www.rcenggstudios.com	DESIGN OF WATER TANK RING WALL FOUNDATION	Revision :
		Date :

TANK GEOMETRY

Tank Internal Diameter	D	=	**3000**	mm
Height of the Tank	H	=	**3600**	mm
Tank Shell thickness	ts	=	**8**	mm
Tank Base thickness	tb	=	**8**	mm

FOUNDATION GEOMETRY

Width of the Ringwall	w	=	**0.650**	m
Height of the Ringwall above HPP	h_1	=	**1000**	mm
Depth of the Ringwall below HPP	h_2	=	**1000**	mm
Width of foundation ring ,W	W	=	**5.5**	m
Thickness of slab	tc	=	**650**	mm
Total height of the Ringwall	h	=		
		=	2000	mm
Inner diameter of the ringwall		=	3-0.65	
		=	2.350	m
Outer diameter of the ringwall		=	3+0.65	
		=	3.650	m
Width of liquid column on the ringwall	a	=	0.65*1000/2-8/2	
		=	321.0	mm
Area of the ring	A_r	=	π*(3.65^2-2.35^2)/4	
		=	6.13	m^2
Section modulus of the ring	Z_r	=	π*(3.65^4-2.35^4) / (32*3.65)	
		=	3.95	m^3
Radius of centre line of ring wall,R		=	2.00	m
Inner radius of the ring wall,R_{r1}		=	1.35	m
Outer radius of the ring wall,R_{r2}		=	2.33	m
Inner radius of the ring wall footing,R_{f1}		=	4.50	m
Outer radius of the ring wall footing,R_{f2}		=	6.50	m
$I_{RING\ WALL}$ =	$(3.14/64)*(R_{r2}^4-R_{r1}^4)$	=	1.27	m^4
$Z_{RING\ WALL}$ =	$I_{RING\ WALL}/R_{r2}$	=	0.55	m^3
$I_{RING\ WALL\ FOOTING}$ =	$(3.14/64)*(R_{f2}^4-R_{f1}^4)$	=	67.46	m^4
$Z_{RING\ WALL\ FOOTING}$ =	$I_{RING\ WALL\ FOOTING}/R_{f2}$	=	10.38	m^3
Area of ring wall footing,A_{fr}	=(3.14*(6.5^2-4.5^2))	=	69.08	m^2
Area of ring wall,A_{rw}	=(3.14*(2.325^2-1.35^2	=	11.25	m^2

SOIL DATA

Unit weight of soil	γ_{Soil}	=	**19.00**	kN/m^3
Unit weight of sand fill	γ_F	=	**19.00**	kN/m^3 (assumed)
Net SBC of soil at foundation depth		=	**48.00**	kN/m^2
Allowable Gross SBC (Without Seismic or wind)		=	48+ (1 x 19)	
		=	**67.00**	kN/m^2
Allowable Gross SBC (With Seismic or wind)		=	(48 x 1.25) + (1 x 19)	
Allowable Gross SBC (With Seismic or wind)	SBC	=	**79.00**	kN/m^2
Angle of Internal friction	Ø	=	**30.00**	°
Earth pressure coefficient at rest	Ko	=	1 - sinØ	
		=	0.50	

LOAD DATA FROM MDS

Empty Weight of the Tank (refer MDS)	EL	=	**15.00**	T
		=	**147.15**	kN
Operating volume (working capacity - refer MDS)		=	25.00	m^3
Operating Weight of liquid (refer MDS)		=	245.25	kN
Operating Weight (including empty weight)	OL	=	**25.00**	T
Operating Weight (including empty weight)	OL	=	**245.25**	kN
Hydrotest volume (Normal capacity-refer MDS)		=	25.00	m^3
Hydrotest Weight of liquid (Refer MDS)		=	245.25	kN
Hydrotest Weight (including empty weight)	HL	=	**25.00**	T
Hydrotest Weight (including empty weight)	HL	=	**245.25**	kN

Loading	Condition	Empty	Operating	Test
Shear force at top of foundation level (kN)	WIND	**3.83**	**3.83**	**-**
	SEISMIC	**-**	**46.54**	**-**
Moment at top of foundation level (kNm)	SEISMIC	**-**	**0.00**	**-**
	WIND	**0.00**	**0.00**	**-**

5.75

Seismic Load	Shear	SL_F	=	46.54	kN
	Moment	SL_M	=	0.00	kNm
Live load on roof		LLr	=	**1.20**	kN/m^2
Total live load on roof		LL	=	π*3.008^2/4*1.2	
			=	8.53	kN

LOADS ON FOUNDATION

Design Liquid Column = (25/ (PI()/4*3^2))*1000	H_D	=	3537 mm
Hydrotest Liquid Column (Height of tank)	H_T	=	3600 mm

Unit weight of Design Fluid	γ_D	=	**10.00** kN/m^3
Unit weight of Test Fluid	γ_T	=	**10.00** kN/m^3
Unit weight of concrete	γ_C	=	**30.00** kN/m^3
Unit weight of Steel	γ_S	=	**78.50** kN/m^3

Load elements directly on the Ringwall

Empty weight of tank on ringwall excluding the base plate

P_e = (147.15-π*2.35^2/4*0.008*78.5)/(π*3)

= 15.32 kN/m

Weight of operating fluid on the ringwall = 10*3.537*0.321

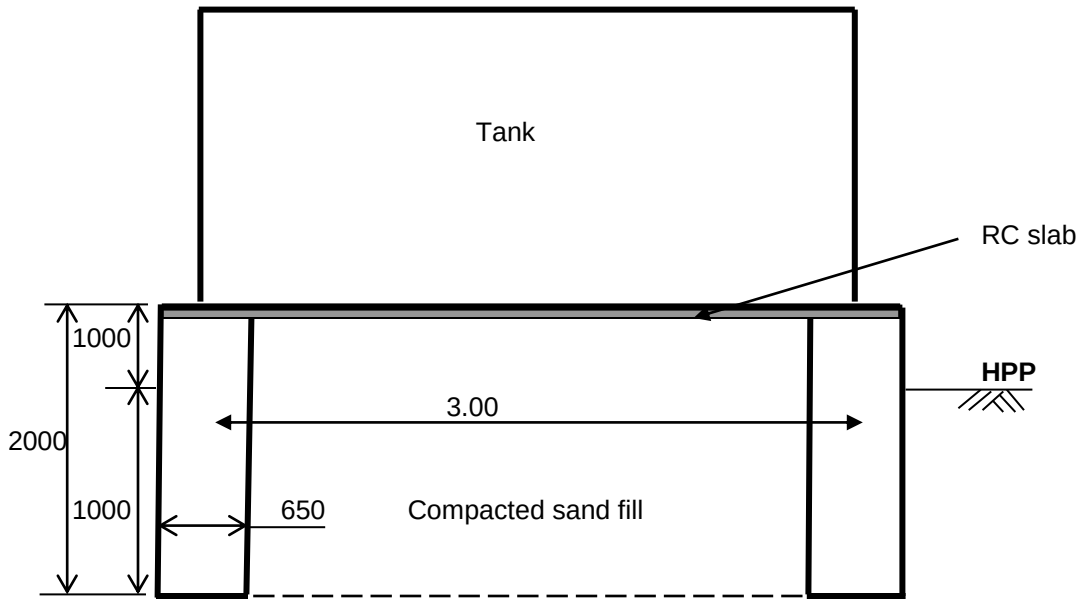
P_o = 11.35 kN/m

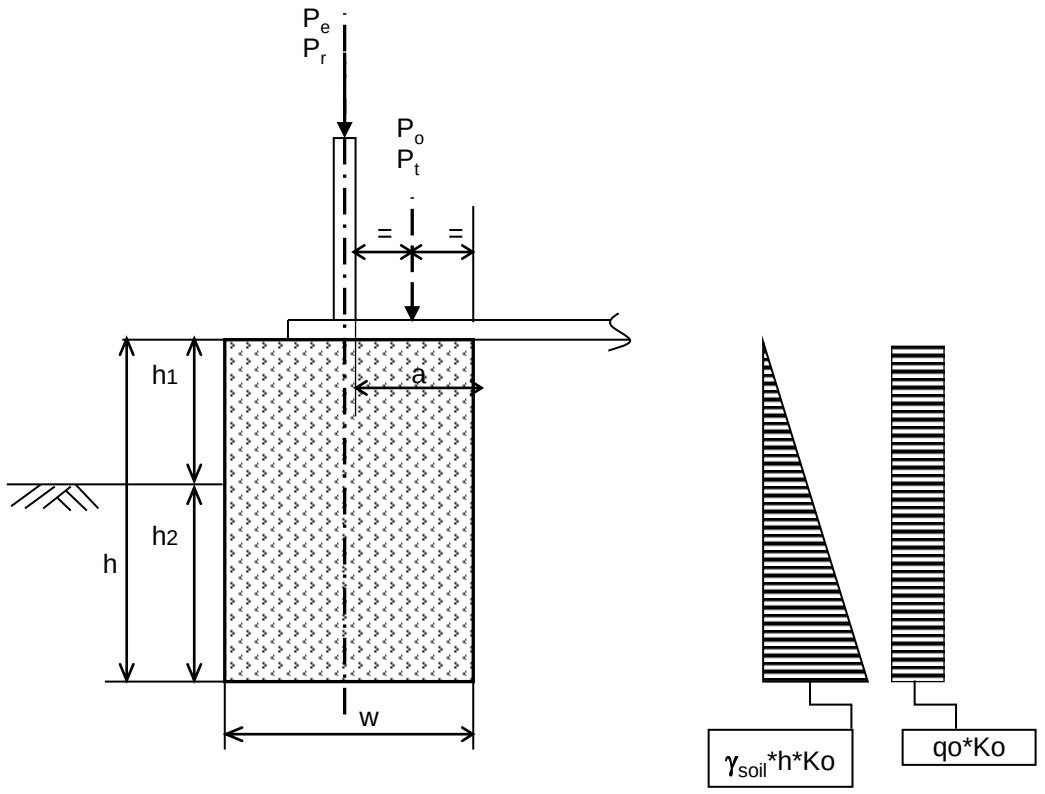
Weight of test fluid on the ringwall & slab = 10*3.6*0.321

P_t = 11.56 kN/m

Load on ringwall due to roof live load = 8.528/(pi*3)

P_r = 0.90 kN/m





Calculation of Pressure under the Ringwall foundation

Pressure due to the empty weight of tank	EL	=	15.32/69.08	
		=	0.22	kN/m^2
Pressure due to operating fluid	OL	=	11.35/69.08	
		=	0.16	kN/m^2
Pressure due to test fluid	TL	=	11.56/69.08	
		=	0.17	kN/m^2
Pressure due to roof live load	LL	=	0.9/69.08	
		=	0.01	kN/m^2
Pressure due to self weight of the ringwall	DL	=		
		=	36.28	kN/m^2

STABILITY CHECK

CHECK FOR BEARING PRESSURE

Load case	LOAD COMBINATION	P/A	M/Z	Pmax	Pmin
1	0.9DL+0.9EL+0.5WL	32.85	0.73	33.58	32.12
2	DL+OL+LL	8.45	0.00	8.45	8.45
3	DL+OL+LL+WL	36.67	1.45	38.12	35.22
4	DL+OL+0.5LL+SL	36.67	23.54	60.21	13.12
5	DL+TL+0.5LL+0.5WL	36.67	0.73	37.40	36.31

CASE I : (0.9DL+0.9EL+0.5WL)

Shear force at the base of the tank (due to wind)		=	3.83	kN
Total moment on the ringwall at the base of foundation		=	(5.75)*0.5	
		=	2.88	kNm
Pressure due to Wind load	M/Zr	=	2.88/3.95	
		=	0.73	kN/m^2
Maximum pressure below ring wall		=	0.9* 0.22+0.73+ 0.9* 36.28	
		=	33.58	kN/m^2
			< Net SBC. OK	

Minimum pressure below ring wall = 0.9* 0.22-0.73+ 0.9* 36.28
= 32.12 kN/m^2
No Tension. Hence OK.

CASE II : DL+OL+LL

Pressure below the ringwall = 0.22+0.16+0.01+36.28
= 8.45 kN/m^2
< Net SBC. OK

Pressure below the tank = 0.63+35.37+25.65+19.5
= 61.65
< Net SBC. OK

CASE III : DL+OL+LL+WL

Shear force at the base of the tank = 3.83 kN

Total moment on the ringwall at the base of foundation = 5.75 kNm

Pressure due to Wind load M/Zr = 5.75/3.95
= 1.45 kN/m^2

Maximum pressure below ring wall = 0.22+0.16+1.45+0.01+36.28
= 38.12 kN/m^2
< Net SBC. OK

Minimum pressure below ring wall = 0.22+0.16-1.45+0.01+36.28
= 35.22 kN/m^2
No Tension. Hence OK.

CASE IV : DL+OL+0.5LL+SL

Shear force at the base of the tank = 46.54 kN

Total moment on the ringwall at the base of foundation = 0+46.53792*2
= 93.08 kNm

Pressure due to Seismic load M/Zr = 93.08/3.95
= 23.54 kN/m^2

P/A = 0.22+0.16+0.01*0.5+36.28
36.67 kN/m^2

Maximum pressure below ring wall = 0.22+0.16+23.54+0.01*0.5+36.28
= 60.21 kN/m^2
< Hence ok

Minimum pressure below ring wall = 0.22+0.16-23.54+0.01*0.5+36.28
= 13.12 kN/m^2
No Tension. Hence OK.

CHECK FOR OVERTURNING

Load case	LOAD COMBINATION	Resisting moment	Overturning moment	Factor of safety	Allowable Factor of safety
1	0.9DL+0.9EL+0.5WL	974.05	2.88	338.80	1.75
2	DL+OL+LL	No overturning moment			1.75
3	DL+OL+LL+WL	1262.50	5.75	219.57	1.75
4	DL+OL+0.5LL+SL	1254.76	93.08	13.48	1.75
5	DL+TL+0.5LL+0.5WL	1254.76	2.88	436.44	1.75

CASE I : (0.9DL+0.9EL+0.5WL)

Empty tank weight = 147.15 kN

Resisting moment due to Empty tank = 0.9*147.15*3.65/2
= 241.69 kNm

Resisting moment due to self weight of ringwall = 0.9* (π*3*0.65*2*30)*3.65/2
= 603.73 kNm

Resisting moment due to slab = ((π*0.25*2.35^2)*0.65*25)*3.65/2
= 128.63 kNm

Total Resisting Moment RM = 241.69+603.73+128.63
= 974.05 kNm

Overturning Moment due to Wind OM = 2.88 kNm

Factor of safety = RM / OM = 974.05 / 2.88
= 338.80 **> 1.75, Hence OK.**

CHECK FOR SLIDING

Load case	LOAD COMBINATION	Resisting Force	Sliding Force	Factor of safety	Allowable Factor of safety
1	0.9DL+0.9EL+0.5WL	266.24	1.92	138.94	1.60
2	DL+OL+LL	No sliding force			1.60
3	DL+OL+LL+WL	333.40	3.83	86.99	1.60
4	DL+OL+0.5LL+SL	333.40	46.54	7.16	1.60
5	DL+TL+0.5LL+0.5WL	333.40	173.99	173.99	1.60

CASE IV : DL+OL+0.5LL+SL

Maximum horizontal force, F_H = **46.54** kN

Maximum vertical Force = $W_{OL} + W_{conc}$ = 245.25+70.48+306.31

(Live load is not considered for sliding check) = **622.0** kN

Co-efficient of friction = 0.38

Sliding Resisting force, R = Weight of conc. * friction + shear capacity of sand
= 622.04 * 0.383+ 95.16
= **333.40** kN

Factor of Safety against sliding = 333.4 / 46.53792
= **7.16** **> 1.6, Hence safe**

CASE V : DL+TL+0.5LL+0.5WL

Maximum horizontal force, F_H = 1.92 kN

Maximum vertical Force = $W_{TL} + W_{conc}$ = 245.25+70.48+306.31

(Live load is not considered for sliding check) = 622.0 kN

Co-efficient of friction = 0.38

Sliding Resisting force, R = Weight of conc. * friction + shear capacity of sand
= 622.04 * 0.383+ 95.16
= **333.40** kN

Factor of Safety against sliding = 333.4 / 1.91625
= **173.99** **> 1.6, Hence safe**

DESIGN OF RING WALL

(considering the ring wall is not backfilled)

MATERIAL

Reinforced Concrete

Grade of concrete f_{ck} = **25** N/mm²

Steel Reinforcement

Grade of steel f_y = **500** N/mm²

Moment due to eccentric loading

Lateral force on ringwall due to fill = 0.5*19*(2)^2/2
= 19.00 kN/m

Moment due to fill = 19*(2000/2-2000/3)/1000
= 6.33 kNm/m

Moment due to load of design fluid on ringwall = 11.35*(0.65/2-0.321/2)

		=	1.87	kNm/m
Moment due to load of test fluid on ringwall		=	11.56*(0.65/2-0.321/2)	
		=	1.90	kNm/m
Case I : 1.5DL+1.5EL+0.75WL				
Lateral force on ringwall due to fill		=	0.5*19*(2)^2/2	
		=	19.00	kN/m
Factored lateral force on ring wall due to fill =	19*1.5	=	28.50	kN/m
Total lateral force		=	28.50	kN/m
Hoop Tension =	28.5*3/2	=	42.75	kN
Area of steel required to resist hoop tension		=	Tension / 0.87*fy	
		=	99	mm^2
Total area of steel required to resist hoop tension		=	**99**	mm^2
Check for Permissible tensile stress				
Unfactored Hoop tension		=	(19)*3/2	
		=	28.50	kN
Actual tensile stress at bottom of wall per unit circumference		=	Ft/(Ac+ mAst) (Refer IS:456 cl B-2.1.1)	
= (28.5*10^3/((650*1000-99)+(280/(3*8.5))*99))		=	0.04	N/mm²
Allowable tensile stress (Refer IS:456 cl B-2.1.1 table)		=	**3.20**	kN/mm²
			> 0.04 N/mm², Hence safe	
CASE II : 1.5DL+1.5OL+1.5LL				
Lateral force on ringwall due to operating fluid		=	0.5*10*3.537*2	
		=	35.37	kN/m
Factored lateral force on ring wall due to operating fluid		=	53.06	kN/m
Lateral force on ringwall due to Live load		=	1.2*2	
		=	2.40	kN/m
Factored lateral force on ring wall due to Live load		=	3.60	kN/m
Lateral force on ringwall due to fill		=	0.5*19*(2)^2/2	
		=	19.00	kN/m
Factored lateral force on ring wall due to fill		=	28.50	kN/m
Total lateral force		=	53.06+3.6+28.5	
		=	85.16	kN/m
Hoop Tension		=	85.16*3/2	
		=	127.73	kN
Area of steel required to resist hoop tension		=	Tension / (0.87*fy)	
		=	294	mm^2
Total area of steel required to resist hoop tension		=	**294**	mm^2
Check for Permissible tensile stress				
Unfactored Hoop tension		=	(19+2.4+35.37)*3/2	
		=	85.16	kN
Actual tensile stress				
= (85.16*10^3/((650*1000-294)+(280/(3*8.5))*294))		=	0.13	N/mm²
Allowable tensile stress (Refer IS:456 cl B-2.1.1 table)		=	**3.20**	kN/mm²
			> 0.13 N/mm², Hence safe	

Case V : 1.5DL+1.5TL+0.75LL+0.75WL

Lateral force on ringwall due to hydro test fluid	=	0.5*10*3.6*2	
	=	36.00	kN/m
Factored lateral force on ring wall due to hydrotest fluid	=	36 *1.5	
	=	54.00	kN/m
Lateral force on ringwall due to fill	=	0.5*19*(2)^2/2	
	=	19.00	kN/m
Factored lateral force on ring wall due to fill	=	28.50	kN/m
Total lateral force = 54+28.5	=	82.50	kN/m
Hoop Tension = 82.5*3/2	=	123.75	kN
Area of steel required to resist hoop tension	=	Tension / 0.87*fy	
	=	285	mm^2
Total area of steel required to resist hoop tension and bending	=	**285**	mm^2

Check for Permissible tensile stress

Unfactored Hoop tension	=	(19+36)*3/2	
	=	82.50	kN
Actual tensile stress			
= (82.5*10^3/((650*1000-285)+(280/(3*8.5))*285))	=	0.13	N/mm²
Allowable tensile stress (Refer IS:456 cl B-2.1.1 table)	=	**3.20**	kN/mm²
		> 0.13 N/mm², Hence safe	

Horizontal reinforcement for ring wall

Design steel required	=	294.00	mm^2
Total height of foundation concrete excluding slab Hc	=	1350.00	mm
Area of minimum steel required	=	0.0020*Hc*w	
	=	0.0020*1350*650	
	=	1755.00	mm^2
Area of steel to be provided	=	1755.00	mm^2
No. of **12** mm dia bars required	=	15.52	Nos.
	say	**24**	numbers
Ast provided	=	2714	mm² >1755mm² Hence safe
Provide 12 numbers on each face.			
Spacing of bars provided	=	110.36	mm
The maximum spacing is limited to 450 mm & 3*wall thick		Hence safe.	

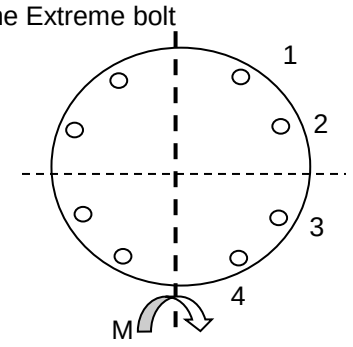
Vertical reinforcement for ring wall

Area of minimum steel required	=	0.0012 * plan area	
	=	780	mm^2 per m
Spacing of **12** mm dia bar	=	145	mm c/c.
Provide 12 mm dia bar @ **150** mm c/c.			
Ast provided	=	754	mm² <780mm² Revise
The maximum spacing is limited to 450 mm & 3*wall thick		Hence safe.	

CHECK FOR ANCHOR BOLTS

Cover	=	**50**	mm
Dia of bar	=	12	mm
Effective depth	=	650-50-12/2	

Dia	=	24	mm	
Numbers	=	8	Nos	
BCD	=	2500	mm	
Projection above rough concrete	=	25+10+150+10+2.5*24		
	=	255	mm	
Bolt length	=	43+850+326		
	=	1148.00	mm	
Edge distance	=	579.00	mm	
Minimum edge distance required	=	142.00	mm	
		Hence ok.		
Total shear to be resisted by the bolts	=	46.54	kN	
Shear to be resisted by one bolt	=	5.82	kN	
Shear capacity of one bolt	=	33.93	kN	
		Hence ok.		
Maximum moment occurs due to seismic	=	**0.00**	kNm	
Bolt circle dia	=	**5.712**	m	
Radius	=	2.856	m	
Total No of bolts	=	**8**		
Tension to be carried by	=	4	bolts	
Total Shear	=	**46.54**	kN	
Shear per bolt = 46.53792 / 8	=	**5.82**	kN	
Distance of bolt from the axis of Moment for 1,4	=	1.093	m	
Distance of bolt from the axis of Moment for 2,3	=	2.639	m	
Tension on the Extreme bolt	=	$\frac{M * r}{\sum r^2}$		
	=	$\frac{0*2.639}{(4*1.093^2) + (4*2.639^2)}$		
	=	$\frac{0.00}{32.64}$		
	=	**0.00**	kN	



MS Anchor Bolt

Check for strength of Bolt

Diameter of bolt	=	**24**	mm	
Tensile stress area	=	**353.00**	mm² (IS:1367 part3)	
Permissible stress in axial tension in bolts	=	**120**	N/mm²	(IS 800 T-8.1)
Permissible stress in shear in bolts	=	**80**	N/mm²	(IS 800 T-8.1)
Tension capacity of the section	=	**40.00**	kN	
Shear Capacity of the section	=	**25.00**	kN	

Tension capacity of M24 Bolt = **40.00 kN** **> 0 kN, Hence safe**

Shear Capacity of M24 Bolt = **25.00 kN** **> 5.82 kN, Hence safe**

CHECK FOR COMBINED SHEAR AND TENSILE STRESS OF BOLTS

Actual shear stress	=	5.82*1000 / 353		
	=	**16.49**	N/mm²	
Actual tension stress	=	0*1000 /353		
	=	**0.00**	N/mm²	
Combined Shear and Tension = $\frac{\text{Actual shear stress}}{\text{Permissible shear stress}}$	+	$\frac{\text{Actual tensile stress}}{\text{Permissible tensile stress}}$		
	=	$\frac{16.49}{80} + \frac{0.00}{120}$		
	=	**0.206**	<=	1.4

Actual Vs Perm. ratio of Combined Shear and Tensile Stress of bolt is less than 1.4, HENCE SAFE

Seismic Load:

Zone factor	z	=	0.24	
Height of the point of attachment of Equipment	x	=	1.00	m
Height of the building/depth of the foundation	h	=	1.00	m
Importance Factor,	I_p	=	1.50	
Component amplification factor	a_p	=	1	
(Table:11 of IS-1893,Part1 Draft)				
Component Response Modification factor	R_p	=	2.5	
(Table:11 of IS-1893,Part1 Draft)				
Design Horizontal Seismic Coefficient	A_h	=	Z/2 * (1+(x/h))* ap/Rp * Ip	
Design lateral force on the Equipment	F_p	=	Z/2 * (1+(x/h))* ap/Rp * Ip * W	
			>= 0.1 * W	
Design lateral force on the Equipment (as per MDS)	Fp_1	=	**0.00**	t
Design lateral force on the Equipment (as per MDS)	Fp_1	=	**0.00**	kN
Moment on top of foundation(as per MDS)		=	**0.0**	t-m
Moment on top of foundation		=	**0**	kNm
Ext dia of ring wall	D	=	3.65	m
Int dia of ring wall	B	=	2.35	m
Height above ground	h	=	1.00	m
Weight of Block above HPP		=	B * D* h * 25	
		=	153.15	kN
Weight of slab 150 thk slab above		=	170.03	kN
Total concrete wt	W_{conc}	=	**323.18**	kN
Design lateral force on the foundation above FGL	Fp_2	=	0.24/2*(1+1/1)*1/2.5*1.5*323.18	
	Fp_2	=	**46.54**	kN
Total shear on top of foundation		=	**46.54**	kN

Wind Data:

Basic wind speed / velocity	Vb	=	**50.0**	m/s
	k1	=	**1.00**	(Table 1 IS 875 Part 3)
	k2	=	**1.00**	(Table 2 IS 875 Part 3)
	k3	=	**1.00**	
Design Wind Speed **$Vz = V_b*k_1*k_2*k_3$**		=	50.00	m/s
Design Wind Pressure **$Pz = 0.6\ V_z^2$**		=	1500.00	N/m^2
	Pz	=	**1.50**	kN/m^2
External dia of tank		=	**3.02**	m
External dia of RING WALL		=	**3.65**	m
Height of ring wall above FGL		=	**1.00**	m
Total ht of ring wall		=	**2.00**	m
Wall height / breadth ratio of tank		=	3.6 / 3.016	
		=	1.19	
	C(f)	=	**0.70**	(Table 24 for b/h ratio 1 to 12)
	F	=	Pz * C(f) * De * H	
		=	1.5 * 0.7 * 3.016 *3.6	
Wind shear (As per MDS)	**F_1**	=	**0.00**	t
Wind shear (As per MDS)	**F_1**	=	**0.00**	kN
Moment at the bottom of foundation "M1"		=	**0.00**	t-m
Moment at the bottom of foundation "M1"		=	**0.00**	kNm
Moment at the bottom of foundation "M2" Due to shear at top of ring beam		=	**0**	kNm
Wind shear on ring wall	**F_2**	=	**3.83**	kN
Moment at the bottom of foundation "M3"		=	5.75	kNm
Total shear		=	**3.83**	kN
Total moment at the bottom of foundation		=	**5.75**	kNm