ ft}</math> - Required depth in z-direction,</p> <p><b>Minimum embedded depth required:</b>  <math>L_{e,req}</math> - Depth of pile required,</p> $L_{e,req} = MAX[L_{e,x}, L_{e,z}]$ $L_{e,req} = MAX[(6.2729 \text{ ft}), (0 \text{ ft})]$ $L_{e,req} = 6.273 \text{ ft}$ <p><math>L_e</math> - Actual embedded length of pile,</p> $L_e = L - h_e - h_2$ $L_e = (6.75 \text{ ft}) - (0 \text{ ft}) - (0 \text{ ft})$ $L_e = 6.75 \text{ ft}$ <p>Ratio - Embedded depth</p> $Ratio = \frac{L_{e,req}}{L_e}$ $Ratio = \frac{(6.273 \text{ ft})}{(6.75 \text{ ft})}$ $Ratio = 0.92933$	<p>Status: <b>PASS</b> Ratio: <b>0.930</b></p>
	<p><b>End-bearing Capacity (ASD)</b>  <math>A</math> - Pile cross-section area</p> $A = b D$ $A = (48 \text{ in}) \times (48 \text{ in})$ $A = 16 \text{ ft}^2$ <p><math>q</math> - End-bearing pressure</p> $q = \frac{P_v}{A}$ $q = \frac{(7.043 \text{ kip})}{(16 \text{ ft}^2)}$ $q = 0.44019 \text{ kip/ft}^2$ <p><b>Check bearing capacity ratio:</b>  Ratio - Capacity</p> $Ratio = \frac{q}{q_a}$ $Ratio = \frac{(0.44019 \text{ kip/ft}^2)}{(2000 \text{ psf})}$ $Ratio = 0.22009$	<p>Status: <b>PASS</b> Ratio: <b>0.220</b></p>
Czerniak	<p><b>Lateral Soil Pressure (ASD):</b>  <math>L/D</math> - Length to least lateral dimension ratio,</p>	

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

$$L/D = \frac{(6.75 \text{ ft})}{(48 \text{ in})}$$

$$L/D = 1.6875$$

Since  $L/D \leq 10$ ,

Pile is short.

#### Considering x-direction:

$H_o = -0.34793 \text{ kip/ft}$  - Lateral force per length of pile,

$M_o = 4.7223 \text{ kipft/ft}$  - Overturning moment per length of pile,

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

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

$$a = \frac{(4 \times (4.7223 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.34793 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (4.7223 \text{ kipft/ft})) + (4 \times (-0.34793 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.6401 \text{ ft}$$

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

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

$$p = \frac{0.75 \times [(4 \times (4.7223 \text{ kipft/ft})) + (3 \times (-0.34793 \text{ kip/ft}) \times (6.75 \text{ ft}))]^2}{(6.75 \text{ ft})^2 \times [(3 \times (4.7223 \text{ kipft/ft})) + (2 \times (-0.34793 \text{ kip/ft}) \times (6.75 \text{ ft}))]}$$

$$p = 0.24383 \text{ kip/ft}^2$$

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

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

$$s = \frac{6 \times [(2 \times (4.7223 \text{ kipft/ft})) + ((-0.34793 \text{ kip/ft}) \times (6.75 \text{ ft}))]}{(6.75 \text{ ft})^2}$$

$$s = 0.93446 \text{ kip/ft}^2$$

#### Check lateral soil pressure capacity:

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

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

$$p_a = (150 \text{ psf/ft}) \times \frac{(4.6401 \text{ ft})}{2}$$

$$p_a = 0.348 \text{ kip/ft}^2$$

Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.24383 \text{ kip/ft}^2)}{(0.348 \text{ kip/ft}^2)}$$

$$\text{Ratio} = 0.70064$$

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

$$p_s = R L_e$$

$$p_s = (150 \text{ psf/ft}) \times (6.75 \text{ ft})$$

$$p_s = 1.0125 \text{ kip/ft}^2$$

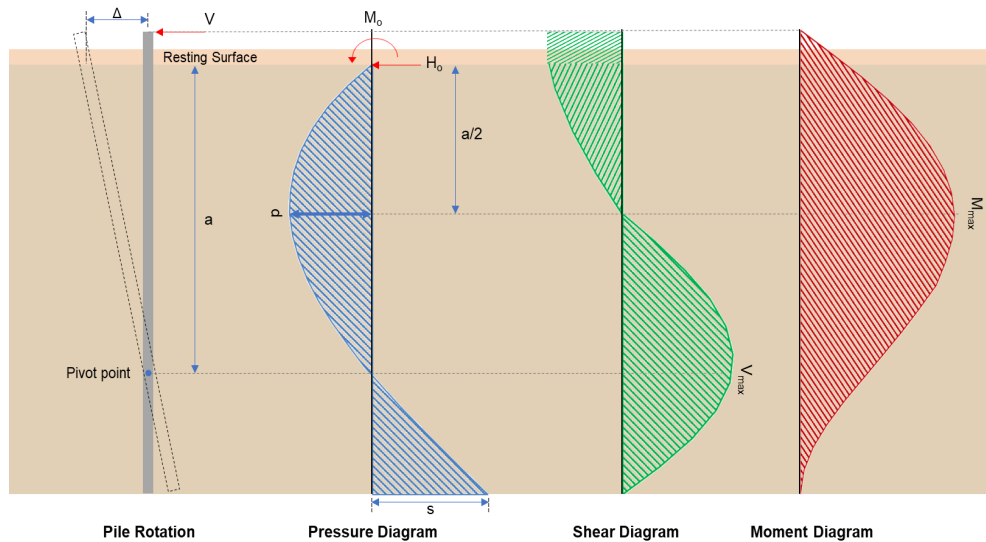
Ratio - Lateral soil capacity

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

$$\text{Ratio} = \frac{(0.93446 \text{ kip/ft}^2)}{(1.0125 \text{ kip/ft}^2)}$$

Status: **PASS**  
Ratio: **0.700**





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

 $H_o$  - Lateral force per length of pile,

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

$$H_o = \frac{(-3.642 \text{ kip})}{1.57 \times (48 \text{ in})}$$

$$H_o = -0.57994 \text{ kip/ft}$$

$M_o$  - Moment per length of pile,

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

$$M_o = \frac{(51.435 \text{ kipft}) + ((-3.642 \text{ kip}) \times (0 \text{ ft}))}{1.57 \times (48 \text{ in})}$$

$$M_o = 8.1903 \text{ kipft/ft}$$

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

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

$$E = \frac{(8.1903 \text{ kipft/ft})}{(-0.57994 \text{ kip/ft})}$$

$$E = 14.123 \text{ ft}$$

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

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

$$a = \frac{(4 \times (8.1903 \text{ kipft/ft}) \times (6.75 \text{ ft})) + (3 \times (-0.57994 \text{ kip/ft}) \times (6.75 \text{ ft})^2)}{(6 \times (8.1903 \text{ kipft/ft})) + (4 \times (-0.57994 \text{ kip/ft}) \times (6.75 \text{ ft}))}$$

$$a = 4.6359 \text{ ft}$$

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

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

$$V_{max} = ((-0.57994 \text{ kip/ft}) \times (48 \text{ in})) \times \left[ 1 - \left[ 3 \times \left( \frac{4 \times (14.123 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left( \frac{(4.6359 \text{ ft})}{(6.75 \text{ ft})} \right)^2 \right] \right. \\ \left. + \left[ 4 \times \left( \frac{3 \times (14.123 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left( \frac{(4.6359 \text{ ft})}{(6.75 \text{ ft})} \right)^3 \right] \right]$$

	$v_{max} = 10.14 \text{ kip}$ <p><math>M_{max}</math> - Max bending moment located at depth <math>a/2</math>,</p> $M_{max} = (H_o D L_e) \left[ \left( \frac{E}{L_e} + \frac{a}{2 L_e} \right) - \left[ \left( \frac{4 E}{L_e} + 3 \right) \left( \frac{a}{2 L_e} \right)^3 + \left[ \left( \frac{3 E}{L_e} + 2 \right) \left( \frac{a}{2 L_e} \right)^4 \right] \right] \right]$ $M_{max} = ((-0.57994 \text{ kip/ft}) \times (48 \text{ in}) \times (6.75 \text{ ft})) \times \left[ \left( \frac{(14.123 \text{ ft})}{(6.75 \text{ ft})} + \frac{(4.6359 \text{ ft})}{2 \times (6.75 \text{ ft})} \right) - \left[ \left( \frac{4 \times (14.123 \text{ ft})}{(6.75 \text{ ft})} + 3 \right) \times \left( \frac{(4.6359 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^3 + \left[ \left( \frac{3 \times (14.123 \text{ ft})}{(6.75 \text{ ft})} + 2 \right) \times \left( \frac{(4.6359 \text{ ft})}{2 \times (6.75 \text{ ft})} \right)^4 \right] \right] \right]$ $M_{max} = 32.731 \text{ kipft}$	
<p>Table 22.4.2.1</p> <p>22.4.2.2, 10.6.1.1</p>	<p><b>Minimum Reinforcement Check (LRFD)</b></p> <p><b>Parameters:</b></p> <p><math>f'_{ck} = 2.5 \text{ ksi}</math> - Concrete strength,  <math>f_{yk} = 60 \text{ ksi}</math> - Longitudinal reinforcement strength,  <math>\phi = 0.65</math> - Reduction factor for axial strength,  <math>\alpha = 0.8</math> - Alpha factor for axial strength,  <math>A_g = 2304 \text{ in}^2</math> - Gross area of concrete,</p> <p><b>Longitudinal reinforcement:</b></p> <p>Required reinforcement due to axial load, <math>A_{st,required}</math></p> $A_{st,required} = \text{Min} \left[ \frac{\frac{P}{\phi \alpha} - (0.85 f'_{ck} A_g)}{f_{yk} - (0.85 f'_{ck})}, (0.08 A_g) \right]$ $A_{st,required} = \text{Min} \left[ \frac{\frac{(11.359 \text{ kip})}{(0.65) \times (0.8)} - (0.85 \times (2.5 \text{ ksi}) \times (2304 \text{ in}^2))}{(60 \text{ ksi}) - (0.85 \times (2.5 \text{ ksi}))}, (0.08 \times (2304 \text{ in}^2)) \right]$ $A_{st,required} = -84.219 \text{ in}^2$ <p><math>A_{min}</math> - Governing minimum reinforcement area,</p> $A_{min} = \text{Max} [A_{st,required}, (0.0018 A_g)]$ $A_{min} = \text{Max} [(-84.219 \text{ in}^2), (0.0018 \times (2304 \text{ in}^2))]$ $A_{min} = 4.1472 \text{ in}^2$ <p><math>n_{rebar}</math> - Required number of reinforcement,</p> $n_{rebar} = \frac{A_{min}}{A_{rebar}}$ $n_{rebar} = \frac{(4.1472 \text{ in}^2)}{(0.3068 \text{ in}^2)}$ $n_{rebar} = 14$ <p><math>A_{st}</math> - Actual total reinforcement area,</p> $A_{st} = n_{rebar} \frac{\pi d_{bar}^2}{4}$ $A_{st} = (14) \times \frac{\pi \times (0.625 \text{ in})^2}{4}$ $A_{st} = 4.2951 \text{ in}^2$ <p><b>Ratio</b> - Capacity</p> $\text{Ratio} = \frac{A_{min}}{A_{st}}$ $\text{Ratio} = \frac{(4.1472 \text{ in}^2)}{(4.2951 \text{ in}^2)}$ $\text{Ratio} = 0.96556$ <p>25.2.3 <math>s_{rebar}</math> - Minimum spacing of reinforcement,</p> $s_{rebar} = \text{Max} [1.5, (1.5 d_{bar})]$	<p>Status: <b>PASS</b> Ratio: <b>0.970</b></p>



$$V_{c,a} = \left[ 2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + \frac{(11359 \text{ lbf})}{6 \times (2304 \text{ in}^2)} \right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,a} = 120 \text{ kip}$$

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

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

$$V_{c,b} = \left[ 2 \times (0.64282) \times \sqrt{(2500 \text{ psi})} + (0.05 \times (2500 \text{ psi})) \right] \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{c,b} = 348.89 \text{ kip}$$

$V_c$  - Governing shear strength of concrete

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

$$V_c = \text{Min}[(296.21 \text{ kip}), (120 \text{ kip}), (348.89 \text{ kip})]$$

$$V_c = 120 \text{ kip}$$

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

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

$$V_{s,a} = 8 \times \sqrt{(2500 \text{ psi})} \times (48 \text{ in}) \times (38.4 \text{ in})$$

$$V_{s,a} = 737.28 \text{ kip}$$

$A_v$  - Ties rebar area,

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

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

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

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

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

$$V_{s,b} = \frac{2 \times (0.11045 \text{ in}^2) \times (60 \text{ ksi}) \times (38.4 \text{ in})}{(10 \text{ in})}$$

$$V_{s,b} = 50.894 \text{ kip}$$

$V_s$  - Governing shear strength of steel

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

$$V_s = \text{MIN}[(737.28 \text{ kip}), (50.894 \text{ kip})]$$

$$V_s = 50.894 \text{ kip}$$

22.5.1.1  $\phi V_n$  - Allowable shear strength

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

$$\phi V_n = (0.65) \times ((120 \text{ kip}) + (50.894 \text{ kip}))$$

$$\phi V_n = 111.08 \text{ kip}$$

**Considering x-direction:**

$V_{max} = 10.12 \text{ kip}$  - Maximum shear force in the x-direction,

$Ratio$  - Capacity

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

$$Ratio = \frac{(10.12 \text{ kip})}{(111.08 \text{ kip})}$$

$$Ratio = 0.091109$$

Status: **PASS**  
Ratio: **0.090**

**Flexural Strength (ACI 318-19, LRFD)**

$S_m$  - Section modulus

$$S_m = \frac{b D^2}{6}$$

$$S_m = \frac{(48 \text{ in}) \times (48 \text{ in})^2}{6}$$

$$S_m = 18432 \text{ in}^3$$

$\lambda = 1$  - Concrete modification factor (Normal concrete),

Allowable flexural strength:

$M_n$  shall be the lesser of:

$\phi M_{n,1}$

$$\phi M_{n,1} = \phi \times 5 \times \lambda \times \sqrt{f'_c} \times S_m$$

$$\phi M_{n,1} = 0.65 \times 5 \times 1 \times \sqrt{2.5 \text{ ksi}} \times 18432.001 \text{ in}^3$$

$$\phi M_{n,1} = 249.600 \text{ kipft}$$

14.5.2.1b

$\phi M_{n,2}$

$$\phi M_{n,2} = \phi \times 0.85 \times f'_c \times S_m$$

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

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

Therefore,

$\phi M_n$  - Allowable flexural strength,

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

$$\phi M_n = \text{MIN}[(249.6 \text{ kipft}), (2121.6 \text{ kipft})]$$

$$\phi M_n = 249.6 \text{ kipft}$$

**Considering x-direction:**

$M_{max} = 32.731 \text{ kipft}$  - Maximum moment in the x-direction,

Ratio - Capacity

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

$$\text{Ratio} = \frac{(32.731 \text{ kipft})}{(249.6 \text{ kipft})}$$

$$\text{Ratio} = 0.13114$$

Status: **PASS**  
Ratio: **0.130**