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CPM
PT Citra Palu Minerals

OBJECT

Strength Calculation for Tailing Thickener Overflow
Poboya 2000tpd Expansion Project
Client Doc Number: HNZ-V-PT0061.08-4840-STR-CAL-001

REFERENCES

3655.15-61.08-4000-F-BOD-001 Process Design Criteria
3655.15-61.08-4000-F-CAL-001 Mass Balance

B	Issued for Approval	08/05/2026	Wawan	Ardiyanto	Murasato	
A	Issued for Review	15/04/2026	Wawan	Ardiyanto	Murasato	
Revision	Description	Date	Prepared By	Reviewed By	Approved	Client App

CLIENT: **PT Citra Palu Mineral**		TITLE: **Strength Calculation for Tailing Thickener Overflow**		REV: **B**	
PROJECT: **Poboya 2000tpd Expansion Project**		**PT. COMO ENGINEERS**	PROJECT No.: **E2602**		
BY: Wawan	DATE: 08/05/2026	CHECKED: Ardiyanto	DATE: 08/05/2026	Doc No: E2602-4840-CAL-101	

Revision History

REV. No.	DATE	DESCRIPTION	REVISION BY
A	April, 14, 2026	Issued for Review	
B	May, 08, 2026	Issued for Approval	

CONTENTS

Description **Page**

1. Introduction

This document consist of additional analysis for tailing overflow tank shell thickness. The dimension is 4.5 m height and 7 m for the diameter. Additional analysis needed to calculate the strength of shell tank to resist walkway platform load that located on top of the tank.

2. Support Document

- 3665.15-61.08-4840-M-DWG-001 - GA - Thickener Overflow Tank

3. Code and Reference

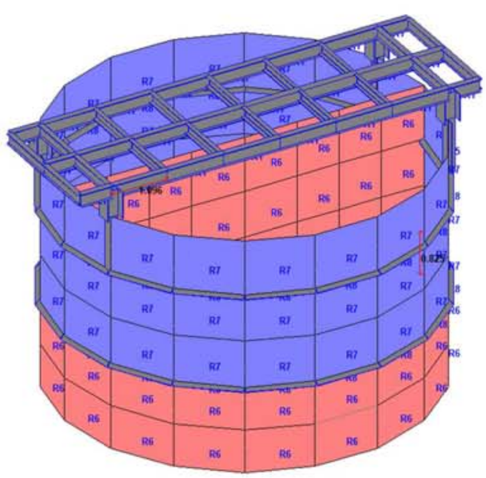
Code and reference that used for this calculation listed below :

- API STD 650 2018 – Wleded Tanks for Oil Storage
- SNI 1729:2020 – Spesifikasi untuk Bangunan Gedung Baja Struktural

4. Design

4.1 Isometric Model

Analysis design for the tank use STAAD Pro software. Tank model picture showed below :



Material			
PLATE			
Shell elev. (m)	Main Thickness (mm)	Corrosion Allowance (mm)	Design Thickness (mm)
Bottom Plate	7	3	10
0 - 4.5	5	3	8
STIFFENER			
Profile elev. (m)	Type		
1.65	L.130.130.12		
3.45	L.130.130.12		
4.5	L.200.200.25		
PLATFORM SUPPORT			
Profile elev. (m)	Type		
4.5	Half Tee. 300.300.10.15		

Picture 1. Tank Model and Properties

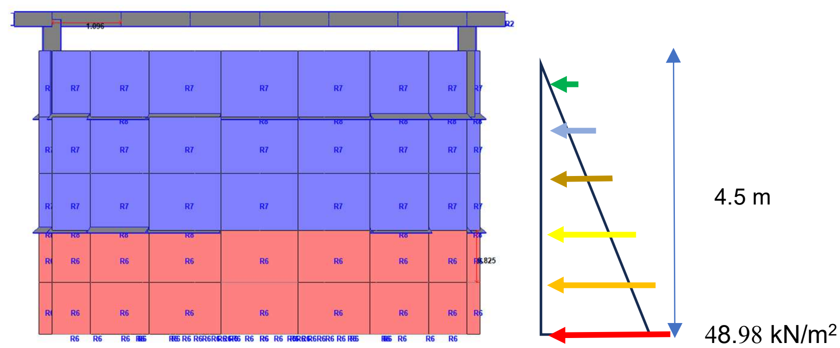
4.2 Load and Combination

4.2.1 Daad Load

Unit weight of steel used as calculation is 78.5 kN/m3.

4.2.2 Hidrostatic Load

Hidrostatic load is pressure load from fluida content. Specific gravity fluida is 1.11 Ton/m^3



Hidrostatic load : 1.11 x 4.995 = 48.98 Ton/m^2 → kN/m^2

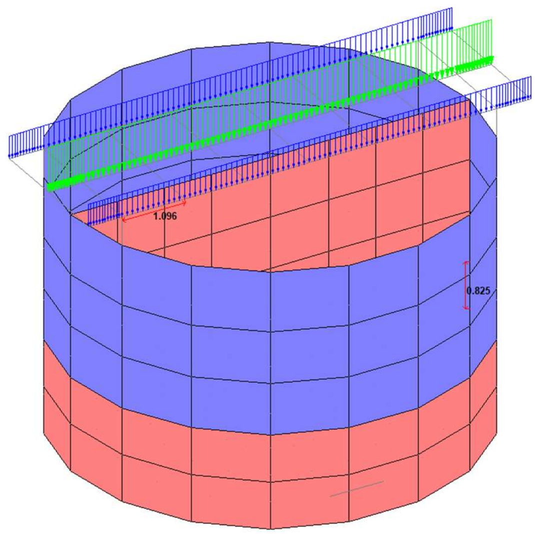
4.2.3 Walkway Platform Load

GRATING

q	=	0.45	kN/m2
Tributary 1	=	1	m
Tributary 2	=	0.5	m
Input load 1	=	0.45	kN/m
Input load 2	=	0.225	kN/m

LIVE LOAD

q	=	5	kN/m2
Tributary 1	=	1	m
Tributary 2	=	0.5	m
Input load :	=	5	kN/m
Input load :	=	2.5	kN/m



Picture 2. Walkway Input Load

4.2.4 Seismic Load

Seismic load calculated based on API 650.

- The seismic overturning moment at the base of the tank shell shall be the SRSS summation of the impulsive and convective components multiplied by the respective moment arms to the center of action of the forces unless otherwise specified.

Ringwall Moment, M_{rw}:

$$M_{rw} = \sqrt{[A_i(W_iX_i + W_sX_s + W_rX_r)]^2 + [A_c(W_cX_c)]^2} \quad \text{(E.6.1.5-1)}$$

Equation Ai :

Impulsive spectral acceleration parameter, A_i:

$$A_i = S_{DS}\left(\frac{I}{R_{wi}}\right) = 2.5QF_aS_0\left(\frac{I}{R_{wi}}\right) \quad \text{(E.4.6.1-1)}$$

However, $A_i \geq 0.007$ (E.4.6.1-2)

and, for $S_1 \geq 0.6$:

$$A_i \geq 0.5S_1\left(\frac{I}{R_{wi}}\right) = 0.625S_P\left(\frac{I}{R_{wi}}\right) \quad \text{(E.4.6.1-3)}$$

I = 1 *(category II)*

Sds = 0.806

Rwi 3.5

Table E.4—Response Modification Factors for ASD Methods

Anchorage system	R_{wi} (impulsive)	R_{wc} (convective)
Self-anchored	3.5	2
Mechanically-anchored	4	2

Ai = 0.23

Equation Ac

Convective spectral acceleration parameter, A_c:

When, $T_C \le T_L$ $$A_c = KS_{D1}\left(\frac{1}{T_c}\right)\left(\frac{I}{R_{wc}}\right) = 2.5KQF_aS_0\left(\frac{T_s}{T_c}\right)\left(\frac{I}{R_{wc}}\right) \le A_i \quad \text{(E.4.6.1-4)}$$

When, $T_C > T_L$ $$A_c = KS_{D1}\left(\frac{T_L}{T_c^2}\right)\left(\frac{I}{R_{wc}}\right) = 2.5KQF_aS_0\left(\frac{T_sT_L}{T_c^2}\right)\left(\frac{I}{R_{wc}}\right) \le A_i \quad \text{(E.4.6.1-5)}$$

Ks = 0.58

Tc = 3.03

Rwc = 2

K = 1.5

S_{D1} = 0.582

Ac = 0.14

Equation Wi and Xi :

E.6.1.1 Effective Weight of Product

The effective weights W_i and W_c shall be determined by multiplying the total product weight, W_p, by the ratios W_i/W_p and W_c/W_p, respectively, Equations E.6.1.1-1 through E.6.1.1-3.

When D/H is greater than or equal to 1.333, the effective impulsive weight is defined in Equation E.6.1.1-1:

$$W_i = \frac{\tanh\left(0.866\frac{D}{H}\right)}{0.866\frac{D}{H}} W_p \qquad \text{(E.6.1.1-1)}$$

When D/H is less than 1.333, the effective impulsive weight is defined in Equation E.6.1.1-2:

$$W_i = \left[1.0 - 0.218\frac{D}{H}\right] W_p \qquad \text{(E.6.1.1-2)}$$

When D/H is greater than or equal to 1.3333, the height X_i is determined by Equation E.6.1.2.1-1:

$$X_i = 0.375H \qquad \text{(E.6.1.2.1-1)}$$

When D/H is less than 1.3333, the height X_i is determined by Equation E.6.1.2.1-2:

$$X_i = \left[0.5 - 0.094\frac{D}{H}\right] H \qquad \text{(E.6.1.2.1-2)}$$

D	=	7	m
H	=	4.5	m
D/H	=	1.56	
Ɣ	=	1.82	
Wp	=	3093.24	kN
perimeter	=	22.00	m
3.67H/D	=	2.36	
Wi	**=**	**2005.43**	**kN**
Xi	**=**	**1.69**	**m**

Equation Wc and Xc :

The effective convective weight is defined in Equation E.6.1.1-3:

$$W_c = 0.230\frac{D}{H}\tanh\left(\frac{3.67H}{D}\right)W_p \qquad \text{(E.6.1.1-3)}$$

The height X_c is determined by Equation E.6.1.2.1-3:

$$X_c = \left[1.0 - \frac{\cosh\left(\frac{3.67H}{D}\right) - 1}{\frac{3.67H}{D}\sinh\left(\frac{3.67H}{D}\right)}\right]H \qquad \text{(E.6.1.2.1-3)}$$

Wc	=	**1087.11**	**kN**
Xc	=	**2.92**	**m**

Value of Ws and Xs :

Ws = Total weight of tank shell and appurtenances

Xs = Height from bottom of the tank shell to the shell's center of gravity

L.130.130.12

A	=	2976 mm^2	=	0.002976	m^2
w	=		=	5.14	kN
n			=	2	
Weight Total L.130			=	10.28	kN

L.200.200.25

A	=	9375 mm^2	=	0.009375	m^2
w			=	16.19	kN
n			=	1	
Weight Total L.130			=	16.19	kN

H.300.300.15.10 H.Tee

A	=	11850 mm^2	=	0.01185	m^2
w			=	1.53	kN
n			=	4	
Weight Total L.130			=	6.14	kN

Shell T 10 mm

A	=	0.22	m^2
w	=	31.09	kN

Shell T 8 mm

A	=	0.22	m^2
w	=	46.63	kN

TOTAL WEIGHT (Ws)		**110.32**	**kN**
Xs	**=**	**2.25**	**m**

From calculation above,

(Ai . Wi) / perimeter	=	20.99	kN/m, at H =	1.69	m
(Ai . Ws) / perimeter	=	1.15	kN/m, at H =	2.25	m
(Ac . Wc) / perimeter	=	7.77	kN/m, at H =	2.92	m

For simplification :

W	=	29.91	kN/m
H	=	2.03	m

4.2.5 Wind Load

Wind load calculated based on SNI 1727 : 2020.

4.2.6 Load Combination

Load combination based on SNI 1729 : 2020

Service load combination :

1. D
2. $D + L$
3. $D + (L_r \text{ atau } R)$
4. $D + 0{,}75\ L + 0{,}75(L_r \text{ atau } R)$
5. $D + 0{,}6\ W$
6. $D + 0{,}75\ (0{,}6\ W) + 0{,}75\ L + 0{,}75\ (L_r \text{ atau } R)$
7. $0{,}6D + 0{,}6\ W$

8. $1{,}0D + 0{,}7E_v + 0{,}7E_h$
9. $1{,}0D + 0{,}525E_v + 0{,}525E_h + 0{,}75L$
10. $0{,}6D - 0{,}7E_v + 0{,}7E_h$

Ultimate load combination :

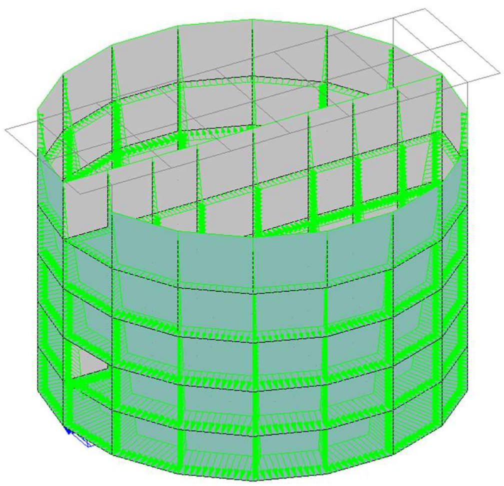
1. $1{,}4D$
2. $1{,}2\ D + 1{,}6\ L + 0{,}5\ (L_r \text{ atau } R)$
3. $1{,}2D + 1{,}6\ (L_r \text{ atau } R) + (L \text{ atau } 0{,}5\ W)$
4. $1{,}2D + 1{,}0\ W + L + 0{,}5(L_r \text{ atau } R)$
5. $0{,}9\ D + 1{,}0\ W$

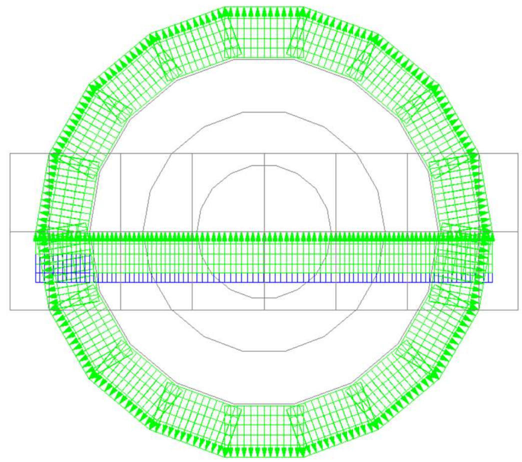
6. $1{,}2D + E_v + E_h + L$
7. $0{,}9D - E_v + E_h$

4.3 Analysis Design

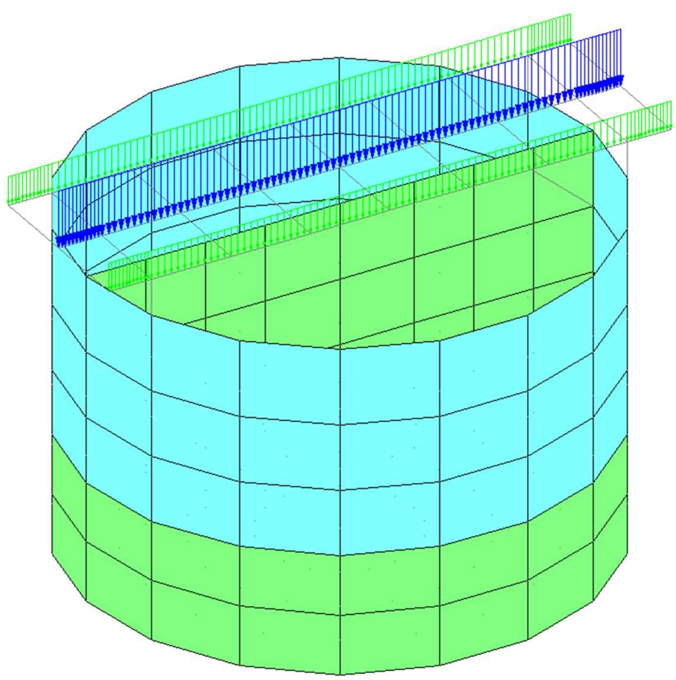
4.3.1 Input Model

a. Hidrostatic Load (MAX =80.34 kN/m^2)

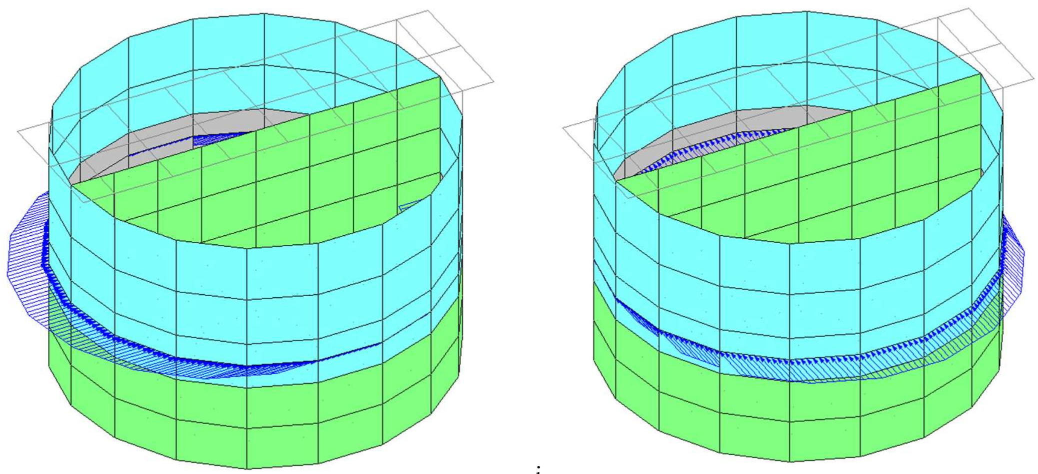




b. Walkway Platform Load

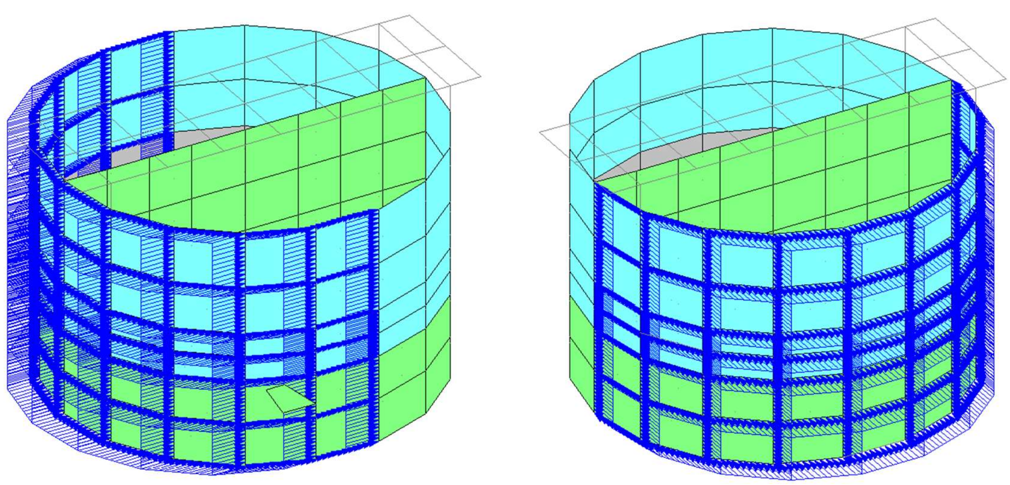


c. Seismic Load (Wi = 29.91 kN/m)

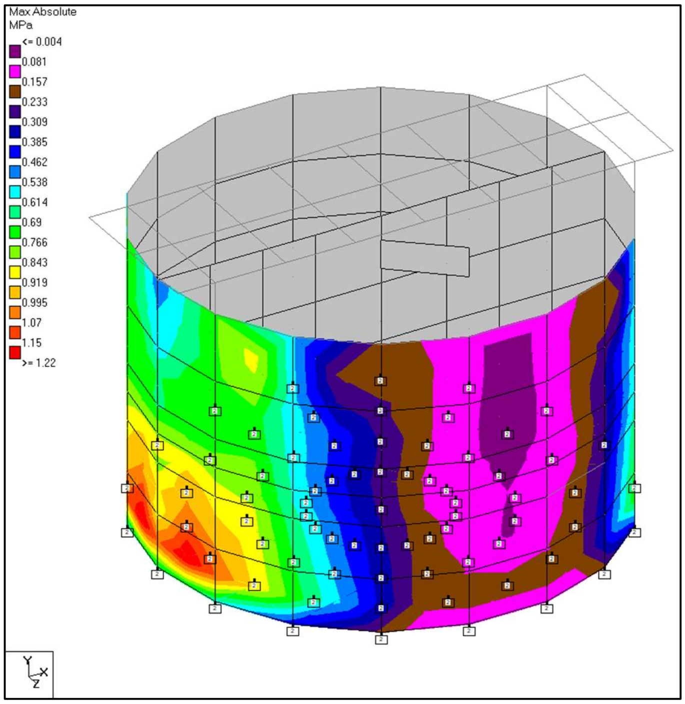


i

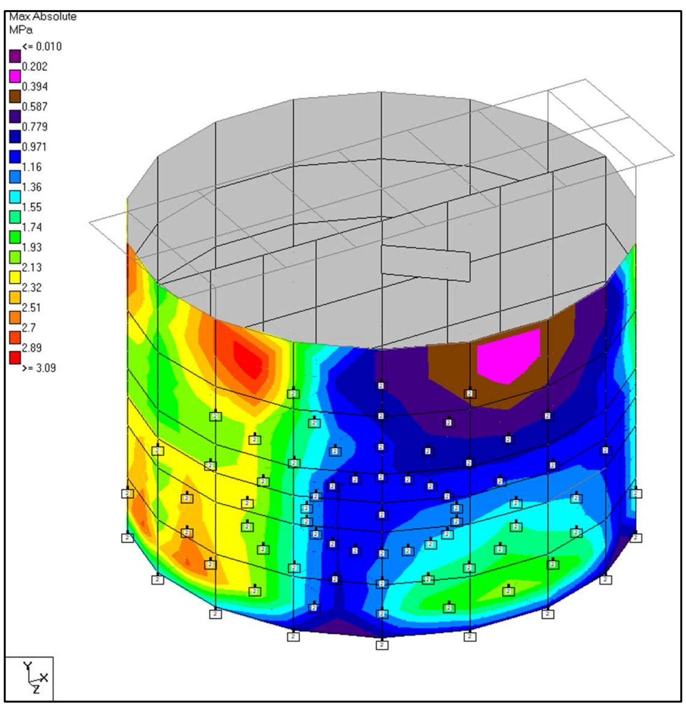
d. Wind Load (0.6 kN/m2)



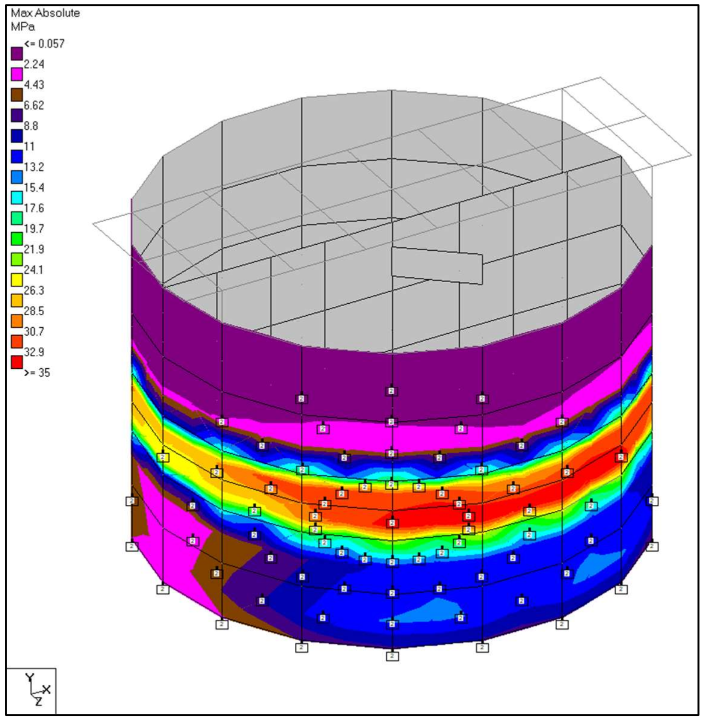
4.3.2 Output Data



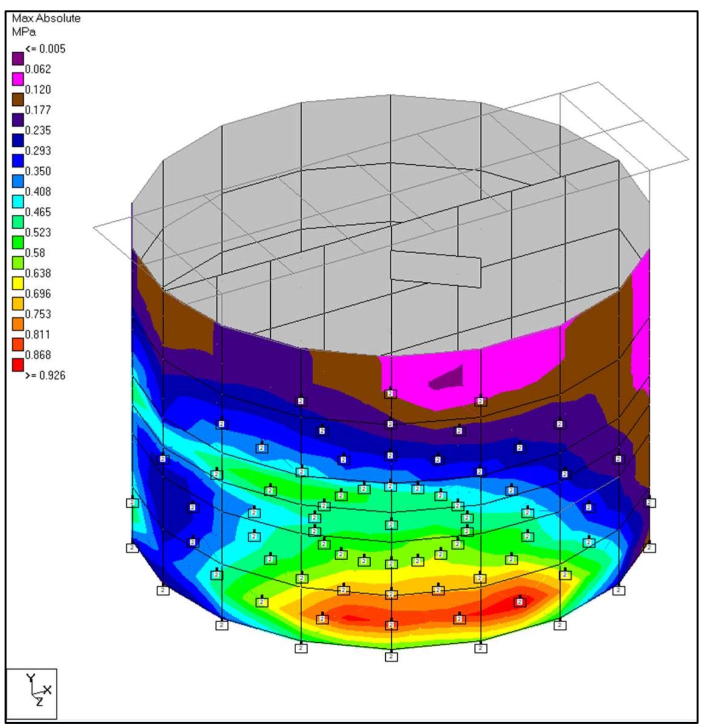
Stress Shell due Selfweight (max : 1.22 MPa)



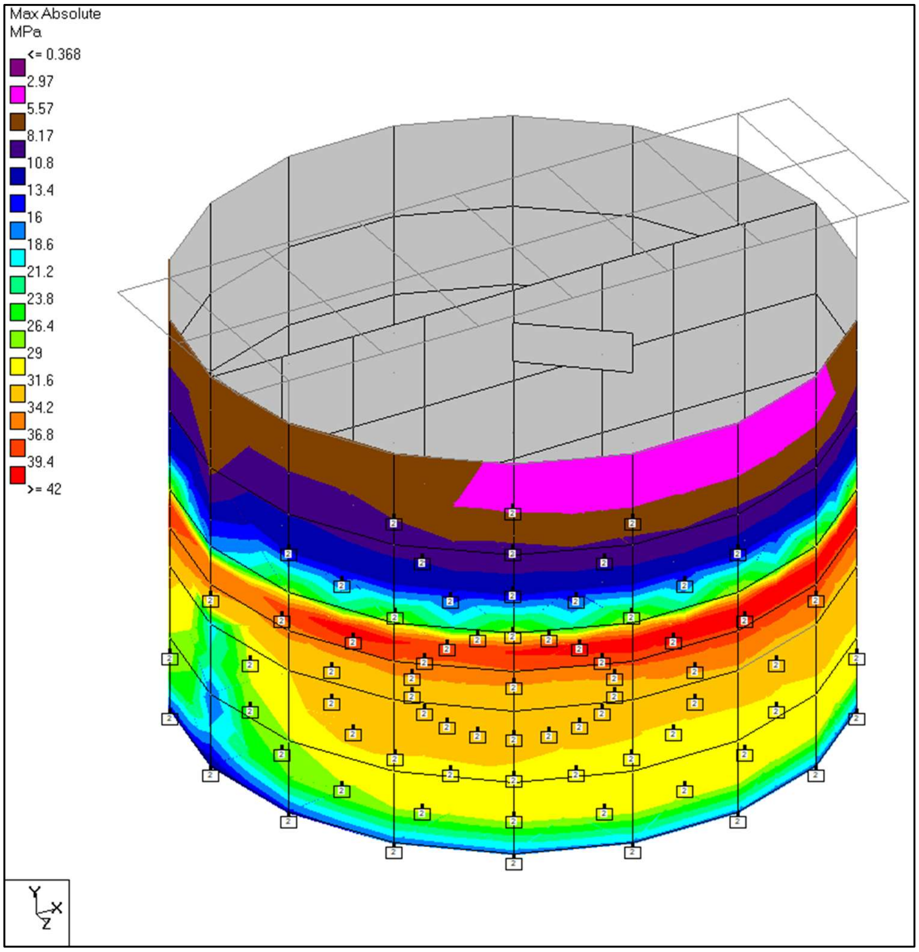
Stress Shell due Platform Support (max : 3.1 MPa)



Stress Shell due Seismic Load EQx (max : 35 MPa)



Stress due Windload Wx+ (max : 1 MPa)

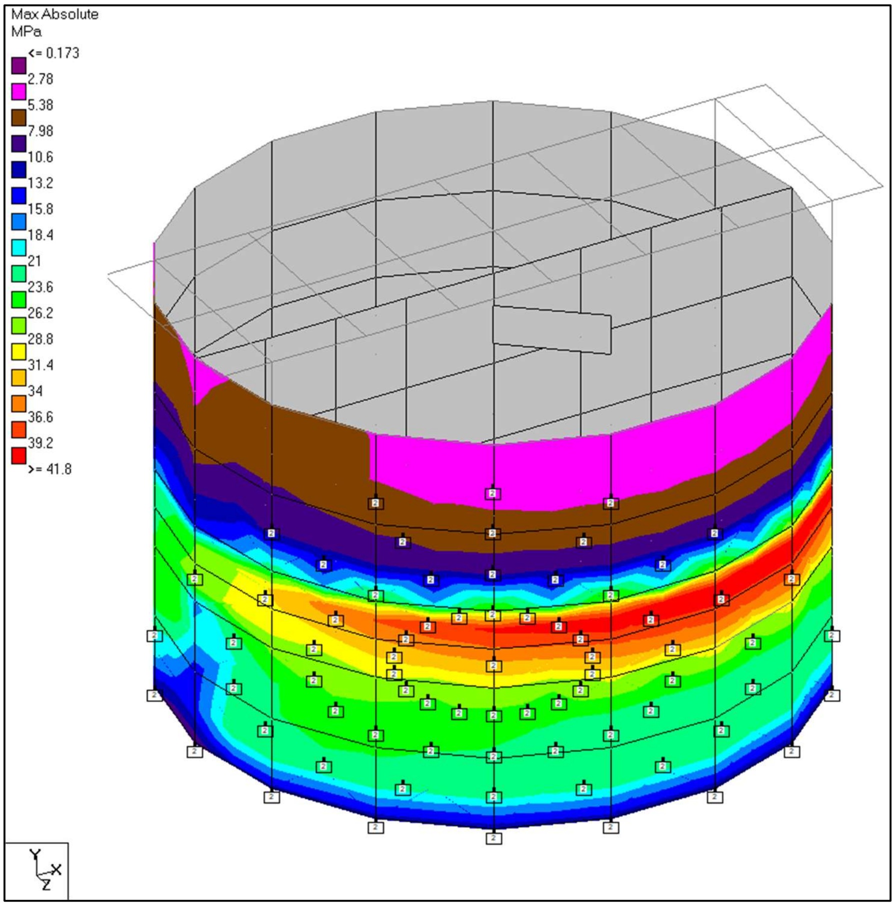


Stress due Load Combination (Service) (max : 70.5 MPa)

Stress Summary Table

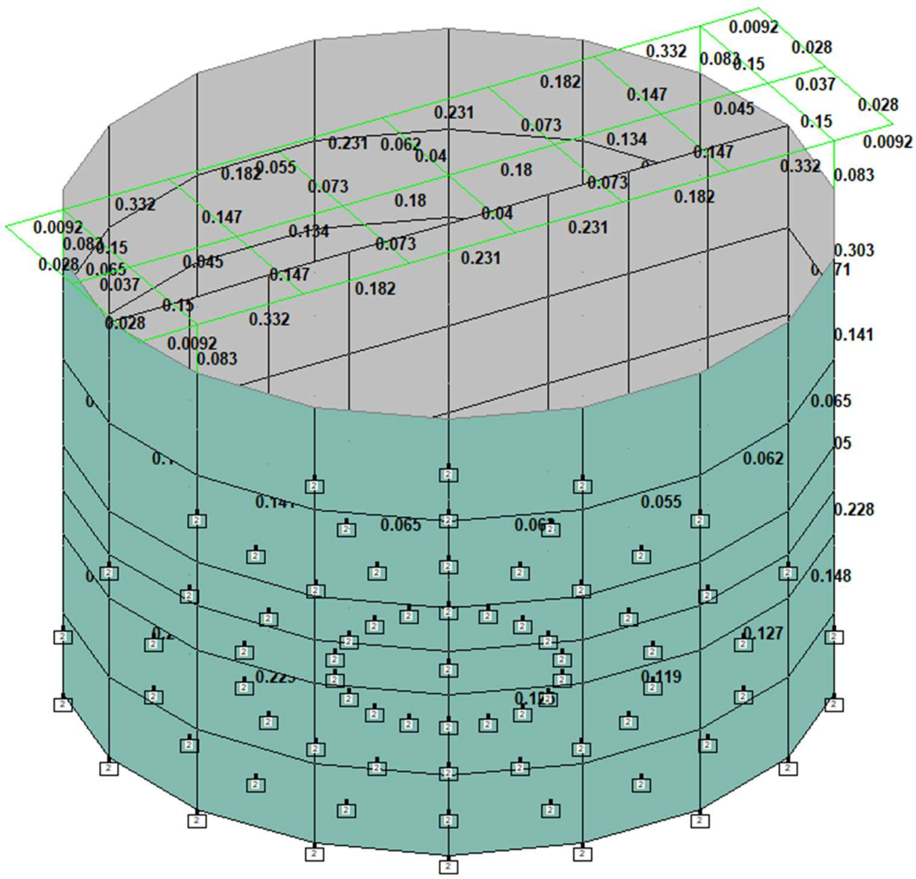
	Plate	L/C	Shear (Local)		Membrane (Local)			Bending Moment (Local)		
			SQX MPa	SQY MPa	SX MPa	SY MPa	SXY MPa	MX kN-m/m	MY kN-m/m	MXY kN-m/m
Max Qx	400	19 201	0.259	0.003	-0.411	0.447	8.497	0	0	-0.07
Min Qx	382	19 201	-0.259	-0.003	0.399	-0.49	-8.771	0	0	0.07
Max Qy	403	20 202	-0.006	0.142	18.419	-0.18	0.113	0.011	0.006	-0.002
Min Qy	385	20 202	0.006	-0.142	-18.386	0.137	0.16	-0.011	-0.006	0.002
Max Sx	403	24 206	-0.004	0.101	**39.427**	0.454	0.538	0.01	0.01	-0.002
Min Sx	385	20 202	0.006	-0.142	-18.386	0.137	0.16	-0.011	-0.006	0.002
Max Sy	39	24 206	0	-0.008	24.936	4.583	0.846	0	0.001	0
Min Sy	268	18 103	0	0	-0.33	-7.609	3.725	0	0	0
Max Sxy	43	24 206	-0.002	-0.008	15.462	-3.049	14.214	0	0	0
Min Sxy	51	24 206	0.003	-0.009	15.006	-4.551	-14.05	0	0	0
Max Mx	276	20 202	0.004	-0.011	0.27	-0.816	0.218	0.018	0.009	-0.008
Min Mx	275	22 204	0.004	0.011	0.27	-0.816	-0.218	-0.018	-0.009	-0.008
Max My	405	23 205	0.028	0.097	38.763	-0.488	1.611	0.011	0.01	0.013
Min My	275	22 204	0.004	0.011	0.27	-0.816	-0.218	-0.018	-0.009	-0.008
Max Mxy	399	19 201	0.202	-0.004	-0.502	0.37	-0.091	0	0	0.086
Min Mxy	381	19 201	-0.202	0.004	0.535	-0.413	-0.182	0	0	-0.086

Maximum stress Sx occurred due combination load 206 : 1.0DL + 0.525 EQ + 0.75LL + 0.75Hidrostatic



Stress due Combination 103 (max : 41.8 MPa)

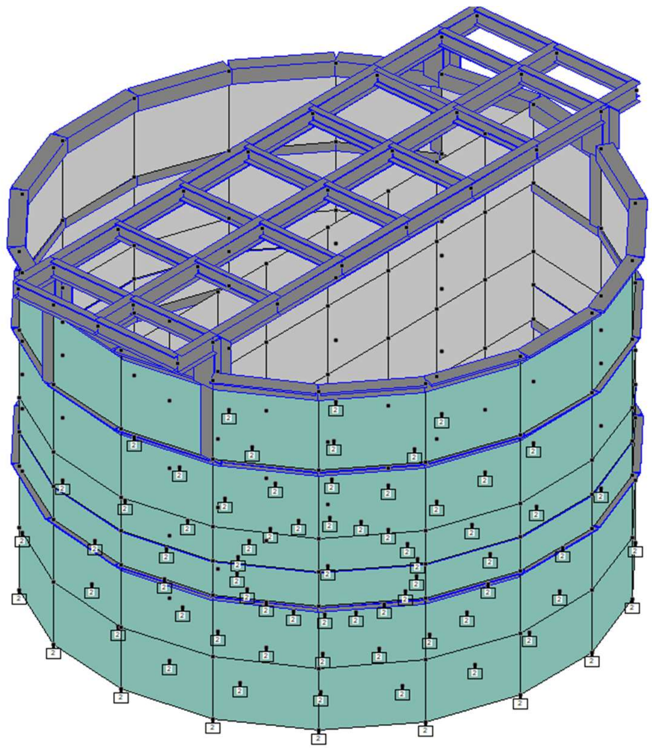
All Stress ratio stiffener frame condition are under allowance (1) :



5. Conclusion

- All component, steel frame and steel shell with current configuration is capable to resist the loads.

- The configuration as follows :



Material			
PLATE			
Shell elev. (m)	Main Thickness (mm)	Corrosion Allowance (mm)	Design Thickness (mm)
Bottom Plate	7	3	10
0 - 1.8	5	3	8
1.8 - 4.5	5	3	8
STIFFENER			
Profile elev. (m)	Type		
1.65	L.130.130.12		
3.45	L.130.130.12		
4.5	L.200.200.25		
PLATFORM SUPPORT			
Profile elev. (m)	Type		
4.5	Half Tee. 300.300.10.15		

Anchor Bolt Design

A-s = Installed Bolt Nominal Root Area (mm^2)
A-s-r = Anchor Required Root Area (mm^2)
Av = Seismic Vertical Earthquake Acceleration Coefficient (g)
Ca-anchor = Anchor Corrosion Allowance (mm)
D = Tank nominal diameter (m)
Dac = Bolt Circle Diameter (m)
Fp = Design Pressure Operating Ratio
Fty = Minimum Yield Strength of the Bottom Shell Course (MPa)
Fy = Anchor Yield Strength per API-650 Table 5.21a (MPa)
Fy-ambient = Anchor Yield Strength at Ambient Temperature per API-650 Table 5.21a (MPa)
H = Tank Height (m)
MWS = Shell Wind Overturning Moment (N.m)
Ma-anchor = Anchor Material
Mrw = Seismic Overturning Moment (N.m)
N = Anchors Quantity
N-min = Minimum Required Number of Anchors per API-650 5.12.3
OD = Tank Outer diameter (m)
P = Internal Pressure (kPa)
P-attachment = Anchor Attachment Design Load per API-650 5.12.13 and Steel Plate Engineering Data-Volume 2 Part V (N)
PWR = Roof Wind Pressure (kPa)
Pt = Test Pressure (kPa)
Sd = Allowable Anchor Stress per API-650 Table 5.21a (MPa)
Sd-shell = Allowable Shell Stress at Anchor Attachment per API-650 Table 5.21a (MPa)
Tb = Load per Anchor per API-650 5.12.2 (N)
U = Net Uplift Load per API-650 5.12.2 (N)
W1 = Corroded Weight of the Roof Plates Plus the Corroded Weight of the Shell and any Other Corroded Permanent Attachments Acting on the Shell (N)
W2 = Corroded Weight of the Shell and any Corroded Permanent Attachments Acting on the Shell Including the Portion of the Roof Plates and Framing Acting on The Shell (N)
W3 = Nominal Weight of the Roof Plates Plus the Nominal Weight of the Shell and any Other Permanent Attachments Acting on the Shell (N)
Wr-pl = Roof Plates Nominal Weight (N)
Wr-pl-corr = Roof Corroded Plates Weight (N)
Wrs-pl-corr = Roof Plates Corroded Weight Acting on The Shell (N)
Ws-framing = Shell New Framing Weight (stiffeners) (N)
Ws-framing-corr = Shell Corroded Framing Weight (stiffeners) (N)
Ws-pl = Shell Plates Nominal Weight (N)
Ws-pl-corr = Shell Corroded Plates Weight (N)
Wss = Roof Structure Nominal Weight Acting on The Shell (N)
Wss-corr = Roof Structure Corroded Weight Acting on The Shell (N)
Y-bolt = Anchor Yield Load (N)
d = Anchor Bolt Diameter (mm)
d-req = Bolt Required Diameter per ANSI B1.1 (mm)
p = Bolt Thread Pitch (mm)
position_angles = Anchors Position Angles (deg)

Av = 0.38 g
Ca-anchor = 1.5 mm
D = 7.0 m
Dac = 7.18 m
Fp = 0.4
Fty = 250.0 MPa
H = 4.5 m
MWS = 22,094.37 N.m
Ma-anchor = A307-B
Mrw = 552,412.65 N.m
N = 12
OD = 7.02 m
P = 0.0 kPa
PWR = 0 kPa
Pt = 0.0 kPa
Wr-pl = 0.0 N
Wr-pl-corr = 0.0 N
Wrs-pl-corr = 0 N
Ws-framing = 8,123.97 N
Ws-framing-corr = 5,520.52 N
Ws-pl = 60,937.3 N
Ws-pl-corr = 38,085.81 N
Wss = 21,458.49 N
Wss-corr = 0.0 N
d = 27 mm
p = 3.0 mm
position_angles = [0 30 60 90 120 150 180 210 240 270 300 330] deg

Anchors Spacing Requirements
Max Allowable Spacing Between Anchors at Shell Outer Diameter per API-650 5.12.3
Max Allowable Spacing (max_allowable_spacing) = 3 m
Actual Spacing (actual_spacing) = 1.84 m

actual_spacing <= max_allowable_spacing ==> PASS

N-min = CEILING(((pi * OD) / 3))
N-min = CEILING(((pi * 7.016) / 3))
N-min = 8

N >= N-min ==> PASS

Anchors meet spacing requirements.

Anchors Average Spacing (half the span on each side of the anchor) at Bolt Circle
Anchors are equally spaced.
Average Spacing (average_spacing) = 1.88 m
Bolt loads will be based on equally spaced anchors.

Anchor Material Properties
Material (A307-B) = A307-B
Minimum Tensile Strength (Sut-anchor) = 415 MPa
Minimum Yield Strength (Sy-anchor) = 250 MPa
Minimum Yield Strength at Ambient Temperature (Sy-ambient-anchor) = 250 MPa

Fy = MIN(Sy-ambient-anchor , 380)
Fy = MIN(250 , 380)
Fy = 250 MPa

Fy-ambient = MIN(Sy-ambient-anchor , 380)
Fy-ambient = MIN(250 , 380)
Fy-ambient = 250 MPa

Uplift Load Cases per API-650 Table 5.21a
W1 = Ws-pl-corr + Ws-framing-corr + Wr-pl-corr
W1 = 38,085.8123 + 5,520.5153 + 0.0
W1 = 43,606.33 N

W2 = Ws-pl-corr + Ws-framing-corr + Wrs-pl-corr + Wss-corr
W2 = 38,085.8123 + 5,520.5153 + 0 + 0.0
W2 = 43,606.33 N
W3 = Ws-pl + Ws-framing + Wr-pl + Wss
W3 = 60,937.2996 + 8,123.9667 + 0.0 + 21,458.4928
W3 = 90,519.76 N

Uplift Case 1: Design Pressure Only
U = (P * (D^2) * 785) - W1
U = (0.0 * (7.0^2) * 785) - 43,606.3275
U = -43,606.33 (Set to 0 N since it cannot be less than 0)

Tb = U / N
Tb = 0 / 12
Tb = 0 N

Sd = (5 / 12) * Fy
Sd = (5 / 12) * 250
Sd = 104.17 MPa

A-s-r = Tb / Sd
A-s-r = 0 / 104.1667
A-s-r = 0.0 mm^2

P-attachment = 1.5 * Tb
P-attachment = 1.5 * 0
P-attachment = 0.0 N

Sd-shell = (2 / 3) * Fty
Sd-shell = (2 / 3) * 250.0
Sd-shell = 166.67 MPa

Uplift Case 2: Test Pressure Only
U = (Pt * (D^2) * 785) - W3
U = (0.0 * (7.0^2) * 785) - 90,519.7592
U = -90,519.76 (Set to 0 N since it cannot be less than 0)

Tb = U / N
Tb = 0 / 12
Tb = 0 N

Sd = (5 / 9) * Fy-ambient
Sd = (5 / 9) * 250
Sd = 138.89 MPa

A-s-r = Tb / Sd
A-s-r = 0 / 138.8889
A-s-r = 0.0 mm^2

P-attachment = 1.5 * Tb
P-attachment = 1.5 * 0
P-attachment = 0.0 N

Sd-shell = (5 / 6) * Fty
Sd-shell = (5 / 6) * 250.0
Sd-shell = 208.33 MPa

Uplift Case 3: Wind Load Only
U = ((PWR * (D^2) * 785) + ((4 * MWS) / D)) - W2
U = ((0 * (7.0^2) * 785) + ((4 * 22,094.3692) / 7.0)) - 43,606.3275
U = -30,980.97 (Set to 0 N since it cannot be less than 0)

Tb = U / N
Tb = 0 / 12
Tb = 0 N

Sd = 0.8 * Fy
Sd = 0.8 * 250
Sd = 200.0 MPa

A-s-r = Tb / Sd
A-s-r = 0 / 200.0
A-s-r = 0.0 mm^2

P-attachment = 1.5 * Tb
P-attachment = 1.5 * 0
P-attachment = 0.0 N

Sd-shell = (5 / 6) * Fty
Sd-shell = (5 / 6) * 250.0
Sd-shell = 208.33 MPa

Uplift Case 4: Seismic Load Only
U = ((4 * Mrw) / D) - (W2 * (1 - (0.4 * Av)))
U = ((4 * 552,412.6546) / 7.0) - (43,606.3275 * (1 - (0.4 * 0.3808)))
U = 278,700.16 N

Tb = U / N
Tb = 278,700.1623 / 12
Tb = 23,225.01 N

Sd = 0.8 * Fy
Sd = 0.8 * 250
Sd = 200.0 MPa

A-s-r = Tb / Sd
A-s-r = 23,225.0135 / 200.0
A-s-r = 116.13 mm^2

P-attachment = 3 * Tb
P-attachment = 3 * 23,225.0135
P-attachment = 69,675.04 N

Sd-shell = (5 / 6) * Fty
Sd-shell = (5 / 6) * 250.0
Sd-shell = 208.33 MPa

Uplift Case 5: Design Pressure + Wind Load
U = ((((Fp * P) + PWR) * (D^2) * 785) + ((4 * MWS) / D)) - W1
U = ((((0.4 * 0.0) + 0) * (7.0^2) * 785) + ((4 * 22,094.3692) / 7.0)) - 43,606.3275
U = -30,980.97 (Set to 0 N since it cannot be less than 0)

Tb = U / N
Tb = 0 / 12
Tb = 0 N

Sd = (5 / 9) * Fy
Sd = (5 / 9) * 250
Sd = 138.89 MPa

A-s-r = Tb / Sd
A-s-r = 0 / 138.8889
A-s-r = 0.0 mm^2

P-attachment = 1.5 * Tb
P-attachment = 1.5 * 0
P-attachment = 0.0 N

Sd-shell = (5 / 6) * Fty
Sd-shell = (5 / 6) * 250.0
Sd-shell = 208.33 MPa

Uplift Case 6: Design Pressure + Seismic Load
U = ((Fp * P * (D^2) * 785) + ((4 * Mrw) / D)) - (W1 * (1 - (0.4 * Av)))
U = ((0.4 * 0.0 * (7.0^2) * 785) + ((4 * 552,412.6546) / 7.0)) - (43,606.3275 * (1 - (0.4 * 0.3808)))
U = 278,700.16 N

Tb = U / N
Tb = 278,700.1623 / 12
Tb = 23,225.01 N

Sd = 0.8 * Fy
Sd = 0.8 * 250
Sd = 200.0 MPa

A-s-r = Tb / Sd
A-s-r = 23,225.0135 / 200.0
A-s-r = 116.13 mm^2

P-attachment = 3 * Tb
P-attachment = 3 * 23,225.0135
P-attachment = 69,675.04 N

Sd-shell = (5 / 6) * Fty
Sd-shell = (5 / 6) * 250.0
Sd-shell = 208.33 MPa

Uplift Case 7: Frangibility Pressure
Not applicable. It is applied if the roof to shell joint is frangible.

Summary of Uplift Cases

Uplift Cases	Total Uplift Load (N)	Load per Anchor (N)	Anchor Allowable Stress (MPa)	Anchor Required Area (mm^2)	Anchor Bolt Required Diameter (mm)	Attachment Design Load (N)	Allowable Shell Stress at Anchor Attachment (MPa)
Design Pressure	0	0	104.17	0.0	6.68	0.0	166.67
Test Pressure	0	0	138.89	0.0	6.68	0.0	208.33
Wind Load	0	0	200.0	0.0	6.68	0.0	208.33
Seismic Load	278,700.16	23,225.01	200.0	116.13	18.84	69,675.04	208.33
Design Pressure + Wind	0	0	138.89	0.0	6.68	0.0	208.33
Design Pressure + Seismic	278,700.16	23,225.01	200.0	116.13	18.84	69,675.04	208.33

- Anchor Bolt Required Diameter = SQRT((A-s-r * (4 / pi))) + (1.22687 * p) + (Ca-anchor * 2)
- Governing Uplift Case = Seismic Load
- Anchor Bolt Minimum Required Area = 116.13 mm^2

Bolt Required Diameter per ANSI B1.1

d-req = SQRT((A * (4 / pi))) + (1.22687 * n) + (Ca * 2)
d-req = SQRT((116.1251 * (4 / pi))) + (1.22687 * 3.0) + (1.5 * 2)
d-req = 18.84 mm

d >= d-req ==> PASS

A-s = (pi / 4) * ((d - (1.22687 * n))^2)
A-s = (pi / 4) * ((27 - (1.22687 * 3.0))^2)
A-s = 427.09 mm^2

Y-bolt = A-s * Sy-ambient-anchor
Y-bolt = 427.0948 * 250
Y-bolt = 106,773.69 N

Anchorage Summary

Required Number of Anchors = 8
Actual Number of Anchors = 12
Bolt Hole Circle Radius = 3.59 m
Required Bolt Diameter = 18.84 mm
Actual Bolt Diameter = 27 mm
Bolt Thread Pitch = 3.0 mm