Structural Calculations

Model SCT-3706-LJR (WTU12-06)

Ojai, CA 93023

PREPARED FOR

One Clarion

January 15, 2021

Designed in Accordance With
ASCE 7-16
2019 CBC
AWWA D103-19
AISI S100-2007

Customer's signature below indicates they have reviewed the design criteria of the tank described herein and thereby grant their approval to proceed with manufacturing per the design requirements determined by these calculations.

Print Name: _____ Signature: _____

Date: _____

Table of Contents

Tank Model	Model SCT-3706-LJR (WTU12-06)		
Design Criteria:	2018 IBC, AWWA D103-19, ASCE 7-16, CBC 2019 CBC-2019		
Tank Diameter	37.12	(ft)	
Tank Eave Height	21.31	(ft)	
Roof Pitch	10	(deg)	
Contents	Rain Water		
Fluid Density	62.4	(pcf)	
Roof Dead Load	5.186	(psf)	
Ground Snow Load	0	(psf)	
Wind Exposure	C		
Ulitmate Wind Speed	110	(mph)	
City	Ojai		
County	Ventura		
State or Province	CA		
Site Latitude	34.4649800		
Site Longitude	-119.1855400		
Soil Site Class	D		
Risk Category	II		Per AWWA D103-19 5.2.1
Ss (0.2 second period)	1.825		
S1(1 second period)	0.699		
Tank Dead Weight	13097	(lb)	
Capacity	21784	(cuft)	
	162955	(gal)	
Weight Tank+Contents	1372413	(lb)	
Materials			
Tank Stackup			
1	18	GA	
2	18	GA	
3	17	GA	
4	14	GA	
5	13	GA	
6	12	GA	

Roof Sheet thickness	22	GA
Washers at Roof sheet base	No	
Stiffeners/Anchors per sheet	3	**Mechanically anchored**
Floor	No	

All Galvanized Steel conform to ASTM A653 and the Galvanized coating to A924, Type G115; 1.15 oz/sqft total for both sides

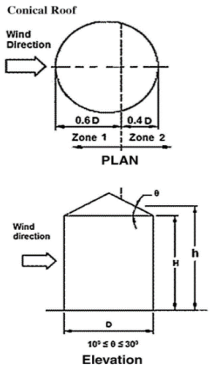
22 ga Thickness and lighter - CS Type A: 33 ksi min Yield (grade 320

18 & 20 ga thickness = SS Grade 40 Class I; 40 ksi Min yield (grade 275)
17 Ga thickness and heavier = SS Grade 55, Class I; 55 ksi min yield (grade 340)
Ladder included per AWWA D103-19 7.4.1
Shell Manhole included per AWWA D103-19 7.1 and designed per API 650

Design Criteria

Project Name	Thacher High School					
Tank Size						
Floor (Y/N)	N					
Sheets per ring	12	(#)				
Sheet Length	116.625	(in)				
Diameter	37.12	(ft)	37	(ft)	1.44	(in)
Sheets high	6					
Sheet Height	42.43	(in)				
Eve ht	21.31	(ft)	21	(ft)	3.693	(in)
Min Freeboard	14.14	(in)				
Anchors/Sheet	3	Mechanically anchored				
Fluid Depth	20.13	(ft)				
Capacity	21784	(ft^3)				
	162955	(gal)				
Usable Capacity (less 16in fluid depth)	20341	(ft^3)				
	152161	(gal)				
Roof						
Roof Style	J-Rib					
Roof Angle	10	DEG				
Peak Ring Diameter	40					
Tank Use						
Tank Content	Rain Water					
Specific Gravity	1					
Fluid Density	62.4	(pcf)				
Contents Temp Range	Ambient					
24" Access Panel	1					
Manway	24 Inch Manway					
Manway Qty.	1					
Site location						
Site Latitude	34.46498					
Site Longitude	-119.18554					
Soil Site Class	D					
S_s (0.2 second period)	1.825					
S_1(1 second period)	0.699					
S_{MS} (0.2 second period)	1.825					
S_{M1} (1 second period)	1.049					
S_{DS} (0.2 Second Period)	1.217					
S_{D1} (one second Period)	0.699					
Region-dependent transition period for longer-period ground motion (Figure 17 AWWA D103-09 14.2.7.3.1)T_L	8					
Seismic Zone	N/A					
Design National Building Code	CBC-2019					
City	Ojai					
County	Ventura					
State or Province	CA					
Country	USA					
Zip or Postal Code	93023					
Risk Category	II	(I, II, III, IV) - Per AWWA D103-19				
Ultimate Wind Speed	110	(mph)				
Wind Exposure Class	C					
Ground Snow Load	0	(psf)				
Is Snow Load Reducible	N	(Y\N)				
Design to NFPA-22	N	(Y\N)				

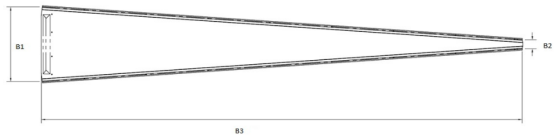
Roof Design Criteria			
Diameter	37.12	(ft)	
Roof Angle	10	(deg)	
Live Roof Load	15	(lb/ft^2)	AWWA D103-19 5.2.5
Roof Weight Estimate	5.6	(kip)	
Dead Load	5.2	(lb/ft^2)	
Exposure factor, C_e	0.9		AWWA D103-19 5.2.4.2/ASCE 7-16 7.3-1
Thermal Factor, C_t	1.2		AWWA D103-19 5.2.4.2/ASCE 7-16 7.3-2
Importance Factor Snow, I_s	1		AWWA D103-19 5.2.4.2
Flat Roof Snow Load, pf = $0.7C_eC_tI_sp_g$	0	(psf)	AWWA D103-19 5.2.4.2/ASCE 7-16 7.3-1
Roof Slope Factor, Cs	1		AWWA D103-19 5.2.4.3
Sloped Roof Snow Load, p_s	0.0	(lb/ft^2)	AWWA D103-19 5.2.4.4/ASCE 7-16 7.3.4/7.4
Basic Wind Speed, V	110.0	(mph)	ASCE 7-16
Directional Factor, K_d	1.00		ASCE 7-16 Table 26.6-1
Wind Exposure Class	C		ASCE 7-16 26.7.2
Topographic Factor $K_{zt}=(1 + K_1K_2K_3)^2$	1.00		ASCE 7-16 26.8.2
Gust Factor	0.85		ASCE 7-16 26.11.1
Roof mean height, h	22.8	(ft)	
Velocity Pressure Exposure Factor, K_z	0.93		AWWA D103-19 Table 8/ASCE 7-16 Table 26.10-1
Strength Level-to-Service Level Factor,λ_w	0.60		AWWA D103-19 15.1.1.5
Velocity Pressure, $q_h=\lambda_w(0.00256*K_z*K_{zt}*K_d*V^2)$	17.24	(psf)	AWWA D103-19 15.1.1.5/ASCE 7-16 26.10-1
Roof Height/Diameter, l/d	0.08		
Depth of protruding elements, D'	0.33	(ft) 4" rib	
$D(q_z)^{0.5}$	154		ASCE 07-16 Figure 29.4-1
D'/D	0.009		
Type of Surface	Moderately Smooth		
Force Coefficient, Cf	0.48		AWWA D103-19 Table 9
Internal Pressure Coefficient, (GC_{pi})	0.18		ASCE 7-16 Table 26.13-1
Wind Load Case 1, $p_{C1}=q_z*G*C_f >= 30C_f$	14.54	(psf)	AWWA D103-19 15.1.1.6
External Pressure Coefficient Zone 1, C_p	-0.8		ASCE 7-16 Figure 29.4-5
Net Design Pressure on Roof Case 1 Zone 1, $p = q_h(GC_p - (GC_{pi}))$	-14.8	(psf)	ASCE 7-16 29.4-4
Net Design Pressure on Roof Case 2 Zone 1, $p = q_h(GC_p + (GC_{pi}))$	-8.6	(psf)	ASCE 7-16 29.4-4
Max Net Design Pressure Zone 1	-14.8	(psf)	
External Pressure Coefficient Zone 2, C_p	-0.5		ASCE 7-16 Figure 29.4-5
Net Design Pressure on Roof Case 1 Zone 2, $p = q_h(GC_p - (GC_{pi}))$	-10.4	(psf)	ASCE 7-16 29.4-4
Net Design Pressure on Roof Case 2 Zone 2, $p = q_h(GC_p + (GC_{pi}))$	-4.2	(psf)	ASCE 7-16 29.4-4
Max Net Design Pressure Zone 2	-10.4	(psf)	
Number of purlin rings	2	(#)	
Distance from peak ring to 1st purlin, LP1	122.0	(in)	
Distance from purlin 1 to purlin 2, LP2	92.0	(in)	
Distance from purlin 2 to eave, LP3	-3.2	(in)	
Peak ring diameter, Dp	3.3	(ft)	
Diameter at purlin 1, Dp1	23.4	(ft)	
Diameter at purlin 2, Dp2	38.5	(ft)	
Diameter at eave, Dp3	37.9	(ft)	
Projected Area between peak ring and 1st purlin, Ap1	420	(ft^2)	
Projected area between purlin 1 and purlin 2, Ap2	733	(ft^2)	
Projected area between purlin 2 and eave, Ap3	-31	(ft^2)	
Area between peak ring and 1st purlin for wind, A1	426	(ft^2)	
Area between purlin 1 and purlin 2 for wind, A2	744	(ft^2)	
Area between purlin 2 and eave, A3	-32	(ft^2)	
Circumference peak ring, Cpr	10	(ft)	
Circumference purlin 1, Cp1	73	(ft)	
Circumference purlin 2, Cp2	121	(ft)	
Circumference eave, Cp3	119	(ft)	

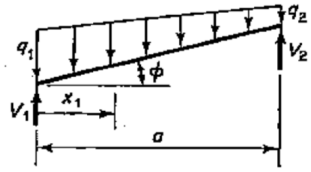


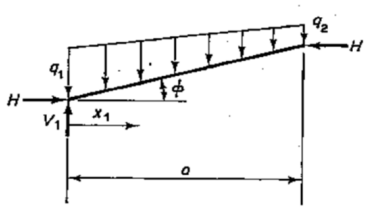
		Dead	Live Roof	Snow	Wind Case 1	Wind Case 2 Zone 1	Wind Case 2 Zone 2
Peak Ring	(kip/ft)	0.030	0.088	0.000	0.086	-0.088	-0.062
Purlin 1	(kip/ft)	0.046	0.132	0.000	0.130	-0.132	-0.093
Purlin 2	(kip/ft)	0.019	0.055	0.000	0.054	-0.055	-0.039
Eave	(kip/ft)	-0.001	-0.002	0.000	-0.002	0.002	0.001

Rafter

Width B1	29.16	(in)		
Width B2	2.62	(in)		
Length B3 (D/2-D,/2)/cos(ϕ)+5	211	(in)	17.57	(ft)
a	202.7	(in)	16.893	(ft)
b	36.6	(in)	3.051	(ft)





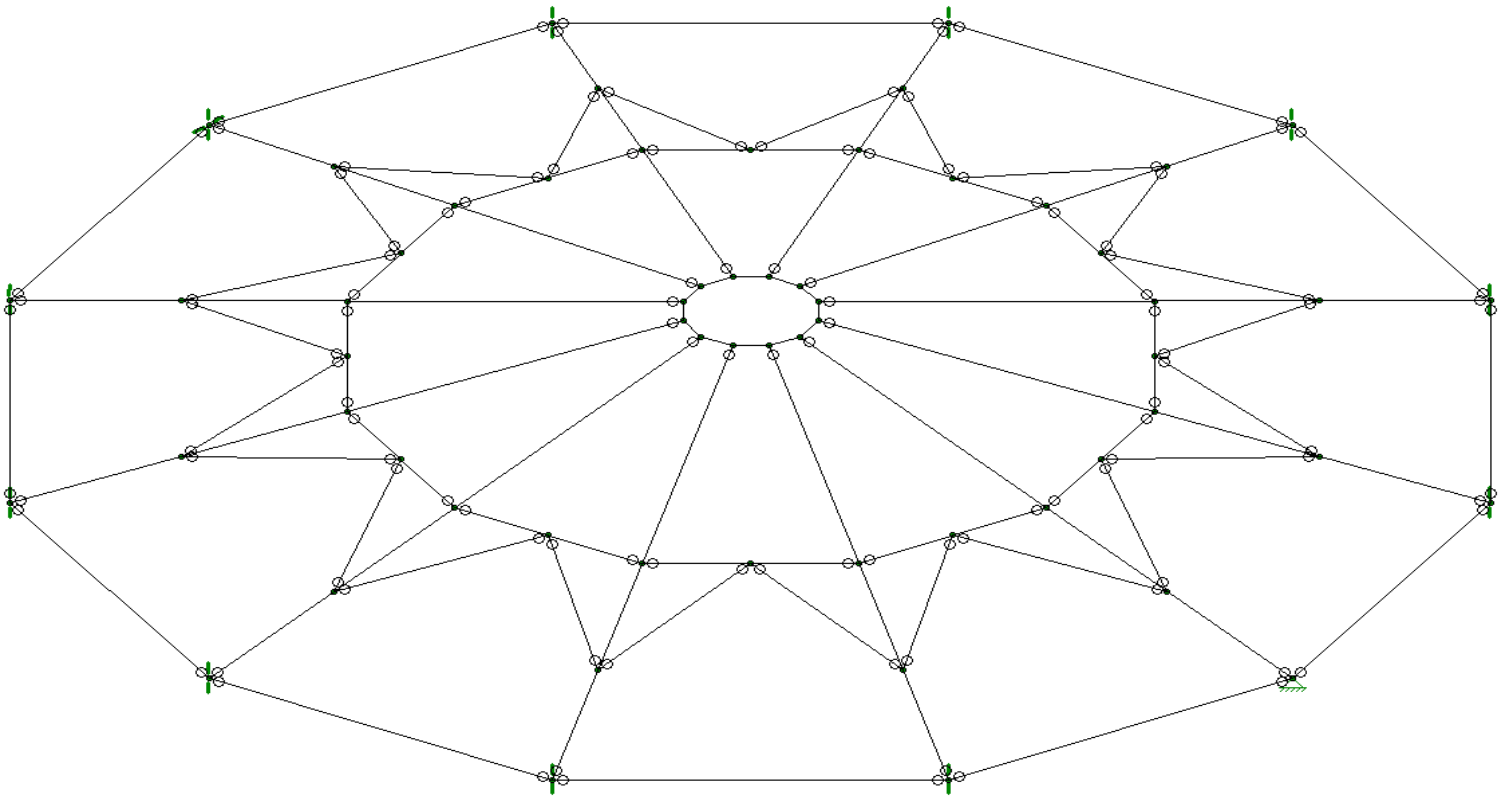


Roof loading From Risa Model max loads (Using Risa Sign Convention)

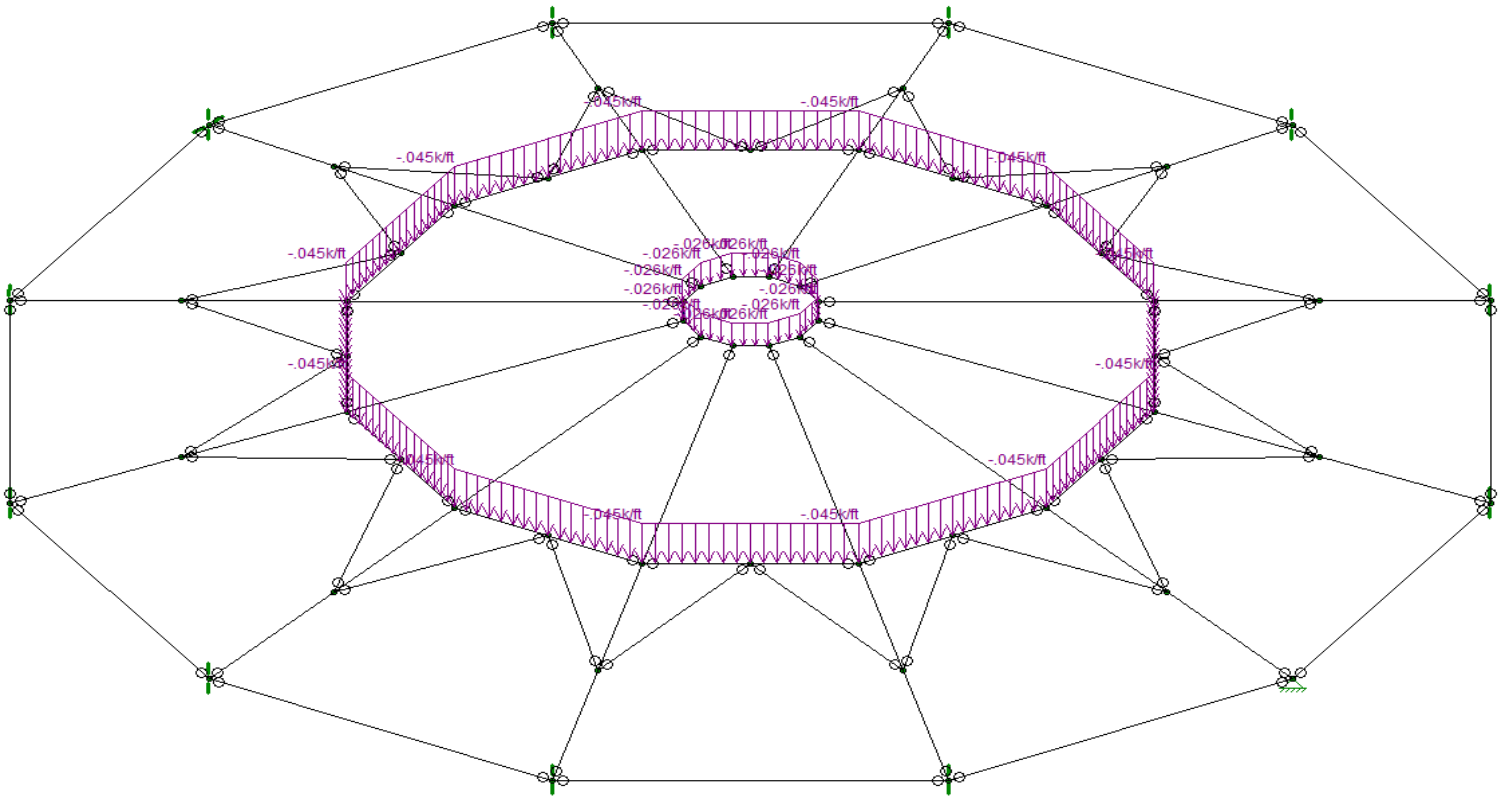
	Peak Ring	Upper Purlin ring	Lower Purlin ring	Eave Tension Member	Rafter	
Controlling Member		48	57	77	2	
Load Case		8	8	17	8	
Compression		12.626	4.74		9.926	(kip)
Tension						(kip)
Moment Y			-0.143		-0.02	(kip-ft)
Moment X		0.5	-1.244		-4.851	(kip-ft)
Shear Y		-0.474			-0.769	(kip-ft)
Shear X		0.058			0.015	(kip)
	AT 5.176" (OAL 10.353")	At 54.237" (OAL 54..237")	At 42.848" (OAL 85.696")		At 214.417" from peak	
	At wall					
Reaction per Rafter (down)	1.12	V	(kip)			
Reaction Total	13.46	V	(kip)			

Peak Ring-> See CFS sheets	CS18x1.75x10	OK
Purlin Ring-> See CFS sheets	C8x3x14	OK
Eave Tension Member-> See CFS sheets	CS08x2.5x12	OK
Rafter-> See CFS sheets	C10x3x12	OK

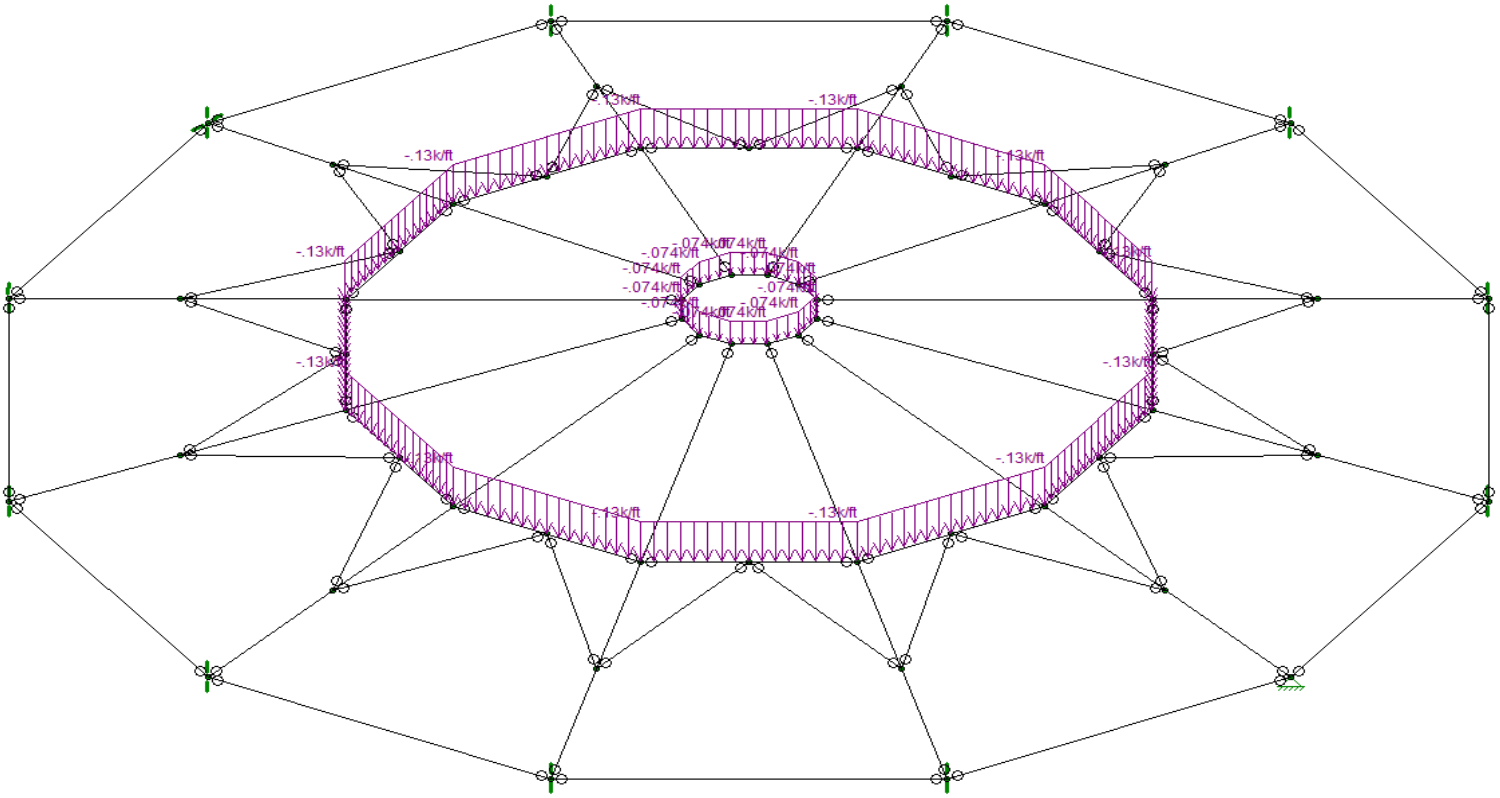
RISA Model - No Loads



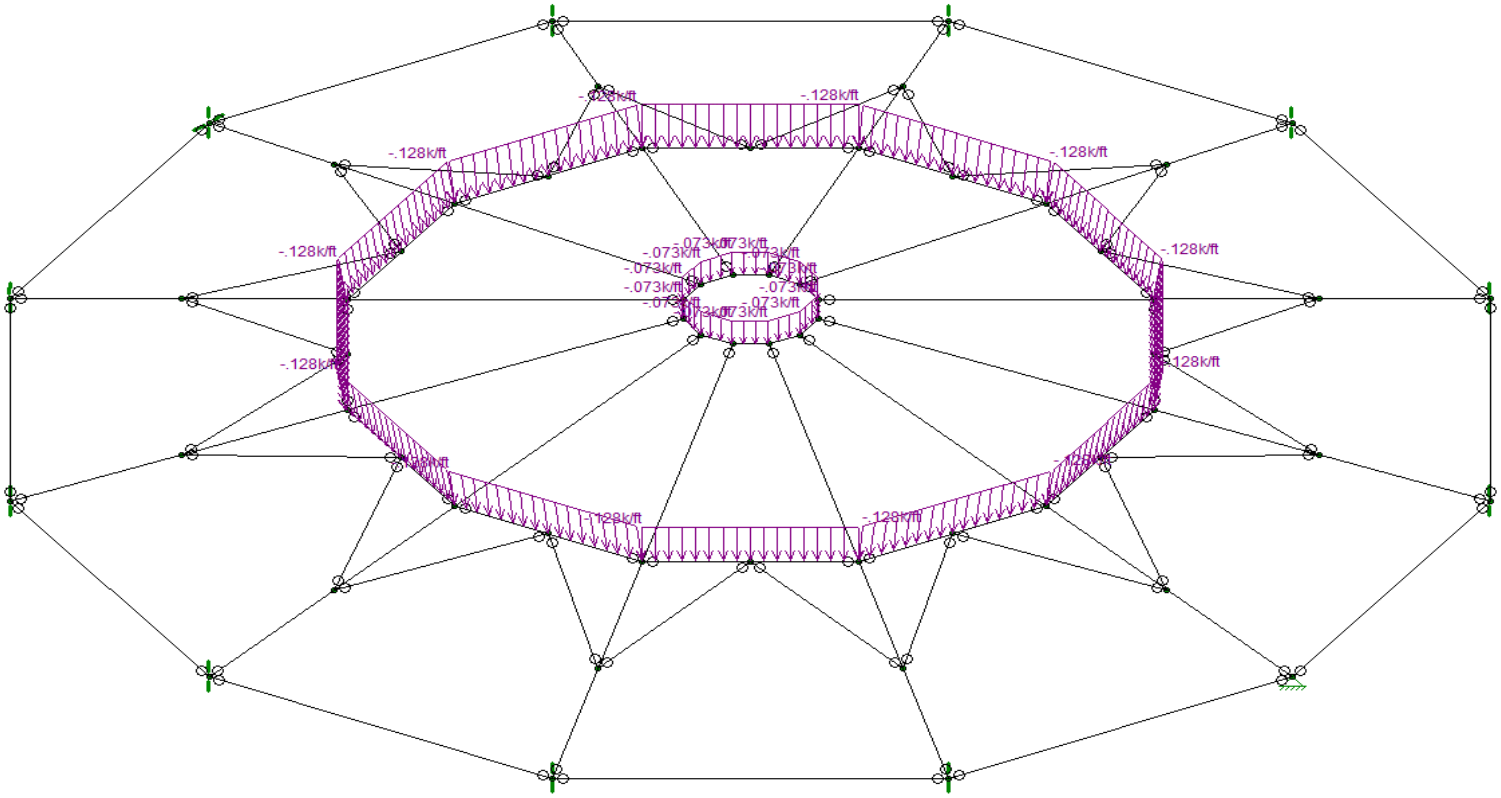
RISA Model - Dead Load



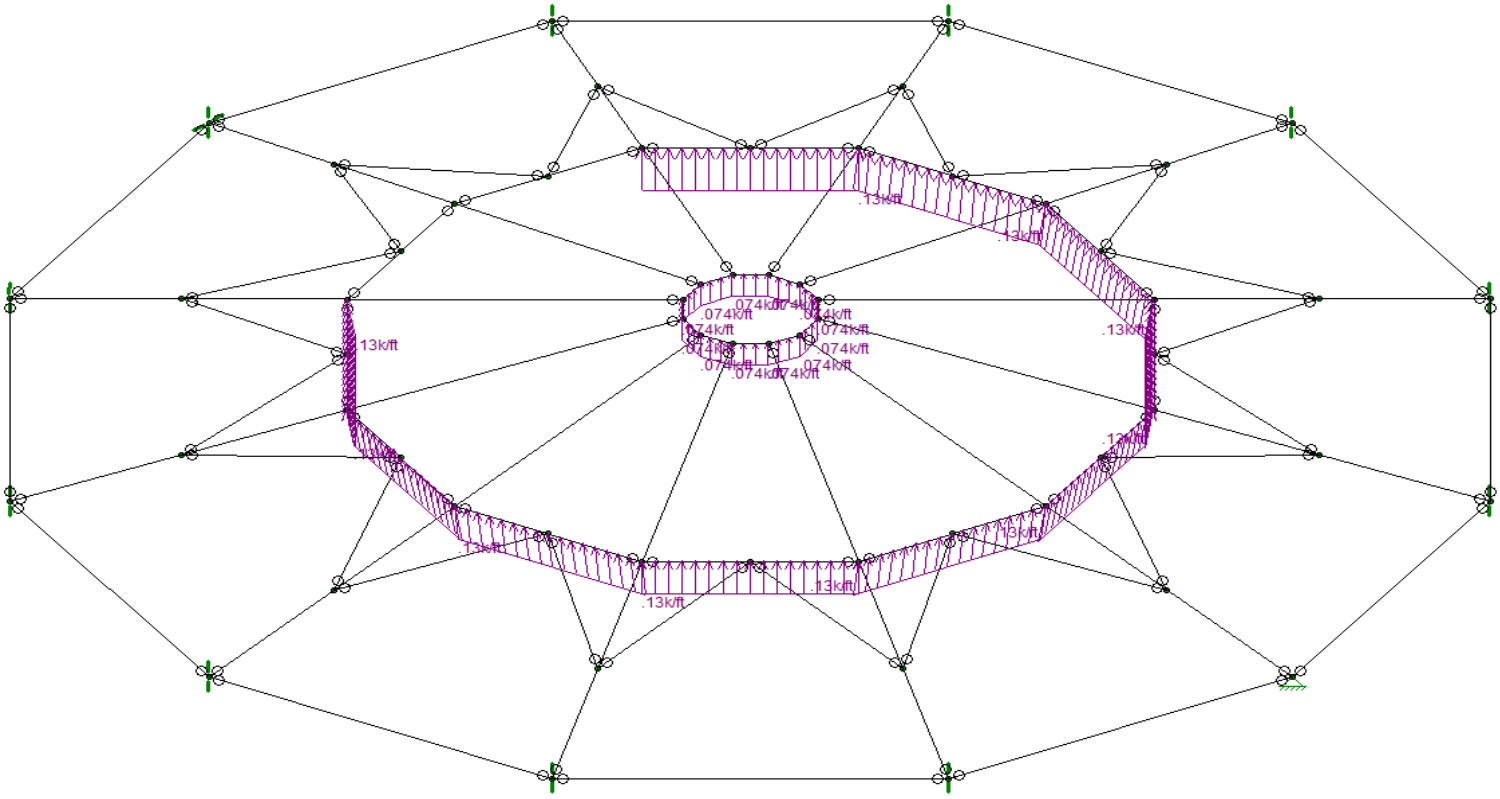
RISA Model - Live Roof Load



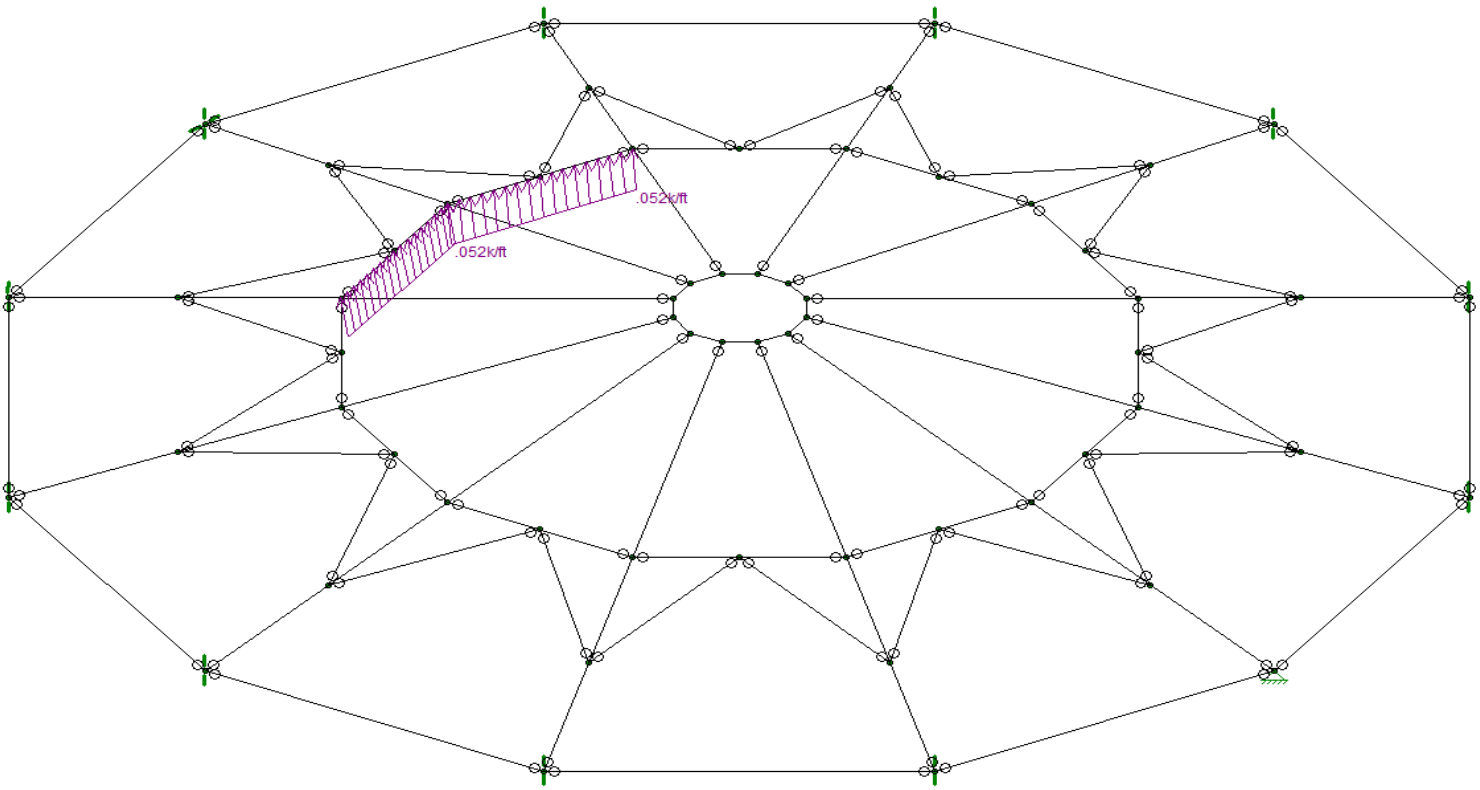
RISA Model - Wind Load Case 1



RISA Model - Wind Load Case 2 Zone 1

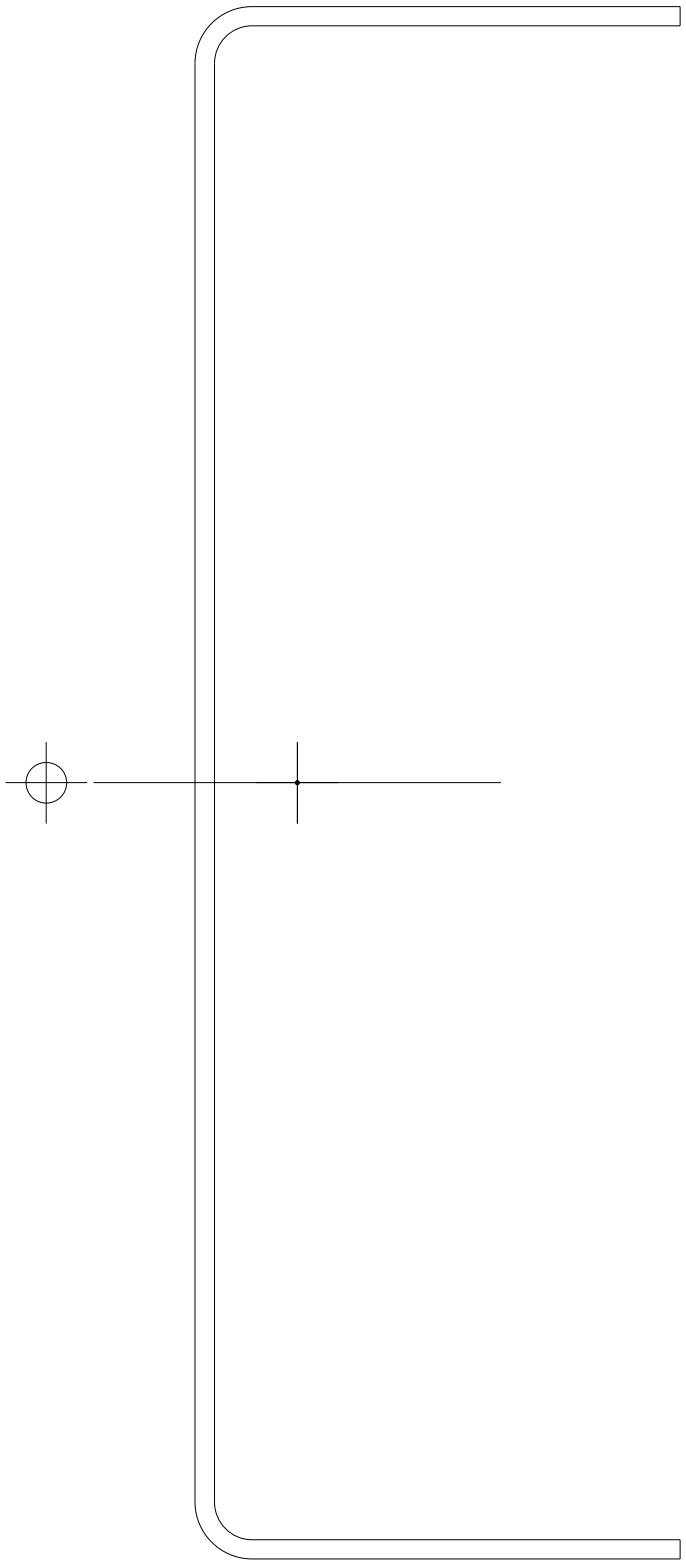


RISA Model - Wind Load Case 2 Zone 2



Section: eave ring CS8x2.5x12.cfss
eave ring CS8x2.5x12

Rev. Date: 12/18/2018 10:23:35 AM
By: wulfn
Printed: 7/22/2020 9:48:15 AM



Section: eave ring CS8x2.5x12.cfss
eave ring CS8x2.5x12

Rev. Date: 12/18/2018 10:23:35 AM
By: wulfn
Printed: 7/22/2020 9:48:15 AM

Section Inputs

```
Material: A653 SS Grade 55
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    55 ksi
Tensile Strength, Fu                  70 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Part 1, Thickness 0.0999 in
Placement of Part from Origin:
X to center of gravity              0 in
Y to center of gravity              0 in
Centerline dimensions, Open shape
        Length      Angle      Radius  Web      k    Hole Size   Distance
          (in)      (deg)        (in)          Coef.       (in)       (in)
  1     2.4475    180.000    0.19400 Single  0.000     0.0000     1.2238
  2     7.8950    -90.000    0.19400 Single  0.000     0.0000     3.9475
  3     2.4475      0.000    0.19400 Single  0.000     0.0000     1.2238
```

Full Section Properties

```
Area      1.2568 in^2   Wt.    0.0042731 k/ft   Width     12.581 in

Ix        11.386 in^4   rx        3.0099 in     Ixy        0.000 in^4
Sx(t)     2.8483 in^3   y(t)      3.9975 in     α          0.000 deg
Sx(b)     2.8483 in^3   y(b)      3.9975 in
                        Height    7.9949 in
Iy         0.692 in^4   ry        0.7418 in     xo        -1.2927 in
Sy(l)     1.3131 in^3   x(l)      0.5266 in     yo         0.0000 in
Sy(r)     0.3509 in^3   x(r)      1.9708 in     jx         4.6001 in
                        Width     2.4975 in     jy         0.0000 in
I1        11.386 in^4   r1        3.0099 in
I2         0.692 in^4   r2        0.7418 in
Ic        12.078 in^4   rc        3.1000 in     Cw         7.5166 in^6
Io        14.178 in^4   ro        3.3587 in     J      0.0041810 in^4
```

Fully Braced Strength - 2016 North American Specification - US (ASD)

```
Material Type: A653 SS Grade 55, Fy=55 ksi
Compression             Positive Moment          Positive Moment
Pao       21.551 k      Maxo       6.1956 k-ft   Mayo       0.5268 k-ft
Ae       0.70529 in^2   Ixe        9.7627 in^4   Iye        0.2878 in^4
                        Sxe(t)     2.2575 in^3   Sye(l)     0.8645 in^3
Tension                 Sxe(b)     2.6599 in^3   Sye(r)     0.1920 in^3
Ta        41.392 k
                        Negative Moment          Negative Moment
                        Maxo       6.1956 k-ft   Mayo       0.9474 k-ft
Shear                   Ixe        9.7627 in^4   Iye        0.6651 in^4
Vay       11.019 k      Sxe(t)     2.6599 in^3   Sye(l)     1.1657 in^3
Vax        9.081 k      Sxe(b)     2.2575 in^3   Sye(r)     0.3452 in^3
```

Member Check - 2016 North American Specification - US (ASD)

Material Type: A653 SS Grade 55, Fy=55 ksi
Design Parameters:

Lx	9.404 ft	Ly	9.404 ft	Lt	9.404 ft
Kx	1.0000	Ky	1.0000	Kt	1.0000
Cbx	1.0000	Cby	1.0000	ex	0.0000 in
Cmx	1.0000	Cmy	1.0000	ey	0.0000 in
Braced Flange: None		kϕ	0 k		
Red. Factor, R: 0		Lm	20.000 ft		

Loads:	P (k)	Mx (k-ft)	Vy (k)	My (k-ft)	Vx (k)
Entered	1.961	0.0000	0.000	0.0000	0.000
Applied	1.961	0.0000	0.000	0.0000	0.000
Strength	7.405	2.6868	11.019	0.4975	9.081

Effective section properties at applied loads:

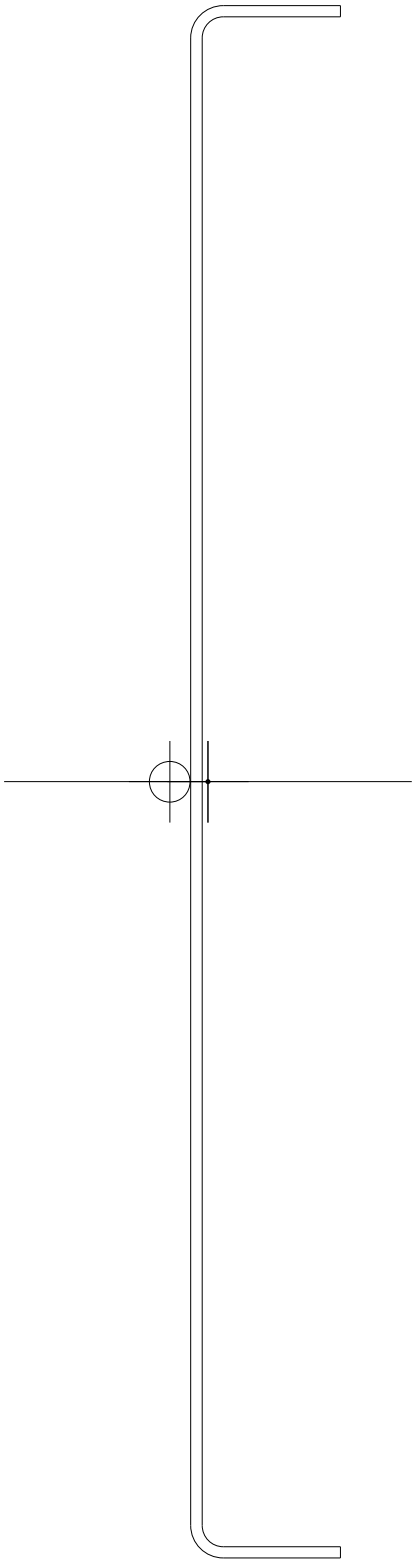
Ae	1.25680 in^2	Ixe	11.386 in^4	Iye	0.692 in^4
		Sxe(t)	2.8483 in^3	Sye(l)	1.3131 in^3
		Sxe(b)	2.8483 in^3	Sye(r)	0.3509 in^3

Interaction Equations

NAS Eq. H1.2-1	(P, Mx, My)	0.265 + 0.000 + 0.000 = 0.265	<= 1.0
NAS Eq. H2-1	(Mx, Vy)	Sqrt(0.000 + 0.000)= 0.000	<= 1.0
NAS Eq. H2-1	(My, Vx)	Sqrt(0.000 + 0.000)= 0.000	<= 1.0

Section: peak-ring #18.cfss
peak-ring #18

Rev. Date: 12/18/2018 10:18:14 AM
By: wulfn
Printed: 7/22/2020 9:50:49 AM



Section Inputs

```
Material: A653 SS Grade 55
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    55 ksi
Tensile Strength, Fu                  70 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Part 1, Thickness 0.1314 in
Placement of Part from Origin:
X to center of gravity             0 in
Y to center of gravity             0 in
Centerline dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1      1.668    180.000    0.24600 Single  0.000      0.000      0.834
  2     17.836    -90.000    0.24600 Single  0.000      0.000      8.918
  3      1.668      0.000    0.24600 Single  0.000      0.000      0.834
```

Full Section Properties

```
Area      2.7468 in^2   Wt.    0.0093393 k/ft   Width     20.904 in

Ix        94.172 in^4   rx         5.855 in     Ixy        0.000 in^4
Sx(t)     10.483 in^3   y(t)       8.984 in     α          0.000 deg
Sx(b)     10.483 in^3   y(b)       8.984 in
                       Height    17.967 in
Iy         0.361 in^4   ry         0.363 in     xo        -0.442 in
Sy(l)      1.811 in^3   x(l)       0.199 in     yo         0.000 in
Sy(r)      0.235 in^3   x(r)       1.534 in     jx        23.928 in
                       Width      1.734 in     jy         0.000 in
I1        94.172 in^4   r1         5.855 in
I2         0.361 in^4   r2         0.363 in
Ic        94.533 in^4   rc         5.866 in     Cw        23.109 in^6
Io        95.070 in^4   ro         5.883 in     J       0.015809 in^4
```

Fully Braced Strength - 2016 North American Specification - US (ASD)

```
Material Type: A653 SS Grade 55, Fy=55 ksi
Compression             Positive Moment          Positive Moment
Pao       35.991 k      Maxo       23.657 k-ft   Mayo       0.646 k-ft
Ae        1.1779 in^2   Ixe        84.457 in^4   Iye        0.361 in^4
                        Sxe(t)      8.620 in^3   Sye(l)     1.811 in^3
Tension                 Sxe(b)     10.338 in^3   Sye(r)     0.235 in^3
Ta        90.465 k
                        Negative Moment          Negative Moment
                        Maxo       23.657 k-ft   Mayo       0.638 k-ft
Shear                   Ixe        84.457 in^4   Iye        0.351 in^4
Vay       11.729 k      Sxe(t)     10.338 in^3   Sye(l)     1.557 in^3
Vax        7.351 k      Sxe(b)      8.620 in^3   Sye(r)     0.233 in^3
```

Member Check - 2016 North American Specification - US (ASD)

Material Type: A653 SS Grade 55, Fy=55 ksi
Design Parameters:

Lx	0.863 ft	Ly	0.863 ft	Lt	0.863 ft
Kx	1.0000	Ky	1.0000	Kt	1.0000
Cbx	1.0000	Cby	1.0000	ex	0.0000 in
Cmx	1.0000	Cmy	1.0000	ey	0.0000 in
Braced Flange: None		kϕ	0 k		
Red. Factor, R: 0		Lm	20.000 ft		

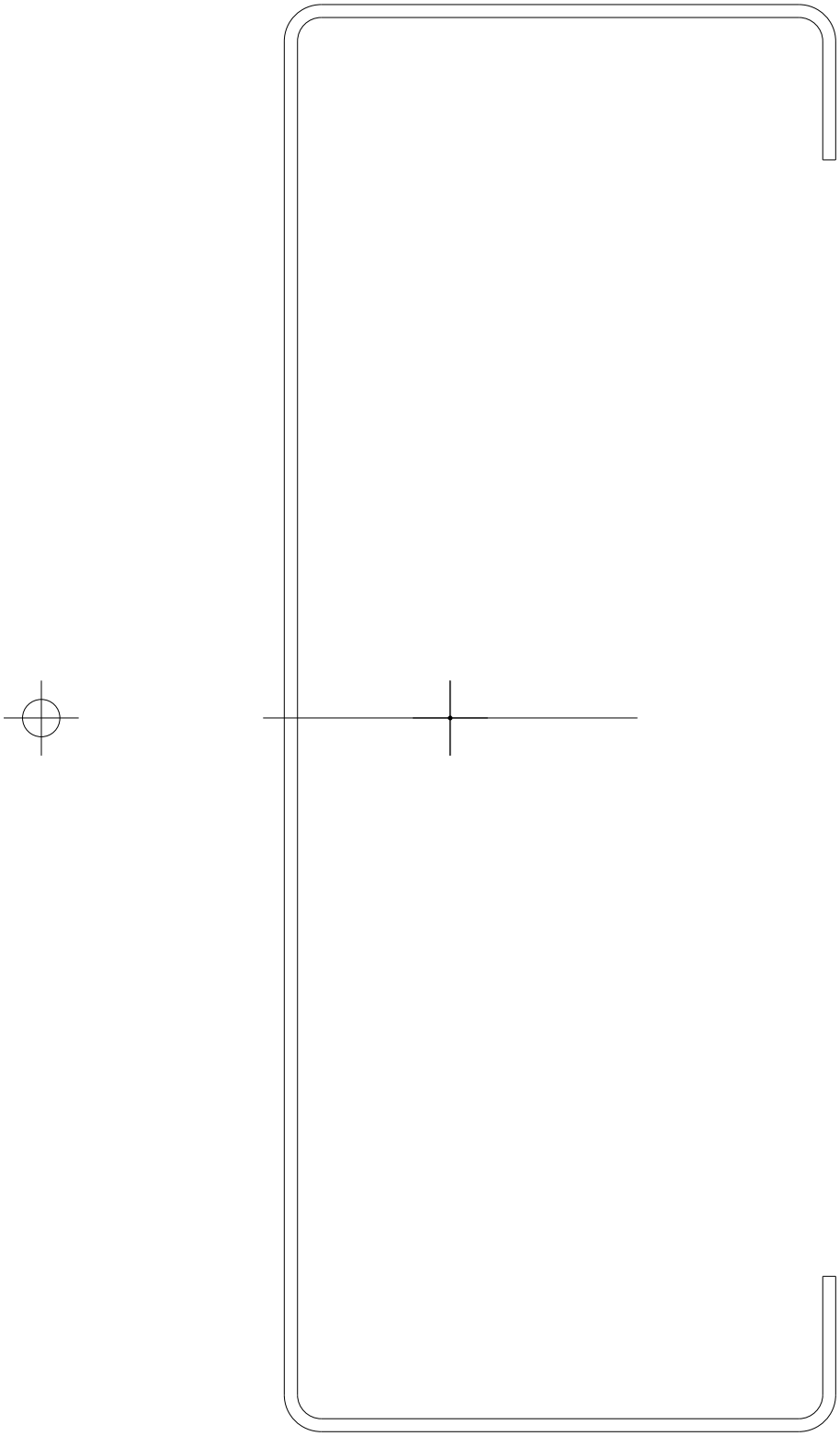
Loads:	P (k)	Mx (k-ft)	Vy (k)	My (k-ft)	Vx (k)
Entered	5.349	0.011	0.000	0.000	0.000
Applied	5.349	0.011	0.000	0.000	0.000
Strength	34.524	23.657	11.729	0.646	7.351

Effective section properties at applied loads:

Ae	2.7468 in^2	Ixe	94.172 in^4	Iye	0.361 in^4
		Sxe(t)	10.483 in^3	Sye(l)	1.811 in^3
		Sxe(b)	10.483 in^3	Sye(r)	0.235 in^3

Interaction Equations

NAS Eq. H1.2-1	(P, Mx, My)	0.155 + 0.000 + 0.000 = 0.155 <= 1.0
NAS Eq. H2-1	(Mx, Vy)	Sqrt(0.000 + 0.000)= 0.000 <= 1.0
NAS Eq. H2-1	(My, Vx)	Sqrt(0.000 + 0.000)= 0.000 <= 1.0



Section Inputs

```
Material: A653 SS Grade 55
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    55 ksi
Tensile Strength, Fu                  70 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Part 1, Thickness 0.075 in
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Centerline dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)          Coef.       (in)       (in)
  1     0.8505     90.000    0.13600 Single  0.000     0.0000     0.4253
  2     3.0750    180.000    0.13600 Single  0.000     0.0000     1.5375
  3     8.0750    -90.000    0.13600 Single  0.000     0.0000     4.0375
  4     3.0750      0.000    0.13600 Single  0.000     0.0000     1.5375
  5     0.8505     90.000    0.13600 None    0.000     0.0000     0.4253
```

Full Section Properties

```
Area      1.1721 in^2   Wt.    0.0039852 k/ft   Width     15.628 in

Ix        12.114 in^4   rx        3.2149 in     Ixy        0.000 in^4
Sx(t)     2.9728 in^3   y(t)      4.0750 in     α          0.000 deg
Sx(b)     2.9728 in^3   y(b)      4.0750 in
                        Height    8.1500 in
Iy         1.582 in^4   ry        1.1617 in     xo       -2.3359 in
Sy(l)     1.6687 in^3   x(l)      0.9479 in     yo         0.0000 in
Sy(r)     0.7183 in^3   x(r)      2.2021 in     jx         4.4329 in
                        Width     3.1500 in     jy         0.0000 in
I1        12.114 in^4   r1        3.2149 in
I2         1.582 in^4   r2        1.1617 in
Ic        13.696 in^4   rc        3.4183 in     Cw        21.296 in^6
Io        20.091 in^4   ro        4.1402 in     J       0.002198 in^4
```

Fully Braced Strength - 2016 North American Specification - US (ASD)

```
Material Type: A653 SS Grade 55, Fy=55 ksi
Compression             Positive Moment          Positive Moment
Pao       20.524 k      Maxo       6.9964 k-ft   Mayo       1.9714 k-ft
Ae       0.67170 in^2   Ixe       11.017 in^4    Iye         1.582 in^4
                        Sxe(t)     2.5493 in^3   Sye(l)     1.6687 in^3
Tension                 Sxe(b)     2.8776 in^3   Sye(r)     0.7183 in^3
Ta        38.602 k
                        Negative Moment          Negative Moment
                        Maxo       6.9964 k-ft   Mayo       1.8041 k-ft
Shear                   Ixe       11.017 in^4    Iye         1.232 in^4
Vay        5.905 k      Sxe(t)     2.8776 in^3   Sye(l)     0.9665 in^3
Vax        8.440 k      Sxe(b)     2.5493 in^3   Sye(r)     0.6574 in^3
```

Member Check - 2016 North American Specification - US (ASD)

Material Type: A653 SS Grade 55, Fy=55 ksi
Design Parameters:

Lx	5.133 ft	Ly	5.133 ft	Lt	5.133 ft
Kx	1.0000	Ky	1.0000	Kt	1.0000
Cbx	1.0000	Cby	1.0000	ex	0.0000 in
Cmx	1.0000	Cmy	1.0000	ey	0.0000 in
Braced Flange: None		kϕ	0 k		
Red. Factor, R: 0		Lm	20.000 ft		

Loads:	P (k)	Mx (k-ft)	Vy (k)	My (k-ft)	Vx (k)
Entered	2.440	0.6510	0.000	-0.0450	-0.049
Applied	2.440	0.6537	0.000	-0.0465	-0.049
Strength	17.096	6.1919	5.905	1.8041	8.440

Effective section properties at applied loads:

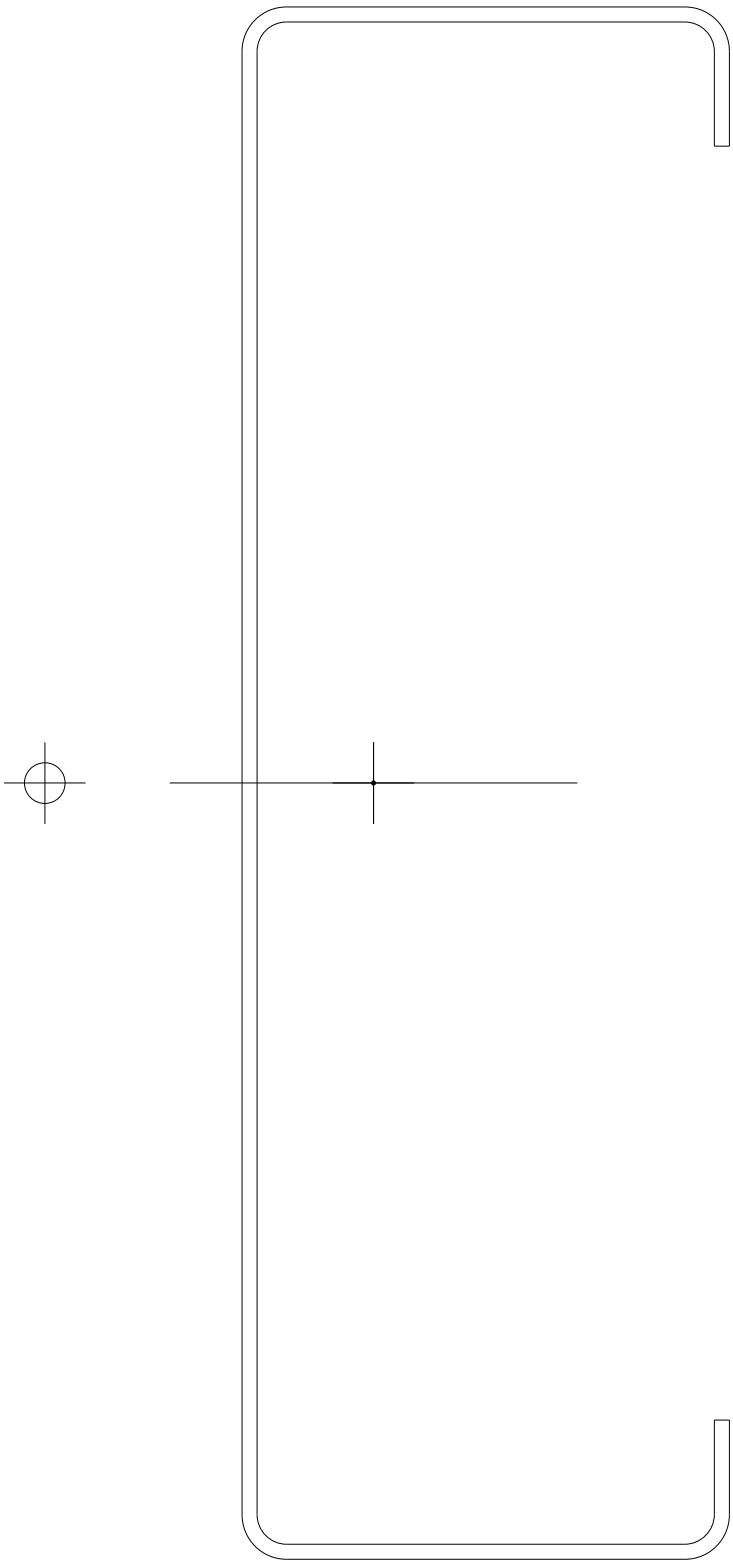
Ae	1.17211 in^2	Ixe	12.114 in^4	Iye	1.582 in^4
		Sxe(t)	2.9728 in^3	Sye(l)	1.6687 in^3
		Sxe(b)	2.9728 in^3	Sye(r)	0.7183 in^3

Interaction Equations

NAS Eq. H1.2-1	(P, Mx, My)	0.143 + 0.106 + 0.026 = 0.274 <= 1.0
NAS Eq. H2-1	(Mx, Vy)	Sqrt(0.009 + 0.000)= 0.093 <= 1.0
NAS Eq. H2-1	(My, Vx)	Sqrt(0.001 + 0.000)= 0.026 <= 1.0

Section: C1012 rafter.cfss
C1012 rafter

Rev. Date: 2/1/2018 7:15:31 PM
By: Bradly Jorgenson
Printed: 7/22/2020 9:41:34 AM



Rev. Date: 2/1/2018 7:15:31 PM
By: Bradly Jorgenson
Printed: 7/22/2020 9:41:34 AM

Section Inputs

```
Material: A653 SS Grade 55
No strength increase from cold work of forming.
Modulus of Elasticity, E          29500 ksi
Yield Strength, Fy                   55 ksi
Tensile Strength, Fu                 70 ksi
Warping Constant Override, Cw         0 in^6
Torsion Constant Override, J          0 in^4

Part 1, Thickness 0.0999 in
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Centerline dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)          Coef.       (in)       (in)
  1      0.866     90.000    0.19400 Single  0.000      0.000      0.433
  2      3.105    180.000    0.19400 Single  0.000      0.000      1.553
  3     10.105    -90.000    0.19400 Single  0.000      0.000      5.053
  4      3.105      0.000    0.19400 Single  0.000      0.000      1.553
  5      0.866     90.000    0.19400 Single  0.000      0.000      0.433
```

Full Section Properties

```
Area      1.7610 in^2   Wt.    0.0059872 k/ft   Width     17.627 in

Ix        27.047 in^4   rx         3.9191 in    Ixy        0.000 in^4
Sx(t)     5.3008 in^3   y(t)       5.1025 in    α          0.000 deg
Sx(b)     5.3008 in^3   y(b)       5.1024 in
                       Height    10.2049 in
Iy         2.286 in^4   ry         1.1395 in    xo        -2.1604 in
Sy(l)     2.6436 in^3   x(l)       0.8649 in    yo         0.0000 in
Sy(r)     0.9771 in^3   x(r)       2.3400 in    jx         5.4385 in
                       Width      3.2049 in    jy         0.0000 in
I1        27.047 in^4   r1         3.9191 in
I2         2.286 in^4   r2         1.1395 in
Ic        29.334 in^4   rc         4.0814 in    Cw         46.480 in^6
Io        37.553 in^4   ro         4.6179 in    J       0.005858 in^4
```

Fully Braced Strength - 2016 North American Specification - US (ASD)

```
Material Type: A653 SS Grade 55, Fy=55 ksi
Compression             Positive Moment          Positive Moment
Pao       32.715 k      Maxo       13.399 k-ft   Mayo       2.682 k-ft
Ae        1.0707 in^2   Ixe        25.713 in^4   Iye        2.286 in^4
                        Sxe(t)     4.8822 in^3   Sye(l)    2.6436 in^3
Tension                 Sxe(b)     5.2071 in^3   Sye(r)    0.9771 in^3
Ta        57.996 k
                        Negative Moment          Negative Moment
                        Maxo       13.399 k-ft   Mayo       2.518 k-ft
Shear                   Ixe        25.713 in^4   Iye        1.901 in^4
Vay       11.786 k      Sxe(t)     5.2071 in^3   Sye(l)    1.6766 in^3
Vax       10.785 k      Sxe(b)     4.8822 in^3   Sye(r)    0.9176 in^3
```

Member Check - 2016 North American Specification - US (ASD)

Material Type: A653 SS Grade 55, Fy=55 ksi
Design Parameters:

Lx	8.383 ft	Ly	8.383 ft	Lt	8.383 ft
Kx	1.0000	Ky	1.0000	Kt	1.0000
Cbx	1.0000	Cby	1.0000	ex	0.0000 in
Cmx	1.0000	Cmy	1.0000	ey	0.0000 in
Braced Flange: None		kϕ	0 k		
Red. Factor, R: 0		Lm	20.000 ft		

Loads:	P (k)	Mx (k-ft)	Vy (k)	My (k-ft)	Vx (k)
Entered	4.023	-3.305	0.396	0.000	0.000
Applied	4.023	-3.333	0.396	0.000	0.000
Strength	21.504	11.418	11.786	2.630	10.785

Effective section properties at applied loads:

Ae	1.7610 in^2	Ixe	27.047 in^4	Iye	2.286 in^4
		Sxe(t)	5.3008 in^3	Sye(l)	2.6436 in^3
		Sxe(b)	5.3008 in^3	Sye(r)	0.9771 in^3

Interaction Equations

NAS Eq. H1.2-1	(P, Mx, My)	0.187 + 0.292 + 0.000 = 0.479 <= 1.0
NAS Eq. H2-1	(Mx, Vy)	Sqrt(0.062 + 0.001)= 0.251 <= 1.0
NAS Eq. H2-1	(My, Vx)	Sqrt(0.000 + 0.000)= 0.000 <= 1.0

Wind Design

City	Ojai		
County	Ventura		
State or Province	CA		
Country	USA		
Exposure	C		
Tank Diameter, D	37.12	(ft)	
Corrugation Depth, D'	0.0365	(ft)	ASCE 7-16 Fig 29.4-1
Eave Height	21.31	(ft)	
Roof angle	10	(deg)	
Roof rise	3.27	(ft)	
Vertical Projection of Roof Area	60.74	(ft^2)	
Directional Factor, K_d	1	Tanks, Round	ASCE 7-16 Table 26.6-1
Topographic Factor $K_{zt}=(1 + K_1K_2K_3)^2$	1		ASCE 7-16 26.8.2
Basic Wind Speed	110	(mph)	
Gust Factor, G	0.85		ASCE 7-16 Fig 26.11.1
H/d	0.574		ASCE 7-16 Fig 29.4-1
D'/D	0.001		ASCE 7-16 Fig 29.4-1
Type of Surface	Moderately Smooth		ASCE 7-16 Fig 29.4-1
Force Coefficent, C_f	0.63		ASCE 7-16 29.4.2.1
Strength Level-to-Service Level Factor,λ_w	0.60		
Velocity Pressure, q_z	$q_z=\lambda_w(0.00256*K_z*K_{zt}*K_d*V^2)$		ASCE 7-16 29.4.2.1
Force, F_w	$F_w=q_z*A*G*C_f$		ASCE 7-16 29.4-1

			Wall			
	Velocity Pressure Exposure Factor, K_z Table 29.3-1	Velocity Pressure	Area	Force	Height	Moment
(ft)	Exposure C	q_z	A	F_w	h	Mw=Fw*h
0		(lb/ft^2)	(ft^2)	(kip)	(ft)	(kip-ft)
15	0.85	15.8	556.8	4.7	7.50	35.3
20	0.90	16.8	185.6	1.7	17.50	29.2
25	0.95	17.6	48.5	0.5	20.65	9.4
30	0.98	18.3	0.0	0.0	0.00	0.0
40	1.04	19.4	0.0	0.0	0.00	0.0
50	1.09	20.3	0.0	0.0	0.00	0.0
60	1.14	21.1	0.0	0.0	0.00	0.0
70	1.17	21.8	0.0	0.0	0.00	0.0
80	1.21	22.4	0.0	0.0	0.00	0.0
90	1.24	23.0	0.0	0.0	0.00	0.0
100	1.27	23.5	0.0	0.0	0.00	0.0
120	1.32	24.4	0.0	0.0	0.00	0.0
				6.8		73.9

		Total						
Force, Tank	F_t	6.8	(kip)	x	0.6	=	4.10	(kip)
Force, Roof	F_r	0.431	(kip)	x	0.6	=	0.26	(kip)
Moment, Tank	M_t	73.9	(kip-ft)	x	0.6	=	44.35	(kip-ft)
Moment, Roof	M_r	10.6	(kip-ft)	x	0.6	=	6.36	(kip-ft)
Total Force	F_w	7.26	(kip)	x	0.6	=	4.36	(kip)
Total Moment	M_w	84.52	(kip-ft)	x	0.6	=	50.71	(kip-ft)

ASD Design

Weight Estimates		
Roof	5.612	(kip)
Tank	7.485	(kip)
Total	13.097	(kip)

Reactions Due to Wind Loading			
Number of Anchors / Sheet	3		
Number of Anchors, N	36		
Uplift/Anchor, $P_w=4M_w/(N*D_{ac}) - W'/N$	-212.00	(lb)	AWWA D103-19 Eq 5-13
Shear per Anchor F_w/N	121.07	(lb)	

Seismic Loads

Reference Section 14 of AWWA D103-19 Table 2		
Per ASCE 7-16 Table 15.4-2, the seismic force-resisting system is considered to be the tank itself: Mechanically-anchored, Steel or fiber-reinforced plastic, Flat-bottom ground-supported tanks		
Seismic Importance factor, I_E	1	
(Soil) Site class	D	
S_s (0.2 second period)	1.825	
S_1(1 second period)	0.699	
S_{MS} (0.2 second period)	1.825	
S_{M1} (1 second period)	1.049	
S_{DS} (0.2 Second Period)	1.217	
S_{D1} (one second Period)	0.699	
Region-dependent transition period for longer-period ground motion T_L	8	
Seismic Design Category:	D	ASCE 7-16 11.6
$T_s=S_{D1}/S_{DS}$	0.57	AWWA D103-19 14.2.6.3.1
$T_0 = 0.2S_{D1}/S_{DS}$	0.11	ASCE 7-16 11.4.6
Natural Period of the Structure, T_i	0	AWWA D103-19 14.3.1
Design Response Spectrum for Impulsive Components, $S_{ai}=S_{DS}$	1.22	AWWA D103-19 EQ 14-5

Tank Type	Mechanically anchored	
Seismic Response Coefficient, C_s	0.117	
Vertical Coefficient, C_v	1.465	ASCE 7-16 Table 11.9-1
Redundancy Factor, ρ	1	ASCE 7-16 12.3.4.1
Vertical Period of Vibration, T_v	0.552	ASCE 7-16 C15.7-2
Corresponding Spectral Response Acceleration for Horizontal Component at T_v, S_{aM}	1.217	ASCE 7-16 11.4.6
Vertical Response Spectral Acceleration, $S_{aMv} > 0.5*S_{aM}$	2.139	ASCE 7-16 11.9.2
Natural Period of Vibration of Vertical Liquid Motion, $S_{av} = S_{aM} * 2/3$	1.426	ASCE 7-16 15.7.2
Impulsive Response Modification Factor, R_i	3	AWWA D103-19 TABLE 5
Convective Response Modification Factor, R_c	1.5	

Tank Diameter, D	37.12	(ft)				
Distance from the bottom of the shell to the MOL (maximum operating level), H	20.13	(ft)				
First mode sloshing wave period, $T_c = 2\pi(D/(3.68g*\tanh(3.68H/D)))^{0.5}$	3.58	(sec)	AWWA D103-19 EQ 14-14			
Damping scaling factor, K	1.5		AWWA D103-19 14.4			
		$T_c =$	3.58	<	8	$= T_L$

Therefore

Design spectral response acceleration for the convective compontent, SAC =K*SD1/Tc <= SDS	0.29		AWWA D103-19 EQ 14-8/14-19
Seismic load reduction factor to convert from strength level to service level, λ_c	0.70		AWWA D103-19 14.2.8.1
Impulsive Design Acceleration, $A_i=$	$\lambda^*S_{ai}*I_E/(1.4*R_i) \geq 0.36S_1*I_E/R_i$		AWWA D103-19 EQ 14-12
		$A_i =$ 0.28 > 0.08 $0.36S_1*I_E$	
$A_i=$	0.28		
Convective Design Acceleration, $A_c=\lambda_c S_{ac}*I_E/R_c$	0.14		AWWA D103-19 EQ 14-13

Design Overturning Moment at the Bottom of the Shell (AWWA D103-19 14.3.2)			
Weight of tank shell and significant appurtenances, W_s	7485	(lb)	
Height from bottom of the shell to the center of gravity of the shell, X_s	8.89	(ft)	
Weight of tank roof, W_r	5612	(lb)	
Weight of tank, $W = W_s+W_r$	5619.35	(lb)	
Height from bottom of the shell to the centroid of the roof, $X_r=H_t+$ Roof Rise/3	22.40	(ft)	
Specific Gravity	1		
Weight of tank contents, $W_T=62.4*G*H*(\pi*D^2/4)$	1359320	(lb)	AWWA D103-19 EQ 14-19
Effective Impulse Weights, W_i			
D/H	1.84		
-For $D/H \geq 1.333$ => $W_i = (\tanh(0.866*D/H))/(0.866D/H)*W_T$	784126	(lb)	AWWA D103-19 EQ 14-16
-For $D/H < 1.333$ => $(1.0-0.218*D/H)*W_T$	812864	(lb)	AWWA D103-19 EQ 14-17
Therefore W_i is	784126	(lb)	
Height from bottom of the shell to the centroid of W_i, X_i			
-For $D/H \geq 1.333$ => $0.375*H$	7.55	(ft)	AWWA D103-19EQ 14-20
-For $D/H < 1.333$ => $(0.5-0.094*D/H)*H$	6.58	(ft)	AWWA D103-19 EQ 14-21
Therefore X_i is	7.55	(ft)	
Effective convective weight, $W_c = 0.230*(D/H)*\tanh(3.67*H/D)*W_T$	555392	(lb)	AWWA D103-19 EQ 14-18
Height from bottom of the shell to the centroid of W_c, $X_c= (1.0-(\cosh(3.67*H/D)-1)/(3.67H/D*\sinh(3.67*H/D)))H$	12.45	(ft)	AWWA D103-19 EQ 14-22
Design overturning moment at bottom of shell, $M_s=((A_i*(W_s*X_s + W_r*H_t + W_i*X_i))^2 + (A_c*W_c*X_c)^2)^{0.5}$	1973708	(ft-lb)	AWWA D103-19 EQ 14-15

Design Shear and Overturning Moment at the Top of the Foundation (AWWA D103-19 14.3.3)			
AWWA Method			
Weight of tank bottom, W_f	4286	(lb)	
Design shear at the top of the foundation due to horizontal design acceleration, $V_i=((A_i*(W_s + W_r + W_f + W_i))^2 + (A_c*W_c)^2)^{0.5}$	239852	(lb)	AWWA D103-19 EQ 14-23
ASCE 7-16 15.7.6.1 Method			
Base shear caused by impulsive component from weight of tank and contents, $V_i = S_{ai}W_i/(R/I_e)$	318006	(lb)	ASCE 7-16 15.7-5
Base shear caused by the convective component of the effective sloshing mass, $V_c = S_{ac}I_eW_c/1.5$	108372	(lb)	ASCE 7-16 15.7-6
Total seismic base shear, $V = (V_i^2 + V_c^2)^{0.5}$	335965	(lb)	ASCE 7-16 15.7-4

Design Overturning Moment at the Top of the Foundation (AWWA D103-19 14.3.3.2)			
For tanks supported by ringwall or berm foundations use M_s from above, M_s =	1973708	(ft-lb)	AWWA D103-19 14.3.3.2.1
Tanks Supported by Mat or Pile Foundations (14.3.3.2.2)			
Height from the bottom of the shell to the centroid of lateral seismic force, X_{imf}			
-For D/H ≥ 1.333 => 0.375*(1.0+1.333((0.866*D/H)/(tanh(0.866*D/H))-1.0))*H	14.93	(ft)	AWWA D103-19 EQ 14-25
-For D/H < 1.333 => (0.5+0.06*D/H)*H	12.29	(ft)	AWWA D103-19 EQ 14-26
Therefore X_{imf} is	14.93	(ft)	
Height from bottom of the shell to the centroid of W_c, X_{cmf}= (1.0-(cosh(3.67*H/D)-1.937)/(3.67(H/D)*sinh(3.67*H/D)))H	15.09	(ft)	AWWA D103-19 EQ 14-27
Design overturning moment across the entire base cross section due to horizontal design acceleration, $M_{mf} = ((A_i*(W_sX_s + W_rXH_t + W_iX_{imf}))^2 + (A_cW_cX_{cmf})^2)^{0.5}$	3564961	(ft-lb)	AWWA D103-19 EQ 14-24

Mechanically Anchored			
Number of Anchors / sheet	3		
Number of Anchors, N	36		
ASD Based Reactions			
Moment for Seismic, M_s	1973708	(ft-lb)	
Uplift/Anchor, $P_s=4M_s/(N*D)-W/N$	5788	(lb)	AWWA D103-19 EQ 5-14
Shear/anchor using highest shear value from ASCE 7-16 and AWWA D103-19, Vf/N	9332	(lb)	
Anchor chair/anchor attachment design load for seismic, $Ps=16M_s/(N*D)-W/N$ (AWWA D103-09 5.9.8.2)	23475	(lb)	
Anchor chair/anchor attachment load rating	55000	(lb)	
	OK		

Horizontal seam for overturning		
Single or Double Punch	Single	
Number of bolts per sheet	12	(#)
Total Horizontal Bolts	144	(#)
Seismic Shear per bolt $Ps=4M_s/(N*D)-W/N$	1438	(lb)
Bottom Sheet Gage	12	(ga)
Bottom Sheet Thickness	0.0970	(in)
Shell Course Yield Strength	55,000	(psi)
Shell Course Ultimate Strength	70,000	(psi)
Horizontal seam Bolt Diamter	0.4375	
Bolt Strength (F_n) (ref note on Side Wall Sheet Allowable Loads page)	64	(ksi)
Shear Bolt Strength		
Shear Bolt Strength per bolt (Pn=AbFn) (AISI S100-2007 EQ E3.4-1)	9.62	(kip)
Safety Factor (Ω) (AISI S100-2007 Table 3.4-1)	2.4	
Allowable Strength per Bolt Pn/Ω	4.01	(kip)
Bolt Shear Check	OK	
Bolt Bearing Strength		
Ratio of Fastener Diameter to Member Thickness d/t	4.5	
Bearing Factor C (AISI S100-2007 Table E3.3.1-1)	3	
Factor of Safety Ω	2.5	
Modification Factor mf (AISI S100-2007 Table E3.3.1-2)	1	
Allowable Bearing Per Fastener ($Pn=C*mf*d*t*F_u$) (AISI S100-2007 EQ E3.3.1-1)	3.6	(kip)
Bolt bearing Check	OK	

Freeboard Requirements		
For Risk Categories I, II, and III		
If $T_c \le 4$ $A_f=K*S_{D1}*I_E/T_C$	0.29	AWWA D103-19 EQ 14-46
If $T_c > 4$ $A_f=4*K*S_{D1}*I_E/T_C^2$	0.33	AWWA D103-19 EQ 14-47
For Risk Category IV		
If $T_c \le T_L$ $A_f=K*S_{D1}/T_c$	0.29	AWWA D103-19 EQ 14-48
If $T_c > T_L$ $A_f=K*S_{D1}*T_L/T_c^2$	0.65	AWWA D103-19 EQ 14-49

Risk Category	II
Tc	3.58
TL	8
Therefore	
A_f	0.29

Sloshing wave height $d=0.42*D*A_f$	4.56	(ft)	AWWA D103-19 EQ 14-45

Risk Category:	I	II	III	IV
$S_{DS} < 0.33$ g	0	0	0	4.56
$S_{DS} \ge 0.33$ g	0	0	3.19	4.56

Actual Free Board Required (Vertical Displacement of Surface Due to Sloshing), d	0.00	(ft)
Actual Free Board Provided, d_f	1.18	(ft)

Sufficient Freeboard?	**Yes**
If no, Check Roof to wall Connection	

Side Wall Sheet (SWS) Design

Sheets per Ring	12	
Diameter	37.12	
42" Sidewall Rings	6.00	
Ring Height	42.43	(in)
Eave Height	21.31	(ft)
Freeboard	14.14	(in)
Fluid Depth	20.13	(ft)
Capacity	21784	(ft^3)
Capacity	162955	(gal)
Fluid Density	62.4	(lb/ft^3)
Minimum Gage	18	

Partial Ring Location (If Applicable)	Ring Number	Fluid Depth	Hydrostatic Pressure at Ring Base	Hydrostatic Tension at Ring Base	Hydrostatic Tension SWS Gage	Allowable Tension Stress for Hydrostatic loading	N_i	N_c	N_h	Seismic Tension	Total Hoop Tension	Seismic Tension SWS Gage	Allowable Tension Stress for Seismic and Wind	Standard Tension Stress Limit	Roof Tension SWS Gage	Allowable Tension Stress for Roof	Sheet Override	Allowable Tension Stress for Ring	Sheet to Use	Wt/ Sheet	Ring Wt	Sidewall Sheet description	Bolt Size	Horizontal Punching
		(ft)	(lb/ft^2)	(lb/ft)	(ga)	(lb/ft)	(lb/ft)	(lb/ft)	(lb/ft)	(lb/ft)	(lb/ft)		(lb/ft)	(lb/ft)	(ga)	(lb/ft)				(lb)				
	1	2.36	147	2730	**18**	**9512**	1163	1771	2730	2211	4941	**18**	**12651**	**9512**	**18**	**9512**		**9512**	**18**	**72.67**	**872**	40 ksi yield, (2) rows 5/16" gr 8.2 bolts @ 2.36" o.c.	5/16	Single
	2	5.89	368	6825	**18**	**9512**	2637	1284	6825	3330	10155	**18**	**12651**	**9512**	**NA**	**NA**		**9512**	**18**	**72.67**	**872**	40 ksi yield, (2) rows 5/16" gr 8.2 bolts @ 2.36" o.c.	5/16	Single
	3	9.43	588	10920	**17**	**13790**	3785	956	10920	4649	15569	**17**	**18341**	**13790**	**NA**	**NA**		**13790**	**17**	**81.75**	**981**	55 ksi yield, (2) rows 5/16" gr 8.2 bolts @ 2.36" o.c.	5/16	Single
	4	12.96	809	15015	**16**	**15193**	4608	746	15015	5817	20831	**14**	**25433**	**19122**	**NA**	**NA**		**19122**	**14**	**113.54**	**1362**	55 ksi yield, (2) rows 5/16" gr 8.2 bolts @ 2.36" o.c.	5/16	Double
	5	16.50	1030	19109	**14**	**19122**	5105	629	19109	6780	25889	**13**	**29898**	**22480**	**NA**	**NA**		**22480**	**13**	**130.20**	**1562**	55 ksi yield, (2) rows 7/16" gr 8.2 bolts @ 2.36" o.c.	7/16	Double
	6	20.04	1250	23204	**12**	**26688**	5276	591	23204	7547	30751	**12**	**35494**	**26688**	**NA**	**NA**		**26688**	**12**	**152.90**	**1835**	55 ksi yield, (2) rows 7/16" gr 8.2 bolts @ 2.36" o.c.	7/16	Double
															NA	**NA**								
															NA	**NA**								
															NA	**NA**								
															NA	**NA**								
															NA	**NA**								
															NA	**NA**								
															NA	**NA**								
															NA	**NA**								
																			Total Weight		7485	(lb)		

Hoop shell Tension - Seismic (AWWA D103-19 14.3.4.2.3)	
Impulsive Hoop Tensile Force, N_i	
For D/H ≥ 1.333 (Eq 14-35) => 4.5 * A*G*D*H*(Y/H-0.5*(Y/H)^2)*tanh(0.866*D/H)	
For D/H < 1.333; and Y <0.75D (Eq 14-36) => 2.77*A*G*D^2*(Y/(0.75*D)-0.5*(Y/(0.75*D))^2)	
For D/H < 1.333; and Y ≥ 0.75D (Eq 14-37) => 1.39*A*G*D^2	
Convective Hoop Tensile Force (Eq 14-38) => Nc=(0.98*Ac*G*D^{2}cosh(3.68*(H-Y)/D)/cosh(3.68*H/D)	
Hydrostatic Hoop Tensile Force => N_h=2.6*GYD	
Distance from MOL to the point under consideration, Y	
Vertical Design Acceleration (AWWA D103-19 14.3.4.3), Av=.19*Sds	0.231167
Total Hoop Tension => Hydrostatic Tension + Seismic Tension	
Increase in allowable stress for loads produced by wind and seismic (AWWA D103-19 5.3.1)	1.33

Chief Bin Sidewall Sheet Allowable Loads

Design based on AISI's "North American Specification for the Design of Cold-Formed Steel Structural Members", 2007 Edition - ASD Method

Nominal Sheet Dimensions: 42.428 in wide x 116.625 in long

Sheet Gage	Coil Width [in]	Min. Ordered Thickness (G115 galv) [in]	Design Net Thickness [in]	Rows of Bolts	Columns of Bolts	Yield Strength F_y [ksi]	Ultimate Srength F_u [ksi]	Bolt Diameter [in]	Bolt Strength F_{nv} [ksi]	Total Bolts in Shear Connection	Hole Size [in]	Net Area [in^2]	(Eq. C2-1) Yielding $A_g \times F_y$ [kips]	(Eq. C2-2) Rupture $A_n \times F_u$ [kips]	(Eq. E3.2-1) Shear Lag $A_n \times F_u$ [kips]	Governing Tension [kips]	(Eq. E3.4-1) Total Bolt Shear [kips]	(Eq. E3.3.1-1) Bolt Bearing [kips]	(Eq. E3.1-1) End Distance [kips]	AISI Design Strength [kips]
20	44.625	0.035	0.0348	19	2	40	55	0.3125	59	36	0.3750	1.11	37.19	30.60	27.56	27.56	67.88	**25.84**	27.99	**25.84**
18	44.625	0.045	0.0453	19	2	40	55	0.3125	59	36	0.3750	1.45	48.41	39.83	35.88	35.88	67.88	**33.63**	36.43	**33.63**
17	44.625	0.051	0.0516	19	2	55	70	0.3125	59	36	0.3750	1.65	75.83	57.74	52.02	52.02	67.88	**48.76**	52.82	**48.76**
16	44.625	0.056	0.0568	19	2	55	70	0.3125	59	36	0.3750	1.82	83.54	63.62	57.31	57.31	67.88	**53.72**	58.20	**53.72**
14	44.625	0.070	0.0715	19	2	55	70	0.3125	59	36	0.3750	2.29	105.15	80.07	72.13	72.13	67.88	**67.61**	73.24	**67.61**
13	44.625	0.082	0.0841	19	2	55	70	0.4375	64	36	0.5000	2.52	123.67	88.22	79.48	79.48	144.32	111.32	86.14	**79.48**
12	44.625	0.097	0.0999	19	2	55	70	0.4375	64	36	0.5000	2.99	146.81	104.74	94.36	94.36	144.32	132.16	102.27	**94.36**
11	44.625	0.112	0.1156	19	2	55	70	0.4375	64	36	0.5000	3.46	169.96	121.25	109.24	109.24	144.32	153.00	118.39	**109.24**
10	44.625	0.127	0.1314	19	2	55	70	0.4375	64	36	0.5000	3.94	193.11	137.76	124.11	124.11	144.32	173.84	134.52	**124.11**
9	44.625	0.141	0.1461	19	3	55	70	0.4375	64	53	0.5000	4.38	214.71	153.18	138.00	**138.00**	212.47	284.56	220.19	**138.00**
8	44.625	0.156	0.1618	19	3	55	70	0.4375	64	53	0.5000	4.85	237.86	169.69	152.87	**152.87**	212.47	315.23	243.93	**152.87**
1313	44.625	0.164	0.1683	19	3	55	70	0.4375	64	53	0.5000	5.04	247.33	176.45	158.96	**158.96**	212.47	327.79	253.64	**158.96**
1212	44.625	0.194	0.1998	19	3	55	70	0.4375	64	53	0.5000	5.99	293.63	209.48	188.72	188.72	**212.47**	389.14	301.12	**188.72**
1111	44.625	0.224	0.2313	19	4	55	70	0.4375	64	70	0.5000	6.93	339.92	242.50	218.47	**218.47**	280.62	594.99	460.41	**218.47**
1010	44.625	0.254	0.2628	19	4	55	70	0.4375	64	70	0.5000	7.87	386.22	275.53	248.23	248.23	**280.62**	676.03	523.12	**248.23**
99	44.625	0.282	0.2922	19	5	55	70	0.4375	64	87	0.5000	8.75	429.43	306.36	276.00	**276.00**	348.77	934.20	722.90	**276.00**
88	44.625	0.312	0.3237	19	5	55	70	0.4375	64	87	0.5000	9.70	475.72	339.38	305.75	305.75	**348.77**	1034.92	800.83	**305.75**
111111	44.625	0.336	0.3469	19	6	55	70	0.4375	64	104	0.5000	10.39	509.89	363.75	327.71	**327.71**	416.92	1325.99	1026.06	**327.71**
101010	44.625	0.381	0.3942	19	6	55	70	0.4375	64	104	0.5000	11.81	579.33	413.29	372.34	372.34	**416.92**	1506.58	1165.80	**372.34**
999	44.625	0.423	0.4383	19	6	55	70	0.4375	90	104	0.5000	13.13	644.14	459.53	413.99	**413.99**	586.29	1675.13	1296.23	**413.99**
888	44.625	0.468	0.4855	19	6	55	70	0.4375	90	104	0.5000	14.54	713.58	509.07	458.62	**458.62**	586.29	1855.71	1435.97	**458.62**
		1	*2*						*3*			*4*						*5*	*6*	

Notes:

1 *Updated minimum ordered thicknesses.*

2 *We are ordering a minimum thickness after galvanization. The design net thickness adjusts to a nominal rather than minimum thickness per AISI Section A2.4, and includes a reduction for the galvanized material coating.*

3 *AISI Appendix A, Table E3.4-1 page A-12 lists F_{nv} = 59 ksi for A354 grade BD bolts and F_{nv} = 67.5 ksi for A490 bolts. A490 bolts are manufactured in 1/2" diameter and larger, A354 bolts are 1/4" diameter and larger, and Grade 8 bolts are 1/4" diameter and larger - all three types have 120 ksi proof, 130 ksi yield, and 150 ksi tensile. AISI Commentary Appendix A, page A-10 explains that smaller diameter bolts have a smaller ratio of tensile stress area to gross area (0.68 for 5/16", 0.71 for 7/16", 0.72 for 1/2", and 0.77 for1" bolts), so intention of using a 10% reduction in shear strength for smaller bolts is to account for this smaller area ratio This is appropriate for 5/16" bolts where area ratio is 10% less, but not for 7/16" bolts where area ratio is only 5% less than for 1/2" and 1" bolts bolts. Therefore to consistent with intention of AISI Standard, using 59 ksi for 5/16" bolts and 67.5x0.95= 64 ksi for 7/16" bolts.*

4 *Net width for section through corner holes = w -N x d + 2 x (s2/4g) AISI (S100-2007-c E3.2 commentary). When multiple bolt lines are used, the effective net section area shall not be taken as greater than 85 percent of the gross area. (AWWA D103-09 Sect. 5.5)*

5 *AISI Standard give two possible cases: more conservative "with consideration of hole deformation", or less conservative "without consideration of hole deformation" - the less conservative "without consideration" approach gives a significantly higher allowable bearing strength on lighter gage sheets, although not all of difference is realized because other conditions (bolt shear, net tension, etc.) limit the overall allowables loads. Since the sidewall sheets over the bin wall are fairly uniformly loaded by pressures from stored grain, hole deformation is also fairly uniform, so there is minimal relative deformation between rings that would cause distortion or misalignments in the bin wall (i.e., all rings of the bin wall expand together fairly evenly) - therefore "without consideration" is an appropriate assumption for sheets in flexible bin wall.*

6 *With more than one row of bolts, it is probably too coservative to assume edge distance limitation affects all bolts in connection because at failure all the holes in the connection would begin to yield and deform together (outermost bolts holes would not yield significantly before innermost bolt holes), so realistically strength of multiple-row connection is higher . Therefore, there is some justification for assuming the outermost row is limited by end distance condition while innermost rows only limited by other conditions. However, without good documentation to justify less conservative interpretation, will apply edge distance limitation to all bolts in connection.*

Chief Bin Sidewall Sheet Allowable Loads

Based on AWWA D103-19 5.5.3

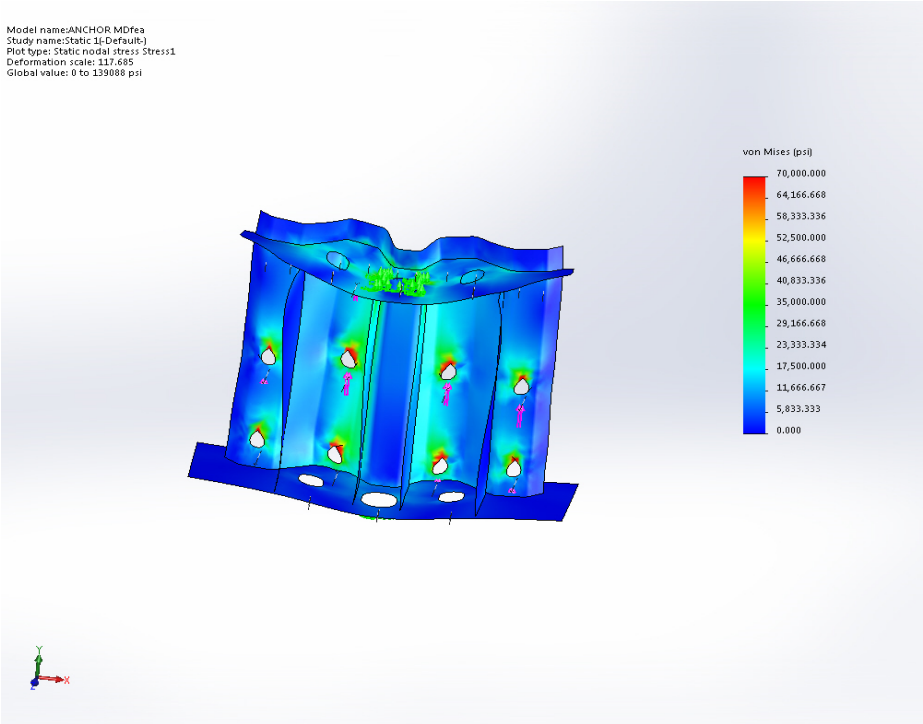
Nominal Sheet Dimensions: 42" Wide x 116.625" Long

Sheet Gage	Coil Width [in]	Min. Ordered Thickness (G115 galv) [in]	Design Net Thickness [in]	Rows of Bolts	Columns of Bolts	Yield Strength F_y [ksi]	Ultimate Srength F_u [ksi]	Bolt Diameter d [in]	Bolt Strength F_{nv} [ksi]	Total Bolts in Shear Connection	Hole Size d [in]	Bolt Tensile Strength [ksi]	Hole Spacing (vert) s [in]	Force trans by bolts/ Force trans by member r	Allowable Tensile Stress			Governing Tensile Stress f_t [ksi]	Hole Bearing Stress [ksi]	Bolt Shear f_v [ksi]	Bolt Tension f_t [ksi]	Governing Stress [ksi]	Allowable Tension [kip]
															$.6F_y(1-.9r+3rd/s)$ f_t [ksi]	$.6F_y$ f_t [ksi]	$0.4F_u$ f_t [ksi]						
20	44.625	0.035	0.0348	19	2	40	55	0.3125	59	36	0.375	120	2.36	0.50	17.973	24.00	22.00	17.97	25.84	29.45	54.55	17.97	27.91
18	44.625	0.045	0.0453	19	2	40	55	0.3125	59	36	0.375	120	2.36	0.50	17.973	24.00	22.00	17.97	33.63	29.45	54.55	17.97	36.33
17	44.625	0.051	0.0516	19	2	55	70	0.3125	59	36	0.375	120	2.36	0.50	24.713	33.00	28.00	24.71	48.76	29.45	54.55	24.71	56.90
16	44.625	0.056	0.0568	19	2	55	70	0.3125	59	36	0.375	120	2.36	0.50	24.713	33.00	28.00	24.71	53.72	29.45	54.55	24.71	62.69
14	44.625	0.070	0.0715	19	2	55	70	0.3125	59	36	0.375	120	2.36	0.50	24.713	33.00	28.00	24.71	67.61	29.45	54.55	24.71	78.90
13	44.625	0.082	0.0841	19	2	55	70	0.4375	64	36	0.500	120	2.36	0.50	27.338	33.00	28.00	27.34	74.25	29.45	54.55	27.34	102.65
12	44.625	0.097	0.0999	19	2	55	70	0.4375	64	36	0.500	120	2.36	0.50	27.338	33.00	28.00	27.34	74.25	29.45	54.55	27.34	121.87
11	44.625	0.112	0.1156	19	2	55	70	0.4375	64	36	0.500	120	2.36	0.50	27.338	33.00	28.00	27.34	74.25	29.45	54.55	27.34	141.08
10	44.625	0.127	0.1314	19	2	55	70	0.4375	64	36	0.500	120	2.36	0.50	27.338	33.00	28.00	27.34	74.25	29.45	54.55	27.34	160.30
9	44.625	0.141	0.1461	19	3	55	70	0.4375	64	53	0.500	120	2.36	0.33	29.225	33.00	28.00	28.00	74.25	29.45	54.55	28.00	182.55
8	44.625	0.156	0.1618	19	3	55	70	0.4375	64	53	0.500	120	2.36	0.33	29.225	33.00	28.00	28.00	74.25	29.45	54.55	28.00	202.23
1313	44.625	0.164	0.1683	19	3	55	70	0.4375	64	53	0.500	120	2.36	0.33	29.225	33.00	28.00	28.00	74.25	29.45	54.55	28.00	210.28
1212	44.625	0.194	0.1998	19	3	55	70	0.4375	64	53	0.500	120	2.36	0.33	29.225	33.00	28.00	28.00	74.25	29.45	54.55	28.00	249.64
1111	44.625	0.224	0.2313	19	4	55	70	0.4375	64	70	0.500	120	2.36	0.25	30.169	33.00	28.00	28.00	74.25	29.45	54.55	28.00	289.00
1010	44.625	0.254	0.2628	19	4	55	70	0.4375	64	70	0.500	120	2.36	0.25	30.169	33.00	28.00	28.00	74.25	29.45	54.55	28.00	328.36
99	44.625	0.282	0.2922	19	5	55	70	0.4375	64	87	0.500	120	2.36	0.20	30.735	33.00	28.00	28.00	74.25	29.45	54.55	28.00	365.09
88	44.625	0.312	0.3237	19	5	55	70	0.4375	64	87	0.500	120	2.36	0.20	30.735	33.00	28.00	28.00	74.25	29.45	54.55	28.00	404.45
111111	44.625	0.336	0.3469	19	6	55	70	0.4375	64	104	0.500	120	2.36	0.00	33.000	33.00	28.00	28.00	74.25	29.45	54.55	28.00	433.50
101010	44.625	0.381	0.3942	19	6	55	70	0.4375	64	104	0.500	120	2.36	0.00	33.000	33.00	28.00	28.00	74.25	29.45	54.55	28.00	492.53
999	44.625	0.423	0.4383	19	6	55	70	0.4375	90	104	0.500	120	2.36	0.00	33.000	33.00	28.00	28.00	74.25	29.45	54.55	28.00	547.64
888	44.625	0.468	0.4855	19	6	55	70	0.4375	90	104	0.500	120	2.36	0.00	33.000	33.00	28.00	28.00	74.25	29.45	54.55	28.00	606.68

Anchor data			
Bolts-Siffener to Anchor	0.4375	(in)	
Bolt Shear Strength, Fnv	64	(ksi)	Note below
Quantity bolts Anchor to Stiffener	9	(ea)	
Stiffener ga	14	(ga)	
	0.0700	(in)	
Quantity bolts Stiffener to sidewall	11		
Sheet ga	12	(ga)	
Min wall sheet thickness	0.0970	(in)	
Sidewall Sheet Yield Strength	55	(ksi)	
Sidewall Sheet Ultimate Strength	70	(ksi)	
Stiffener Yield Strength	55	(ksi)	
Stiffener Ultimate Strength	70	(ksi)	
Vertical gusset thickness	0.25	(in)	
Weld length		(in)	
Weld Leg Length	0.1875	(in)	
8 ga stiffener thinkess in wldmt	0.1618	(in)	
Ultimate Strength Stiffener in weldment	70	(ksi)	
Length of weld on base plate, L	14	(in)	
Base plate thickness	0.5	(in)	
Base Plate Yield strength	50	(ksi)	

Anchor + Stiffener to Sidewall Sheet			
1. Bolt Shear Strength (without hole deformation)			
Φv (LFRD)	0.65		Table E3.4-1
Va, (each)	6.25	(kip)	Eq 3.4-1
Va, Total	56.3	(kip)	

2. Bolt bearing			
Stiffener (Anchor to Stiffener)			
Φv (LFRD)	0.65		
d/t	6.25		
C	3.00		Table E3.3.1-1
mf	1		Table E3.3.1-2
Pn, (each)	6.43	(kip)	
Pn, (total)	57.9	(kip)	
Sidewall			
Φv (LFRD)	0.65		
d/t	4.51		
C	3.00		Table E3.3.1-1
mf	1		Table E3.3.1-2
Pn, (each)	8.91	(kip)	
Pn, (total)	98.0	(kip)	
3. Check Weld			
L/t	86.5		
Φ (LFRD)	0.5		
Pn	118.96	(kip)	Eq. E2.4-1, E2.4-3
4. Check weld assembly with fea			
Applied load	55	Kip	
where applied	Siffener Mounting Holes		
How constrained	Washer sized area on top plate and vertically on bottom hole radius		
Steel Grades	See above		



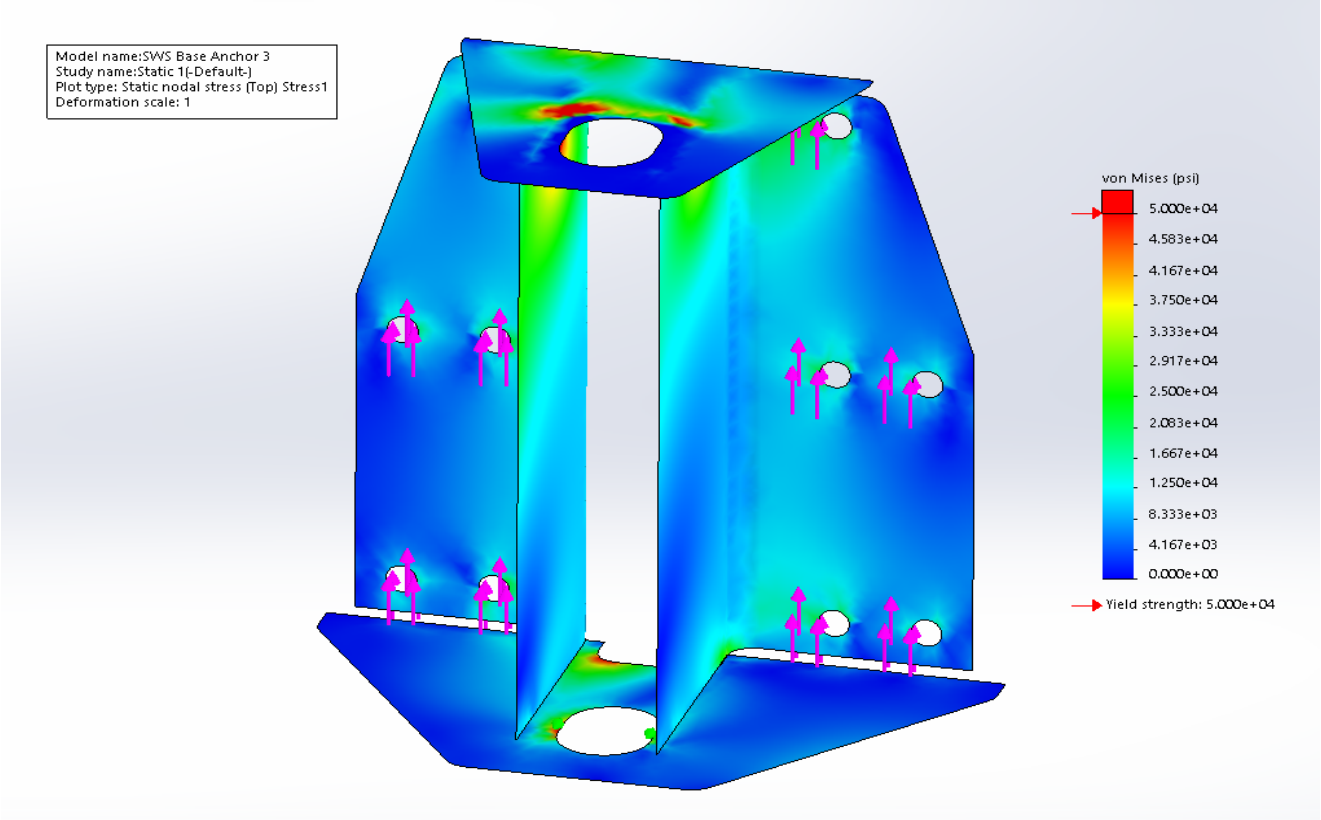
AISI Appendix A, Table E3.4-1 page A-12 lists Fnv = 59 ksi for A354 grade BD bolts and Fnv = 67.5 ksi for A490 bolts. A490 bolts are manufactured in 1/2" diameter and larger, A354 bolts are 1/4" diameter and larger, and Grade 8 bolts are 1/4" diameter and larger - all three types have 120 ksi proof, 130 ksi yield, and 150 ksi tensile. AISI Commentary Appendix A, page A-10 explains that smaller diameter bolts have a smaller ratio of tensile stress area to gross area (0.68 for 5/16", 0.71 for 7/16", 0.72 for 1/2", and 0.77 for1" bolts), so intention of using a 10% reduction in shear strength for smaller bolts is to account for this smaller area ratio This is appropriate for 5/16" bolts where area ratio is 10% less, but not for 7/16" bolts where area ratio is only 5% less than for 1/2" and 1" bolts bolts. Therefore to consistent with intention of AISI Standard, using 59 ksi for 5/16" bolts and 67.5x0.95= 64 ksi for 7/16" bolts.

Anchor rating	55.00	Kip

Anchor data			
Bolts-Sidewall to Anchor	0.4375	(in)	
Bolt Shear Strength, Fnv	64	(ksi)	Note below
Quantity bolts Anchor to Stiffener	10	(ea)	
Anchor Material Thickness	0.2500	(in)	
Quantity bolts anchor to sidewall	10		
Sheet ga	12	(ga)	
Min wall sheet thickness	0.0970	(in)	
Yield Strength	55	(ksi)	
Ultimate Strength	70	(ksi)	
Vertical gusset thickness	0.25	(in)	
Weld length	7.5	(in)	
Weld Leg Length	0.25	(in)	
Anchor material thickness in weldment	0.2500	(in)	
Ultimate Strength anchor material in weldment	70	(ksi)	
Length of weld on base plate, L	15	(in)	
Base plate thickness	0.5	(in)	
Base Plate Yield strength	50	(ksi)	

1. Bolt Shear Strength (without hole deformation)			
Φv (LRFD)	0.65		Table E3.4-1
Va, (each)	6	(kip)	Eq 3.4-1
Va, Total	63	(kip)	

2. Bolt bearing			
Sidewall			
Φv (LFRD)	0.65		
d/t	4.51		
C	3.00		Table E3.3.1-1
mf	1		Table E3.3.1-2
Pn, (each)	8.91	(kip)	
Pn, (total)	89.1	(kip)	
3. Check Weld			
L/t	60.0		
Φ (LFRD)	0.5		
Pn	196.88	(kip)	Eq. E2.4-1, E2.4-3
4. Check weld assembly with fea			
Applied load	55	Kip	
where applied	Siffener Mounting Holes		
How constrained	Washer sized area on top plate and vertically on bottom hole radius		
Steel Grades	See above		



AISI Appendix A, Table E3.4-1 page A-12 lists Fnv = 59 ksi for A354 grade BD bolts and Fnv = 67.5 ksi for A490 bolts. A490 bolts are manufactured in 1/2" diameter and larger, A354 bolts are 1/4" diameter and larger, and Grade 8 bolts are 1/4" diameter and larger - all three types have 120 ksi proof, 130 ksi yield, and 150 ksi tensile. AISI Commentary Appendix A, page A-10 explains that smaller diameter bolts have a smaller ratio of tensile stress area to gross area (0.68 for 5/16", 0.71 for 7/16", 0.72 for 1/2", and 0.77 for1" bolts), so intention of using a 10% reduction in shear strength for smaller bolts is to account for this smaller area ratio This is appropriate for 5/16" bolts where area ratio is 10% less, but not for 7/16" bolts where area ratio is only 5% less than for 1/2" and 1" bolts. Therefore to be consistent with intention of AISI Standard, using 59 ksi for 5/16" bolts and 67.5x0.95= 64 ksi for 7/16" bolts.

Anchor rating	55.00	Kip