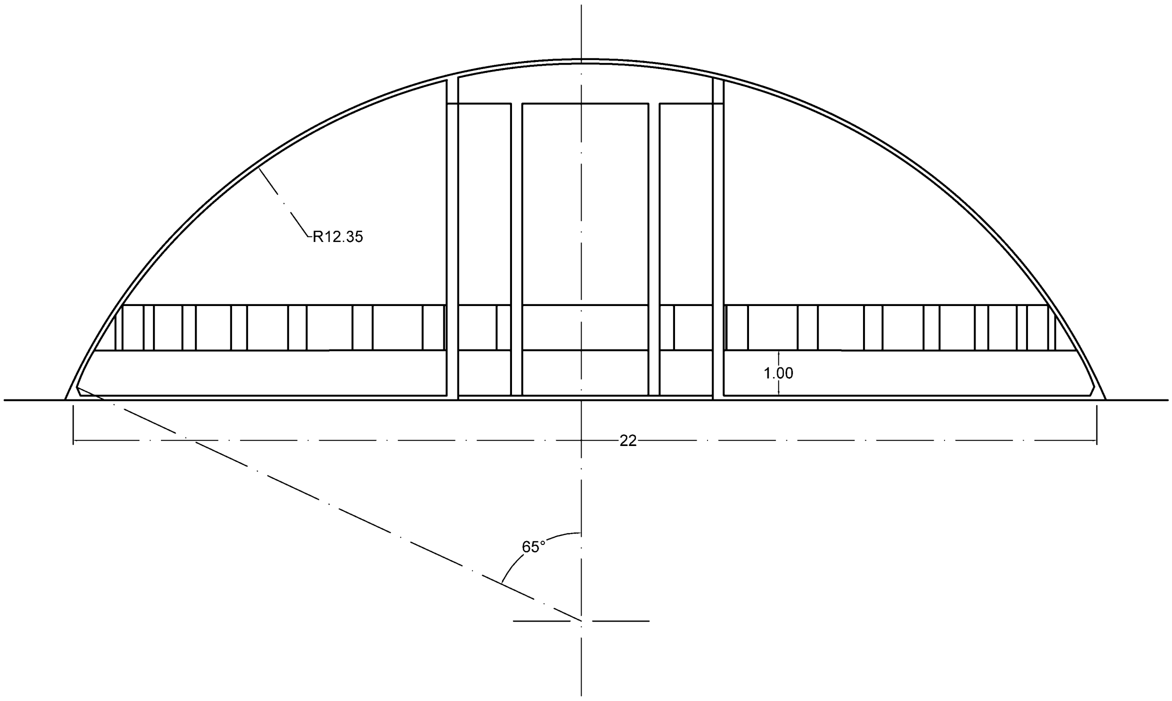
Elevated tank (spherical domes)

1. **Short note about function**
   The main objective of this dome. To cover top of elevated tank and achieve architectural purpose
2. **Dimension and layout**
   $span = 22\ m$
   $Radius = 12.35\ m$
   $\theta_0 = 65^{\circ}$
   $t_s = 12\ cm\ by\ assume$



3. **Load**
   $dead\ load = 2.5 * .12 = .3\ t/m^2$

   $live\ load\ = .1\ t/m^2\ \ form\ \ ECP\ 201$

   تصور الجزء من الكود وتحطة هنا صفحة 31 في كود الاحمال

   Dome exposed to wind loads

$$ratio\ between\ span\ and\ hight = \frac{22}{7.35} = .33 \cong .4$$

$$c_e = .4\ for\ \text{Quarter front} - \text{facing wind direction}$$

نضع صورة الجدول صفحة 99 في كود الاحمال

Domes high between 30 and 50 meter

$$k = 1.5\ from\ ECP\ 201\ 2012\ table\ 7-3\ \ page\ 88$$

$$p_e = 1.5 * .5 * .4 = .3\ kN/m^2 \rightarrow .03\ t/m^2$$

Total load of wind and live load

$$P_{total} = .03 + .1 = .13\ t/m^2$$

4. Straining action

By using sap2000

As a thin shell have

$$t_s = .12\ m$$

$$p_{total} = .13\ t/m^2\ on\ H.P$$

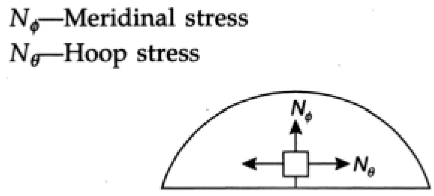
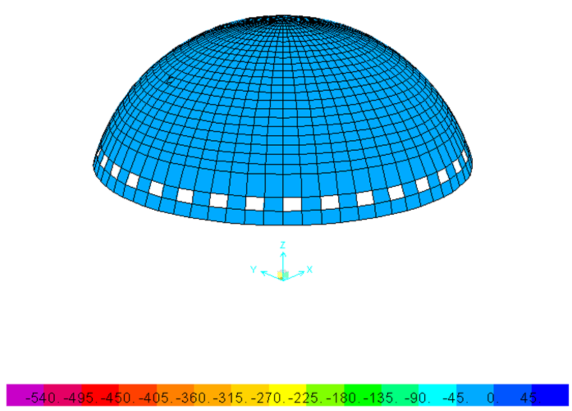
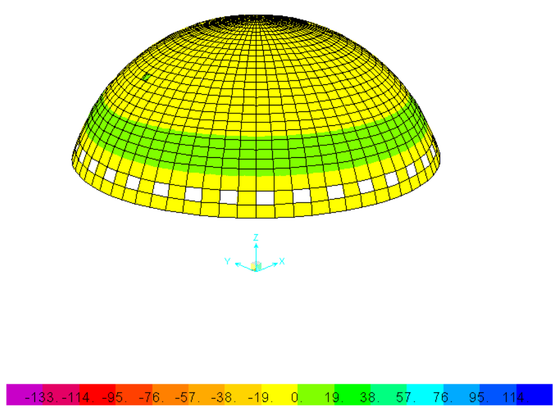


Figure: - membrane force spherical shell

$$dead\ load\ :\ Calculated\ by\ sap\ 2000\ according\ to\ section\ properties$$



Meridian force –all load- ultimate



Hoop force-all load- ultimate

Load type	Case of loading	Meridian force		Hoop force	
		Max-Cop	Max-ten	Max-Cop	Max-ten
All load	Ultimate	-6.5	0	-4.13	$+1.08$
All load	Working	-4.5	0	-2.9	$+.74$

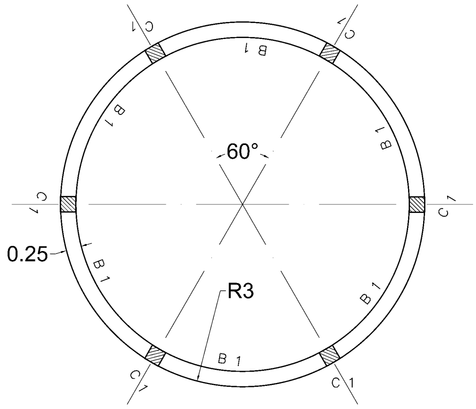
Reference	Step	*Calculation*
Chapter 19 (Design of Reinforced Concrete Shells and Folded Plates)	1	Check compression for buckling $\sigma_{cr} = \frac{E * t}{R\sqrt{3}}$ $\sigma_{cr} = \frac{242487.11 * 12}{1235 * \sqrt{3}} = 1360.32\ kg/cm^2$ $\sigma_{cr-allow} = \frac{1360.32}{4} = 340.08\ kg/cm^2$ $\sigma_{ac} = \frac{4.5 * 1000}{12 * 100} = 3.75\ kg/cm^2$ $\sigma_{ac} \ll \sigma_{cr-allow}$ Very safe against buckling
	2	Design of section Water section $N_\theta = +1.08\ ton$ $Hoop\ stress = \frac{1.08 * 1000}{12 * 100} = .9\ kg/cm^2$ $t_v = 12 * \left(1 + \frac{.9}{0}\right) = \infty$ $\eta = 1.7$ Allowable tensile stress $F_{ctr} = \frac{.6 * \sqrt{30}}{1.7} = 1.9\ N/mm^2 \rightarrow 19\ kg/cm^2$ $Hoop\ stress << F_{ctr}$ $A_s = \frac{.9}{\frac{3600}{1.15} * .93} = 3.09 * 10^{-4}\ very\ small$ Used minimum reinforcement $A_s = \frac{.2}{100} * 100 * 12 = 2.4\ cm^2 \rightarrow 5\ \emptyset\ 8/m$

	3	Check edge moment
		$Moment = .063\ \ t.m$
		Air section
		$12 - 1.5 = C1\sqrt{\frac{.063 * 10^5}{300 * 100}}$
		$C1 = 22.9 \qquad j = .826$
		$A_s = \frac{.063 * 10^5}{3600 * .826 * 10.5} = .20\ cm^2$
		$A_{s-min} = 1.5\ cm^2 \qquad used\ 5\ Ø\ 8/m\ \ l = 5m$

Elevated tank (ring beams and columns)

1. **Short note about function**

To support domes in the middle of span



2. **Dimension and layout**

$$\boldsymbol{B1 \rightarrow 25 * 50\ cm}$$

$$\boldsymbol{Span = 3.14\ m}$$

$$\boldsymbol{C1 \rightarrow 25 * 25\ cm}$$

5. **Load**

On ring beam

Dead load come from Owen weight of beam and dead load transferred to beam from domes that carry

$o.w = 2.5 * .25 * .50 = .31\ t/m$

$live\ load\ come\ from\ domes$

On columns

$Dead\ load$

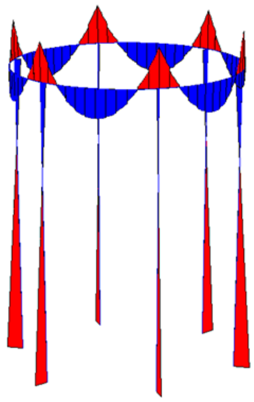
Owem weight of colume and dead load trnsfred from ring beam

Live load

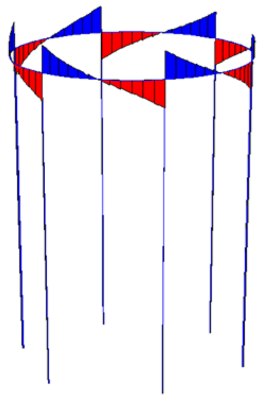
Load trnsfered by ring beam

6. **Straining action**

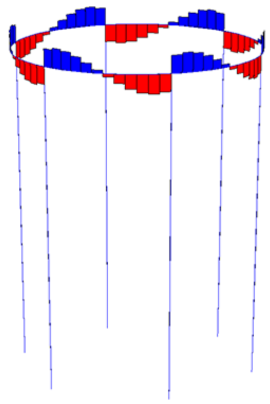
By using sap2000



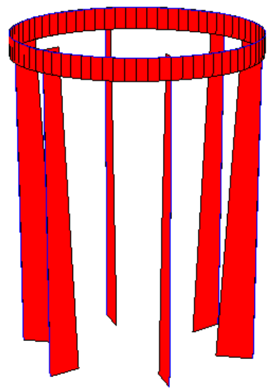
Bending moment



Shear force



Torsion force

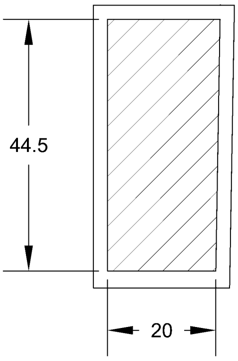


Axial force

Elements	Load	Load case	Bending moment		Shear force		Torsion		Axial force	
			Min	Max	Min	Max	Min	Max	Min	Max
Beam	All load	Ultimate	-.30	+.23	0	.61	0	.25	0	0
Columns	All load	Ultimate	0	0	0	0	0	0	-1.58	-3.20

Reference	Step	*Calculation*
	1.	Design of beam
		$b = 25\ cm$
		$t = 50\ cm$
ECP 202 table 4-13		$d^* = 3\ cm$
		$d = 50 - 3 = 47\ cm$
	1.1	Design shear and torsion
		$Q_u = .61\ ton$
		$M_{tu} = .25\ \ t.m$
		For shear
		$q_u = \frac{Q_u * 1000}{b * d}$
		$q_u = \frac{.61 * 1000}{25 * 47} = .52\ kg/cm^2$
		$q_{cu} = .75 \sqrt{\frac{300}{1.5}} = 10.60\ kg/cm^2$

For torsion



Effective section on torsion

$$A_\circ = .85 * X_1 * Y_1$$

$$A_\circ = .85 * 20 * 44.5 = 756.5\ cm^2$$

$$t_e = \frac{x_1 * y_1}{2(x_1 + y_1)}$$

$$t_e = \frac{20 * 44.5}{2(20 + 44.5)} = 6.89\ cm$$

$$q_{tu} = \frac{.25 * 10^5}{2 * 756.5 * 6.89} = 2.39\ kg/cm^2$$

$$.2 * \sqrt{\frac{300}{1.15}} = 2.828\ kg/cm^2$$

$$q_{tu} < .2 * \sqrt{\frac{300}{1.15}} \quad Neglect\ torsion$$

$$q_u < q_{cu} \quad no\ shear\ designe$$

Used minimum stirrups $5\emptyset 8/m$ $closed\ stirrups$

1.2	Design section under bending moment
1.2.1	$M_u = .23 \quad t.m$ Water section
1.2.1.1	Working stage

$M_w = .17 \quad t.m$

Check stress

$$F_M = \frac{6 * M_w}{b * t^2}$$

$$F_M = \frac{6 * .17 * 10 * 10^6}{250 * 470^2} = .20\ Mpa$$

$$t_v = t * \left[1 \mp \frac{F_N}{F_M}\right]$$

$$t_v = 470 * \left[1 + \frac{0}{.20}\right] = 470\ mm$$

$$\eta = 1.65$$

$$F_{ctr} = .6 * \frac{\sqrt{30}}{1.65} = 1.99\ Mpa$$

$$F_M \ < \ F_{ctr} \qquad safe$$

1.2.1.2 Ultimate stage

$M_u = .23 \quad t.m$

$$50 - 3 = C1\sqrt{\frac{.23 * 10^5}{300 * 25}}$$

$C1 = 33.5$ $j = .826$

$$A_s = \frac{.23 * 10^5}{3600 * .826 * .85 * 47} = .1936\ cm^2$$

$A_{s-min} = 1.76\ cm^2$ $used\ 2\ \emptyset\ 12$

1.2.2 $M_u = .30\ \ t.m$ aire section

$$50 - 3 = C1\sqrt{\frac{..30 * 10^5}{300 * 25}}$$

$C1 = 29.4$ $j = .826$

$$A_s = \frac{.30 * 10^5}{3600 * .826 * .85 * 47} = .252\ \ cm^2$$

$A_{s-min} = 1.76\ cm^2$ $used\ 2\ \emptyset\ 12$