HYDRO DYNAMIC LOAD

(Reference : IS 1893 (Part 2) : 2014 , IITK-GSDMA Guidelines)

LONGITUDINAL (X) DIRECTION

Shape of Tank = Rectangular
Length of Tank = 4.0 m
Width of Tank = 4.0 m
Wall thickness (above base Slab) = 400 mm
Level at of top of tank = 6 m
Water level = 6 m
Total height of wall = 6 m
Thickness of top slab = 200 mm
Maximum thickness of wall considered = 400 mm
Thickness of wall = 400 mm
Base slab thickness = 400 mm
Height of water = 6 m
Average height of water above Base slab h = 6 m
Unit weight of concrete = 25 kN/m3
Unit weight of water = 10 kN/m3
Unit weight of Brick = 19 kN/m3
Grade of concrete = 35
Free Board provided = 0 m

Calculation of weight of various parts of tank

Sl.No	Element	Length	avg H	Thk	No	vol.	weight	
		m	m	m	no	m3	kN	
1	0.4m thick walls	4.0	6	0.4	4	38.4	960.0	
2	Base slab	4.0	4	0.4	1	6.4	160.0	
3	Top slab	4.0	4.0	0.4	1	6.4	160.0	
4	Frame load					0	25.0	
5	Pipe loads	15.0	0.600dia	350kg/m	4	-	5.3	
6	Water	4.0	4.0	6	1	96	960.0	

Weight of empty tank = 1310.3 kN
Mass of empty Tank **ms** = 133562.7 kg

Spring Mass Model Parameters

(Refer Section 4.2.1.2 IITK-GSDMA guidelines)

Weight of water = 960.0 kN
Volume of water = 96 m3
Mass of water = 97859.33 kg
height / length h/L = 1.5
mi/m = 0.902
mi = 88269.11 kg
mc/m = 0.176
mc = 17223.24 kg
Note: 90.2 % of water is exited in impulsive mode
and 17.6 % of water is exited in convective mode
hi/h = 0.44
hi = 2.64 m
hc/h = 0.79
hc = 4.76 m

Time Period

Time Period of Impulsive mode Ti = 2*PI()*sqrt((d)/g))

where d = deflection of tank wall at height h- when loaded by uniform pressure q where

(((mi/2)*hi)+(mw^{-}*(h/2)))/((mi/2)+mw^{-}) = h^{-}

mw^{-} = mass of one wall (inner dimension) perpendicular to loading direction
= 24465 kg

$\bar{h}$ = (((88269.1131498471/2)x 2.64)+24464.832 x(6/2))/((88269.1131498471/2)+24464.832)

= 2.77 m

q = ((mi/2+mw-)*g)/Bh

= 28040.00 N/m^2

= 28.04 kN/m^2

Deflection of wall , considering a strip of unit width of wall as cantilever and subjected to a concentrated force P = q x h x 1.0

Deflection of cantilever section = $\frac{P(\bar{h})^3}{3EI}$

P = qh x 1

168.2400005 kN

Moment of Inertia I = $1 * t^3 / 12$

= 0.005333333 m^4

Young's Modulus (E) = 5000*sqrt(fck)

29580.39892 N/mm2

29580398.92 kN/m2

Deflection of cantilever section (Max-d) = W x h^3 / 3 EI

= 0.007555176 m

Time Period of Impulsive mode Ti = 2*PI()*sqrt((d)/g))

= 0.174 sec

Time Period of Convective mode Tc = Cc*sqrt(L/r)

h / L = 1.5

Cc = 4.5 From Fig 7

Tc = 2.873 sec

Design Horizontal seismic coefficient

For Impulsive Mode Ahi = (Z/2)(I/R)(Sa/g)i

Zone factor for Zone V Z = **0.24**

Importance Factor I = **1.5**

Response Reduction Factor R = **2.5** tank with fixed base

Damping = 5 %

Ti = 0.174 sec

Table 1

(In Units of 'g')

S.No	Time Period (Sec)	Damping Factor (as a % of critical damping) 5%	2%	0.5%
1	0.00	1.000	1.400	1.75
2	0.05	1.750	2.450	3.0625
3	0.10	2.500	3.500	4.375
4	0.20	2.500	3.500	4.375
5	0.30	2.500	3.500	4.375
6	0.40	2.500	3.500	4.375
7	0.45	2.222	3.111	3.888889
8	0.50	2.000	2.800	3.5
9	0.55	1.818	2.545	3.181818
10	0.75	1.333	1.867	2.333333
11	0.95	1.053	1.474	1.842105
12	1.15	0.870	1.217	1.521739
13	1.35	0.741	1.037	1.296296
14	1.55	0.645	0.903	1.129032
15	1.75	0.571	0.800	1
16	1.95	0.513	0.718	0.897436
17	2.15	0.465	0.651	0.813953

18	2.35	0.426	0.596	0.744681
19	2.55	0.392	0.549	0.686275
20	2.75	0.364	0.509	0.636364
21	2.95	0.339	0.475	0.59322
22	3.15	0.317	0.444	0.555556
23	3.35	0.299	0.418	0.522388
24	3.55	0.282	0.394	0.492958
25	3.75	0.267	0.373	0.466667
26	3.95	0.253	0.354	0.443038
27	4.15	0.241	0.337	0.421687
28	4.35	0.230	0.322	0.402299
29	4.55	0.220	0.308	0.384615
30	4.75	0.211	0.295	0.368421
31	4.95	0.202	0.283	0.353535
32	5.15	0.194	0.272	0.339806
33	5.35	0.187	0.262	0.327103
34	5.55	0.180	0.252	0.315315
35	5.75	0.174	0.243	0.304348
36	5.95	0.168	0.235	0.294118

Sa/g from IS 1893 - part 1 -2002 Fig 2		=	**3.61**	
Therefore	Ahi	=	0.26	
For Convective Mode	Ahc	=	(Z/2)(I/R)(Sa/g)c	
Tc		=	2.873	sec
Sa/g from IS 1893 - part 1 -2002 Fig 2		=	**0.45**	
Therefore	Ahc	=	0.033	
Base Shear				
Base shear in impulsive mode	Vi	=	(Ahi)*(mi+mw+mt)g	
		=	287539.2	N
		=	287.539	kN
Base shear in Convective mode	Vc	=	(Ahc)*mc*g	
		=	5575.68	N
		=	5.58	kN
Total Base Shear	V	=	sqrt(Vi^2+Vc^2)	
at the bottom of wall		=	287.593	kN
This acts at the centre of gravity of the tank.				
Total seismic weight of the tank		=	2270.3	kN
% of base shear		=	12.668	%
Hydrodynamic pressure on wall				(Clause 4.9.1)
Impulsive Hydrodynamic Pressure	piw	=	Qiw (y) (Ah)i *r g h*	
Lateral hydrodynamic impulsive pressure	*p*	=	mass density of liquid	
on wall	f	=	circumferential angle	
where	y	=	vertical dist. of point on tank wall from bottom of wall	
	Qiw(y)	=	0.866*(1-(y/h)^2)*tanh (0.866 L /h)	
y/H (at base of wall)	Qiw(y)	=	0.866*(1-0)*tanh(0.866*4/6)	
Qiw(y=0)		=	0.451	
	Ahi	=	0.26	
	p	=	1000	kg/m3
	g	=	9.81	m/sec2
	h	=	6.000	
	piw	=	0.451*0.26*1000*9.81*6	
Impulsive hydrodyanmic pressure		=	6901.92	N/m2

at the base of wall = 6.9 kN/m2

Convective Hydrodynamic Pressure

pcw = Qcw(y)*(Ah)c*r*g*L*

Convective Hydrodynamic Pressure on wall — Qcw(y) = 0.4165*cos h (3.162 y/L)/cosh(3.162 h/L)

y = 0

Qcw(y) = 0.4165*cosh(0)/cosh(3.162*6/4)

At base of wall = 0.007

Ahc = 0.033

pcw = 0.007*0.033*1000*9.81*4

= 9.06444 N/m2

Convective Hydrodynamic pressure at the base of wall (y=0) = 0.009 kN/m2

Equivalent Linear Pressure Distribution

Impulsive Hydrodynamic pressure

Base Shear due to Impulsive liquid mass

$$q_i = \frac{(A_h)_i * m_i * g}{2B}$$

$$= \frac{0.26 \times 88269.1131498471 \times 9.81}{2 \times 1000 \times 4}$$

= 28.15 kN/m

Value of linearised pressure

Bottom

$$a_i = \frac{q_i * (4h - 6h_i)}{h^2}$$

$$= \frac{28.15 \times (4 \times 6 - 6 \times 2.64)}{6^2}$$

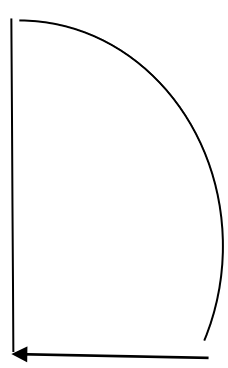
= 6.38 kN/m2

Top

$$b_i = \frac{q_i * (6h_i - 2h)}{h^2}$$

$$= \frac{28.15 \times (6 \times 2.64 - 4 \times 6)}{6^2}$$

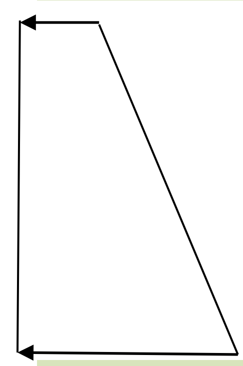
= 3.00 kN/m2



6.90 kN/m2

Actual Pressure distribution

3.00 kN/m2



6.38 kN/m2

Linearised Pressure distribution

Convective Hydrodynamic pressure

Base Shear due to Impulsive liquid mass

$$q_c = \frac{(A_h)_c * m_c * g}{2B}$$

$$= \frac{0.033 \times 17223.2415902141 \times 9.81}{2 \times 1000 \times 4}$$

= 0.70 kN/m

Value of linearised pressure

Bottom

$$a_c = \frac{q_c * (4h - 6h_c)}{h^2}$$

Top

$$b_c = \frac{q_c * (6h_c - 2h)}{h^2}$$

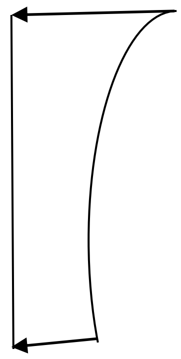
$= \dfrac{0.7 \times (4 \times 6 - 6 \times 4.76)}{6^2}$

= **-0.09 kN/m2**

$= \dfrac{0.7 \times (6 \times 4.76 - 2 \times 6)}{6^2}$

= **0.32 kN/m2**

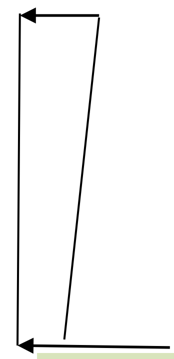
0.01 kN/m2



0.00 kN/m2

Actual Pressure distribution

0.32 kN/m2



-0.09 kN/m2

Linearised Pressure distribution

Sloshing Wave Height

Maximum Sloshing Wave Height	dmax	=	(Ah)c * R * L/2	
	(Ah)c	=	0.033	
Response Reduction Factor	R	=	2.5	
	L	=	4.00	m
	dmax	=	0.17	m
Free Board provided		=	0	m

Free Board provided is less than the sloshing height

Anchorage Requirement

	h/L	=	1.5
	1/(Ah)i	=	3.846

As h/L is less than 1/Ahi, Anchorage is not essential from overturning consideration