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Study of Intze Water Tank in Different Seismic Zones As per IS :1893(Part 2)

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Abstract—*All over the world, water storage tanks are widely used to store water for many applications, drinking water etc. Mainly intze tank an elevated RC water tank is widely used in India because of water pressure maintained by gravity and for economy point of view. IS:3370part I (General Requirement) and Part II (Reinforced concrete structure) code of practice-concrete structures for storage of liquids is used for designing of Intze tank. All tanks are designed as crack free structure. In this research paper, the capacity 250m^3 intze tank have been designed and analyzed by response spectrum method. Seismic response such as Base Shear, Base Moment, Tank displacement under empty and fill condition in different seismic zones II, III, IV and V have been calculated and then results have been compared.*

1. Introduction

The word “Water Tank” is generally referred as water storing structure. Water tank both elevated and ground level tanks plays important role in water supply network in day to day life. During the past earthquake, many water tanks were damage and great loss was faced by inhabitant. Water tank are meant for maintaining pressure in water supply mains and any damage in water tanks shall lead to a lot of inconvenience to people. Thus, water tank needs to design as earthquake resistant structure.

1.1 RC Elevated Water Tank

RC Elevated water tank have many benefits. Elevated water tank do not require the continuous operation of pumps. elevated water tank. Instead of large capacity circular tank, Intze tanks are economical than other shape tanks. Elevated water tanks are used to supply water to particular areas so that water can reach to the publicby means of gravity.Square or rectangular tank is the simplest form of elevated water tank. Instead of large capacity circular tank, Intze tanks are economical than other shape tanks.

Design of elevated tank consists of –

a) Design of container
b) Design of staging
c) Design of foundation

Due to lack of knowledge of supporting system. Water tanks were collapsed or heavily damaged.

A. Classification of water tank

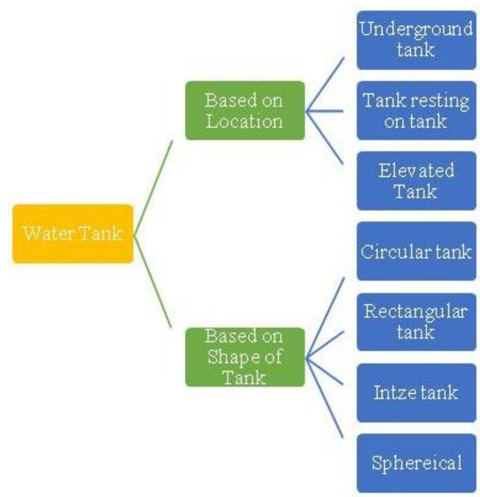

Fig. 1: **Classification of water tank**

B. Structural Element of Intze Tank

Structural elements of intze tank consist of-

1. Top spherical dome
2. Top ring beam
3. Circular side walls
4. Bottom ring beam
5. Conical dome
6. Bottom spherical dome
7. Bottom circular girder
8. Tower with columns and braces
9. Foundation

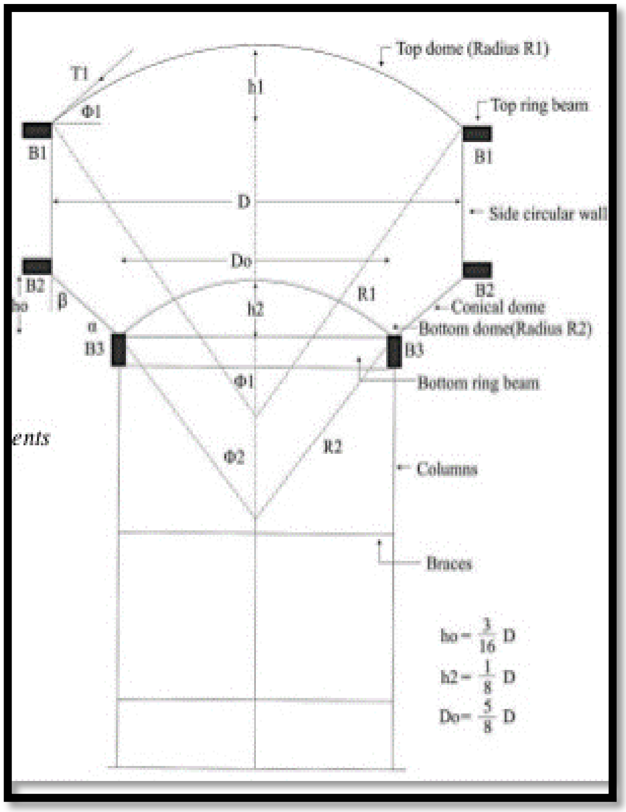

Fig. 2: Intze Tank Components

1. **Top Spherical Dome (cover roof)**
   Top dome shall be designed for live load of 1.5 kN/m^2, if not specified.
2. **Top ring beam**
   It is necessary to resist the horizontal component of t thrust of the dome.
3. **Cylindrical side walls**
   It has to be designed for hoop tension caused due to horizontal water pressure.
4. **Bottom Ring Beam**
   This ring beam is provided to resist horizontal component of reaction of the conical wall on the cylindrical wall.
5. **Conical Dome**
   This will be designed for hoop tension due to water pressure.
6. **Bottom Spherical Dome**
   It is designed to support the loading of water above it in addition to its self-weight.
7. **Bottom Circular Girder**
   This girder is supported on columns and should be designed for resulting bending moment and torsion.
8. **Tower with columns and braces**
   Entire load of tank gets transferred to the columns and if staging height is greater than 6m, horizontal bracing should be provided.
9. **Foundation**
   A combined footing is generally provided to support all the columns.

2. Design of Intze Tank

Statement Design of intze tank of 250m^3. The height of tank 16m up to bottom of tank.

D=8.10m, h=4.05m, h_1=1.2m, D_o=5.06m, h_o=1.52m, h_2=1.01M

a)Top Dome

$h_1(2R_1-h_1)=(\frac{D}{2})^2$

$1.2(2R_1-1.2) = (8.10/2)^2$

R_1=7.43m

$\sin \emptyset_1=\frac{8.10}{2\times7.43}$=0.545

$\cos \emptyset_1$=0.838

Assume thickness of slab=100mm

Self- weight=0.1x25=2.5kN/m^2

Live load=1.5kN/m^2

Total Load=4.0kN/m^2

Meridional force=$\frac{wr\,(1-\cos\,\theta)}{\sin\,\theta^2}$

=16.20kN

Meridional stress=$\frac{16.20\times10^3}{10^3\times100}$

=0.162<8N/mm^2 (safe)

Hoop force=$\frac{wr\,(1-\cos\,\theta-\cos\,\theta^2)}{(1+\cos\,\theta)}$

=-8.735kN

=8.735kN tensile

Hoop stress=$\frac{8.73\times10^3}{10^3\times100}$

=0.087<1.5N/mm^2 (safe)

Provide nominal reinforcement 8mm@140mm c/c.

b) Top Ring Beam(B_1)

D=8.10m

Meridional thrust per metre length of the beam at the base=16.20kN/m.

Its horizontal component

W=16.20cosΦ_1=16.20×0.838=13.575kN/m.

Hoop tension=$\frac{wD}{2}$ =55kN

$A_{st}=\frac{55\times1000}{130}$=423$mm^2$

Provide 3-16mm=603mm^2

Provide 500mm400mm size ring beam.

c) Cylindrical Wall

Hoop Tension=$\frac{\gamma_w hD}{2}$

=$\frac{10\times h\times8.10}{2}$

=40.5h

=40.5×4.05=164kN(maximum)

$A_{st}=\frac{T}{130}$

=$\frac{164\times10^3}{130}$

=1261.5mm^2

f_{ct}<1.5N/mm^2
A_T=1000t+(9.33-1)×1261.5
$f_{ct}=\frac{164\times10^3}{1000t+10508.2}<1.5$
98.8<t
Provide 400mm thick cylindrical wall.

d) Ring Beam(B_2)

Top Dome load=2ΠR_1h_1w
=224kN
Load/m=$\frac{224}{\pi\times D}$
=8.8kN/m
Cylindrical wall load=0.45×4.05×25
=45.56kN/m
Self -weight of B_1=(0.3-0.2)×0.15×25
=0.375kN/m
Self- weight of B_2=(1-0.3)×0.6×25
=10.5kN/m
Total load =65.23kN/m
Adopted size of Beam 1000mm×600mm
$H_1=w_1\tan\beta$ $\tan\beta=\frac{(D-Do)}{2\times ho}$=1
=65.23kN/m
Horizontal water force $H_2=\gamma_w hd$
=10×4.0×0.6
=24.3kN/m
H=H_1+H_2
=89.53kN/m
Hoop tension=$\frac{HD}{2}$
=362.59kN/m
$A_{st}=\frac{362.59\times10^3}{130}$
=2789.20mm^2
A_T=1000×600+(9.33-1)×2789.2
=623234.0mm^2
$f_{ct}=\frac{362.59\times10^3}{623234}$=0.58<1.5N/mm^2 (OK)

e) Conical Dome

average diameter=$\frac{(D+Do)}{2}$=6.58m
average depth of water=2.78m
weight of water above conical dome=π×6.58×2.78×1.52×10
=873.50kN
Assume 500mm thick slab
Width of slab=$\sqrt{1.52^2+1.52^2}$
=2.15m
2.15×6.58×π×0.5×25
=555.55kN
Total Load=3089.0kN
Load/m(w_2)=$\frac{3089}{\pi\times5.06}$=194.32kN/m
Meridional thrust $T_3=\frac{194.32}{\cos\beta}$
=274.80kN/m
Meridional stress=$\frac{274.80\times10^3}{10^3\times500}$
=0.549<1.5N/mm^2 (safe)
Provide 2800mm^2 on each face.

f) Bottom Dome

$h_2(2R_2-h_2)=(D_o/2)^2$
1.01(2R_2-1.01)=(5.06/2)^2
R_2=3.67m
$\sin\emptyset_2=\frac{5.06}{2\times3.67}$=0.689
$\cos\emptyset_2$=0.724
Assume 250mm thick slab
Self -weight =2πRht×25
=2π×3.67×1.01×0.25×25
=145.56kN
Volume of water above dome=

$$\frac{\pi}{4}\times5.06^2\times5.57-[\frac{2\pi\times3.67^2\times1.01}{3}-\frac{\pi\times(3.67-1)\times5.06^2}{12}]$$

=101.33m^3
Weight of water above dome=101.33×10
=1013.4kN
Total load=1159kN
Meridional thrust $T_4=\frac{w}{\pi D\sin\theta}$
=105.82kNm
Meridional stress=0.42<8N/mm^2(safe)
Hoop force=$\frac{WR}{2}$ tension
W=$\frac{1159}{2\pi\times3.67\times1.01}$=49.76kN/m^2

Hoop tension=$\frac{49.76\times3.67}{2}$

=91.31kN

Hoop stress=0.36N/mm^2<1.5N/mm^2(safe)
Provide nominal reinforcement 12mm@120mm c/c.

g) Bottom Circular Beam(B_3)

Inward thrust from conical dome=$T_3\cos\alpha$ $\cos\alpha=0.70$
=274.80×0.70
=192.36kN/m
Outward thrust from bottom dome=$T_4\cos\emptyset_2$
$=105.82\times0.724$
=76.61kN/m
Net inward thrust=115.74kN/m
Hoop compression in beam=$\frac{115.74\times5.06}{2}$
=292.8kN
Assume beam size 750mm×1200mm
Hoop stress=$\frac{292.8\times10^3}{750\times1200}$
=0.32<8N/mm^2 (OK)
Provide nominal reinforcement 2800mm^2
Further columns and braces for staging are designed using SAP 2000v21 software for different seismic zones by response spectrum method as per IS:1893 2016 part II.

3. Analysis and Comparison of Results

Model of 250m^3 capacity has been prepared and analyzed in SAP2000 v21 software by "Response Spectrum Method" to get following results:

Table1. Time Period(sec) at empty condition and fill condition

Mode Number	Empty condition	Full condition
Mode 1	0.650477	1.074598
Mode 2	0.650477	1.074598
Mode 3	0.55418	0.877796
Mode 4	0.119604	0.171849
Mode 5	0.119604	0.171849
Mode 6	0.082736	0.117603
Mode 7	0.074034	0.114544
Mode 8	0.074034	0.114544
Mode 9	0.052082	0.085593
Mode 10	0.050027	0.07075
Mode 11	0.050027	0.07075
Mode 12	0.047895	0.068895

Since time period is same for all seismic zones.

Table 2: Base Shear(kN) for all seismic zones

Zone	Empty Condition	Full Condition
II	188.763	304.14
III	302.021	486.624
IV	453.032	729.935
V	679.548	1094.903

Table3. Base Moment(kNm) for all seismic zones

Zone	Empty Condition	Filled Condition
II	3182.4385	5091.7627
III	5091.9016	8146.8204
IV	7637.852	12220.23
V	11456.778	18330.345

Table 4: Storey Displacement(mm) for all seismic zones

Storey Height from base (H)	Zone	Empty Condition	Filled Condition	Permissible Limit(H/500)
16m	II	5.489	8.917	32
	III	8.783	14.268	32
	IV	13.175	21.402	32
	V	19.762	32.103	32
12m	II	4.28	6.933	24
	III	6.848	11.094	24
	IV	6.265	10.112	24
	V	9.398	15.168	24
8m	II	2.61	4.213	16
	III	4.177	6.741	16
	IV	6.265	10.112	16
	V	9.398	15.168	16
4m	II	0.975	1.571	8
	III	1.56	2.514	8
	IV	2.34	3.771	8
	V	3.511	5.657	8

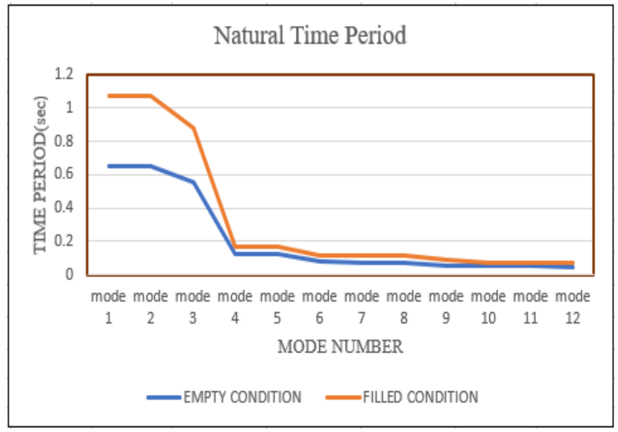

Fig. 4: Fundamental Natural Time Period

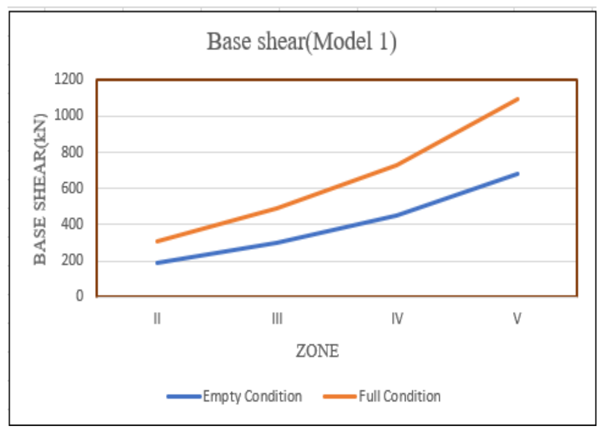

Fig. 5: Base Shear for all seismic zones

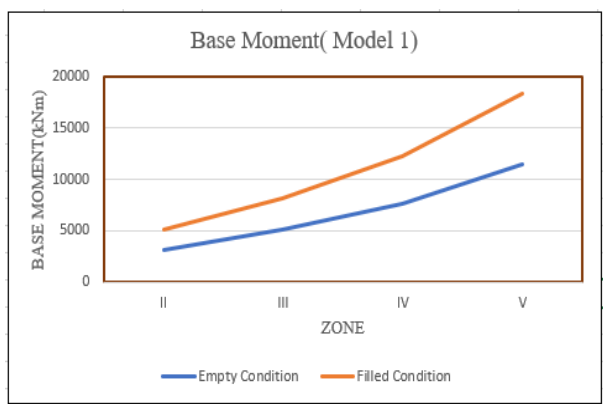

Fig. 6: Base Moment for all seismic zones

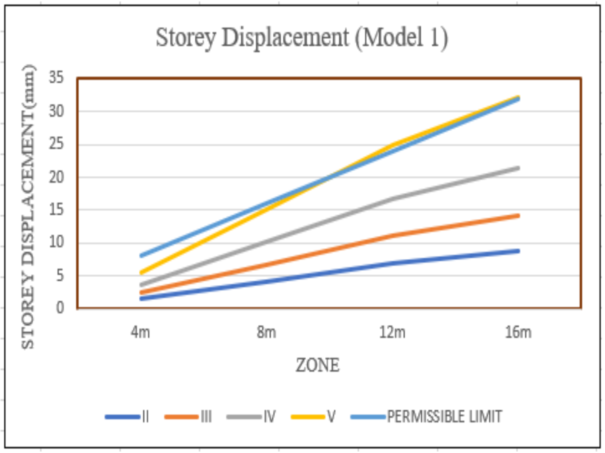

Fig. 7: Displacement for all seismic zones

4. Conclusions

Following conclusions are obtained from the analysis presented in this paper**.**

1. From the comparison of empty and fill condition, it is observed that base shear, base moment and displacement obtained from full condition is greater than empty condition.
2. Lateral force is more in tank full condition when compared to tank empty condition hence tank full case is considered for seismic analysis.
3. As seismic zone going up, base shear and base moment are also getting rise.
4. As seismic intensity increase, base shear values increases from zone II to V for both the conditions because base shear directly depend upon zone factor(Z). Zone factor value for seismic zone V(0.36) is maximum.
5. Time period is same in all seismic zones.
6. As seismic intensity zones increase, base moment values increases from zone II to V for both the conditions.
7. simple bracing fails in seismic zone V because storey displacement values exceed permissible limit values but in seismic zone II,III,IV, simple bracing is safe because storey displacement values lies within permissible limit values(H/500).

References

[1] Ranjit Singh Lodhi, (2014), "Design of Tank in Perspective of Revision of IS:3370" *International Journal of Scientific Engineering and Technology* Vol 3, Issue No. 9, pp 1193-1197.

[2] Kaviti Harsha, (2015)," Seismic Analysis and Design of Intze Type Water Tank" *International Journal of Science Technology & Engineering*, Vol 2, Issue 3.

[3] Dhaval V. Shankhpal,(2018), " Study and Analysis of Intze Water Tank with manual and software-based design with base isolation" *International Journal of Advanced Engineering Research and Science*, Vol-5, Issue-10.

[4] IS 3370(Part 2):2009 Indian Standard Code of practice for Concrete structures for storage of Liquids.

[5] IS 456:2000 Indian Standard Code of Practice for Plain and Reinforced Concrete.

[3] IS:11682-1985 Indian Standard Code of Practice for Design of RCC staging for overhead water tanks.

[4] IS 1893(Part 2):2016 Indian Standard Code of Practice for Criteria for Earthquake Resistant Design of Structures liquid retaining tanks.

[5] IS 13920:2016 Indian Standard Code of Practice for Ductile design and detailing of reinforced concrete structures subjected to seismic forces.