A Comparison Study and Seismic Analysis of Different Types of Overhead Water Tank by Response Spectrum Method

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Abstract— The aim of this Research work is Reaction spectrum analysis, seismic analysis or comparison of overhead Intze Tank, circular Tank, and rectangular Water Tanks with unfilled, half filled and completely filled condition in earthquake 3rd to 5th Zone. This whole analysis is done by STAAD Pro V8i SS6. The seismic zones of Zone-III, Zone-IV, Zone-V and the equivalent lateral load characteristics have been taken from IS 1893 (PART 1)-2002 & draft code IS 1893 (Part 2) and IS 875 (PART 3) -1987. For this different condition of water tank. It have circular, rectangular & Intze shape. Water Tank having 1800000 litres holding capacity and supported on RCC frame stages height 24m & 30 m under seismic movement loads provide according to code section 2 of IS 1893:2002.

Keywords: Overhead Intze Tank, rectangular Tank, lateral displacement, Water Tank, base shear, IS: 3370 1965, STAAD Pro V8i, 1893 (PART 1)-2002, Response Spectrum Method

I. Introduction

The term 'water tank' refers to a structure that is used for storage of liquids. New ideas and innovation has been made for the storage of water and other liquid materials in different forms and ways as the water is very important for humans, More over it is essential for human life. Water tank has been develop nearly about 80 years ago and accepted as well-designed, efficient and economical unit for commercial as well as residential use. Also, it is inescapable part of water supply system, and widely used for storage and processing of variety of liquid like material such as water, petroleum products. Sufficient water distribution is depends on the design of a water tank also it is depends on the need of water in that certain area. Therefore Water tanks are very essential for public service and for industrial structure. The Indian continent is in the grip of natural disasters such as seismic activity, tropical storm and so on. These natural disasters, specially seismic movement is define as sudden shaking movement of the earth. Seismic movement generally occur in weaker site or injure the population as well as demolishing complete towns. The frequency of seismic movement at an experienced site during particular time interval is known as seismic movement in that area. Seismic resulting as Surface faulting, tsunamis, soil liquid factions, ground resonance, landslides, ground failure, devastation and damage to built and natural habitats, loss of life, infrastructure failure, psychological fear of the country, and a decrease in the area's economic development are all examples of natural disasters. Seismic analysis according to IS 1893 (Part I): 2002.

A. Elevated Water Tank, And Earthquake Influence

Water supply is important ability that must remain serviceable after the disaster. Many states of India have various water supply framework which relies upon raised tanks for capacity. Elevated water tank is large elevated storing container to hold a water supply at tallness adequate to pressurize a water dispersion framework. In significant urban communities the fundamental supply plan is increased by individual supply frameworks of organizations and mechanical homes for which raised tanks are a basic part. Features of an elevated water tank are to provide strengthening, durability; leakage problem should also be avoided by identify good construction practices. Be that as it may, as a general rule these structures don't regularly keep going as long as they are intended for. These structures have an arrangement that is particularly helpless against Lateral powers like seismic tremor, wind powers because of the huge absolute mass aggregated at the highest point of slim supporting structure. So it is critical to check the importance of these powers for specific district.

Water supply is basic for controlling flames that may happen during seismic tremors which cause a lot of harm and loss of lives. Accordingly, raised tanks ought to stay practical in the post-tremor period to guarantee water supply is accessible in seismic tremor influenced districts. Also, water is useful for living as it used for drinking purposes hence elevated water tanks should be remain functional even after cyclones and heavy winds Nonetheless, several elevated tanks were injured or buckled during past earthquakes.

In general, water retaining structure distress has been observed very earlier about 9th to 10th years of administration life. Because of certain issues identified with auxiliary perspectives and over notice of seismic analysis, wind analysis in earthquake inclined and wind zones. From the past situations we learnt that tanks have suffered with varying degree of damages, which include: Buckling of ground-supported slender tanks, rupture of steel tank shells at pipe-joint locations, failure of elevated tank supporting towers, cracks in ground-supported RC tanks, and so on. Water tanks can experience suffering in various components due to several reasons such as improper structural configuration design, poor quality of materials, corrosive reinforcement, wind forces, poorer workmanship, seismic forces etc.

Water is source for every creation in this world. Earth contains 72% of water, in that about 96% is contained by the oceans, 3% is composed by ice glaciers and only 1% contains pure water which can be used for drinking. So storing water is not a requirement, it is necessity to supply the need of water. Water tanks are one of the techniques to store water. Water tanks are structures to hold high capacity of water storage to supply water requirements for public, industrial and irrigational purposes.

Water tanks are classified based on position and shapes.

S.No.	Classification based on position	Classification based on shape
01.	Underground tanks	Rectangular
02.	Surface level water tanks	Square
03.	Overhead tanks Circular	Intz, Spherical bottom, Domed bottom, Coned bottom

1) Underground Tanks

This type of water tank is used for storing water below ground level mainly for storing rainfall runoff, waste sewage and drinking water. As these are installed below ground level this helps people to utilize their land to maximum. There are many types of materials which are used in design of tanks. Plastic materials are widely used in design of tanks, as most of the people prefer the plastic tanks which are readily available in the market.

a) Advantages of Underground Water Tank

When space is limited, these types of tanks are very useful.

As overhead tanks may not be aesthetically pleasing, so these tanks are hidden in ground from view.

b) Disadvantages

These tanks construction are very costly and difficult than the aboveground tanks.

Motor and pumps are needed to extract water from these tanks.

2) Overhead Water Tanks

These tanks are elevated from ground level. They circulate water through its distributary channels or pipes to households. Water can be drawn by gravity without any use of pressurised motors and pumps. For construction of overhead tanks, concrete with reinforced steel is used widely.

a) Advantages

These tanks can draw water through gravity without use of any motors and pumps.

b) Disadvantages

These types of tanks can be affected by change in weather conditions.

The overhead water tanks require anchoring when there is less water in the tank.

3) Design Aspects of Water tanks

Determine the capacity of tank based on the usage of public.

Dimensions of the tanks are to be calculated.

Loads and loading combinations are to determine according to code books.

Hydraulic loads imposed by water on the inner surface are to be determined for fully and partially filled tank conditions.

Wind effects are to be considered for overhead tanks.

Materials which are used is to be impervious.

B. How Staad. Pro Helps for the Designing of water Tanks

Structural analysis and design (Staad. pro) is effective and high potential analysing software developed by Bentley organization. Staad pro perform design and assigning of different load factor on building model with virtual 3d view. It makes difficult calculations of bend moment shear force and deflection of structure members with load combination and Indian standard codes. Firstly, design of prototype model of water tank model is created in software interface with specified dimensions of structures, material properties, and load conditions are assigned. Giving required parameters and load definitions. Finally perform analysis for model to integrate evaluation of structure to get information in detail about structural behaviour under load conditions. Commonly in conventional method of analysis, it is fatigue process to do process.

C. Significance and Scope of present Study

The study of harms in histories reveals that damage or failure of reinforced concrete elevated water tanks for different capacities. Scrutinising the effects of lateral forces has been acknowledged as a necessary step to understand the natural hazards what's more, its hazard to the general public over the long haul. Most water supply frameworks in developing nations, for example, India, rely upon the reinforced elevated water tanks. The quality of these tanks to withstand against lateral loads. It's very important to examine reinforced cement concrete elevated water tank suitably.

At top of water tank it have slender staging which consist a huge mass which is more difficult concern for the failure of tank due to earthquakes. Since of large mass, particularly when tank is full, lateral forces is high and less prominent the lateral force design criteria in the zone of high seismic activity. Nonetheless, some harm (repairable) might be worthy during extreme shaking not influencing the usefulness of tank. Whatever might be the reason for misery however water tanks ought to satisfy the reason for which it has been structured and developed with least up keep all through its planned life. The elevated water tanks are every now and again utilized in seismic zones districts likewise be projected for wind force, henceforth lateral force conduct of them must be explored in detail. Because of the absence of information of supporting System a portion of water tank were collapsed or heavily damages. So there is have to concentrate on lateral loads wellbeing of life saver structure utilizing as for substitute supporting system.

Hence the existing study is analyzing the lateral force behaviour of elevated different types of tanks under various acceleration Response spectra or earthquake characteristics alongside with wind forces in the earth quake zones considered, using structural software STAAD.Pro V8i.

D. Objectives

Circular water tank, rectangular water tank, intze type water tanks for analysis purpose modelling is used with a capacity of 1800000 litres, which are mounted on a reinforced cement concrete frame of 30 meters height and 8 columns with a horizontal surface. Overhead water reservoirs are in the middle soil in the III to V regions. The M30 grade and Fe415 steel grade are used. For seismic analysis, comparison of all these models and the spectral reaction study technique are done in Staad Pro v8i SSS6.

Mainly this study includes the behaviour of supporting pattern of liquid storing tanks under the lateral loads also to demonstrate which is more effective in different earthquake areas as per (draft code) IS 1893 (Part 2) and GSDMA guide lines, IS 875 (PART - 3)- 1987

At this juncture different supporting systems such as basic bracing, radial bracing with central column, concentric columns are evaluated and compared for different tank filling condition for the seismic zones of Zone-III, Zone-IV, Zone-

V and the corresponding earthquake characteristics and wind characteristics have been taken from IS 1893 (Part 1)-2002 & draft code IS 1893 (Part-2) and IS 875 (Part-3) 1987 respectively.

The core objectives of the current study are

To evaluate the Circular water tank, rectangular water tank, intze type water tanks modelling is used with a capacity of 1800000 litres, which are mounted on a reinforced cement concrete frame of 30 meters height and 8 columns with a horizontal surface of elevated water tanks in various Earthquake zones such as Zone-III, Zone-IV, Zone-V as per IS: 1893 Part-2 draft codal provisions and IS 875 (Part-3) 1987 guide lines by using Staad.Pro.V8i.

To analyse the Base shear, as impulsive mode and convective mode and the total lateral base shear as per IS: 1893 Part-2 draft codal guide lines.

To evaluate the Base shear and base moment at bottom of Water Tank due to wind load in various seismic zones as per IS 875 (Part-3) 1987 codal provisions.

To evaluate the total over turning moment at the bottom of the tank in impulsive mode and convective mode and the total overturning moment as per IS: 1893 Part-2 draft codal guide lines.

To analyse the Roof displacements for Circular water tank, rectangular water tank , intze tank in Earthquake zones of Zone-III, Zone-IV, Zone-V for both wind load and seismic loads.

Mainly this study is done for understanding the behaviour of laterally loaded supported pattern of liquid storage tanks under lateral loads.

II. Literature Survey

Chaduvula, U. et al. (2013) a 1:4 scale model of a cylindrical steel elevated water tank subjected to simultaneous horizontal, vertical, and rocking motions, with earthquake excitation (accelerations) of 0.1g and 0.2g and rising angle of rocking motion The impulsive base shear and base moment increase with increasing earthquake acceleration, according to research. The convective base shear and base moment increase as the earthquake acceleration increases, but decrease as the angular motion increases. As a result, there is no discernible effect of water sloshing on rocking motion. As the impulsive pressure of the tank decreases with increasing tank acceleration, there is a nonlinearity in the structure.

Issar Kapadia et al., "DESIGN, ANALYSIS, OR COMPARISON OF UNDERGROUND RECTANGULAR WATER TANK USING STAAD PRO VI8 SOFTWARE" was completed. In this analysis of the UG Rectangular tank, specifically how the shape deflected and what behaviour were produced when the tank was empty or full, using STAAD Pro software.

B.V. Ramana Murthy, M Chiranjeevi "DESIGN OF RECTANGULAR WATER TANK USING STAAD PRO SOFTWARE" was completed. In this article, he stated that minor project was conducted for 15 days, from May 21 to June 7, 2010, at the time of our minor project, we covered a variety of topics such as construction view, designing, formwork details, reinforcement details, water treatment plant method, and execution.

Ankit Agarwal, Pooja Semwal had done "THE SEISMIC ANALYSIS OF OVERHEAD WATER TANKS A REVIEW PAPER". This review paper provides the structural stability and behaviour of different shapes and sizes of reinforced concrete cement overhead water tanks during the penetrable force like earthquake. The objective of this analysis is to understand the shapes of water tanks as per different seismic zones IInd, IIIrd, IVth and Vth in India.

Smt. Dhotre Chandrakala et al. "ANALYSIS ON OVERHEAD CIRCULAR WATER TANK FOR VARIOUS BEARING CAPACITY WITH SLOPING GROUND" .For this analysis to study the effects of B.C. of soil on the quantity of concrete and steel required to construct circular tank and Variation of axial force, S.F. OR B.M. will be compared for different components of tank like columns, base beam and bracing beam due to sloping ground.

Dona Rose K J et al., had done "A STUDY OF OVERHEAD WATER TANKS SUBJECTED TO DYNAMIC LOADS". The author of this paper focuses on the complex response of circular tanks. ANSYS software is using for modelling of tanks with various capacities and staging heights. Its done in two different ways full and half-filled tanks, taking into account the sloshing effect as well as the hydrostatic effect.

Gaikwad Madhurar V. et al., "COMPARISON BETWEEN STATIC AND DYNAMIC ANALYSIS OF ELEVATED WATER TANK" was completed. The primary goal is to compare the static and dynamic analyses of elevated water tanks, as well as dynamic responses of tanks, the hydrodynamic effect on tanks, and adverse effect of impulsive and convective pressure outcomes.

M N S R Madhuri, B Sri Harsha "DESIGN OF CIRCULAR WATER TANK USING STAAD PRO SOFTWARE" was completed. For this author discussed about the types of tanks, their design aspects, what are rules to determine the capacity for the tanks and other design features for elevated tanks.

Mehul S. Kishori et al., "PARAMETRIC STUDY OF RECTANGULAR WATER TANK USING DIFFERENT METHODOLOGY" had been completed. The author conducted a parametric analysis in this paper on the behaviour or designing of ground Rectangular concrete tank subjected to static loading conditions, with a focus on IS:3370, PCA, and STAAD-Pro. The impact of different water tank aspect ratios and end conditions for the same capability is examined in this paper.

Ngerebara Owajiokiche Dago et al., had completed "Geotechnical Subsoil Investigation for the Design of Water Tank Foundation". In this journal the author had conducted some geotechnical subsoil investigation at Unyeada in Andoni Local Government Area, in the Niger Delta for determining what type of tank should be suitable at that area. In this investigation he conducted some soil stability experiments like bearing capacity, standard penetration test etc., and proposed to go with shallow foundation which will be safe in that area.

Dr. Suchita Hirde et al., had studied on "SEISMIC PERFORMANCE OF ELEVATED WATER TANKS". In this journal the author had studied the performances of tank in seismic zone areas in India. She also done some study on damaging of water tanks in past due to earthquakes, then she modelled and analysed 240 tanks for different parameters in earthquake zone.

B.V. Ramana Murthy, M Chiranjeevi "DESIGN OF RECTANGULAR WATER TANK USING STAAD PRO SOFTWARE" was completed. In this article, it was conducted for 15 days from May 21 to June 7, 2010, in order to gain systematic understanding of different techniques or problems occurs the field. Construction behaviour, Designing, Formwork Details, Reinforcement Details, and Process are all different topics.

Durgesh C. Rai and Bhumika Singh (2004), examined Because of easiness of construction or many robust shape it offers compared to framed construction, reinforced concrete pedestals (circular, hollow shaft style supports) are a common option for elevated tanks. In the recent Indian earthquakes of Gujarat (2001) and Jabalpur (1997), thin concrete pedestal shells (150 to 200 mm) performed poorly. As several of the pedestals near the base formed circumferential stress exural cracks, a few of them collapsed. Many tanks are never fully filled with liquid, according to the IITK-GSDMA Guidelines (For Seismic Design of Liquid Storage Tanks). As a result, a two-mass idealisation of the tank is preferable to the one-mass idealisation used in IS 1893: 1984. Housner (1963b) suggested two mass models for elevated tanks, which are widely used in most foreign codes.

III. Model Parameters

A. *Geometric Data*

An Intz type Elevated water tank is considered for analysis.

Capacity of water tank	=	1800 cu.m
Height of staging	=	30 M
Diameter of the Cylindrical Portion (D1)	=	20 M
Height of water in the Cylindrical Portion (h1)	=	8 M
Height of the Conical Portion (h2)	=	2.5 M
Diameter of the tank at base of Conical portion (D2)	=	12 M
Height of the Bottom Dome (h3)	=	4 M
Radius of Bottom Dome (R1)	=	6 M
Height of the Top Dome (h4)	=	2.5 M
Radius of Top Dome (R2)	=	21.25 M
Cylindrical Wall Thickness	=	250 Mm
Conical slab Thickness	=	350 Mm
Thickness of Bottom Dome	=	250 Mm
Thickness of Top Dome	=	125 Mm
Ring Beams at Bottom slab level	=	500 x 1000 mm
Column size	=	500 x 500 mm
Brace Beams	=	300 x 500 mm
Ring Beams at Top slab level	=	250 x 450 mm

Material Properties

Grade of Concrete (fck)	=	M_{30}
Poisson's Ratio (μ)	=	0.17
Damping	=	5%
Grade of steel (fy)	=	Fe-415 (i.e., fy = 415 N/mm^2)

B. *Volume Calculations*

Required Capacity of OHT	= 1800 Cu.m
Diameter of the Cylindrical Portion (D1)	= 20 m
Height of water in the Cylindrical Portion (h1)	= 8 m
Height of the Conical Portion (h2)	= 2.5 m
Diameter of the tank at base of Conical portion (D2)	= 12 m
Angle subtended by the conical Slab with Horizontal (f0)	= 45 degree
Height of the Bottom Dome (h3)	= 2 m
Radius of Bottom Dome (R1) = $1/2*((D2^2/(4*h3))+3)$ = $(10^2/(4x2)+2)/2$	= 8.25m

The Volume of the Intz Tank is given by the Following Equation:

V1 = pie/4xD1^{2}xh1 =3.14/4x16^{2}x7	= 2407.4 m^3
V2 = pie/12xh2x (D1^2+D2^2+D1xD2) = 3.14/12x3x(16^2+10^2+16x10)	= 505.3 m^3
V3 = p/3xh3^{2}x(3xR1-h3) = 3.14/3x2^{2}x(3x7.25-2)	= 106.7 m^3
Total Volume = V1+V2-V3 =2407.44+505.27-106.73	= 2806.0 m^3
Consider freeboard of the Cylindrical Portion (FB)	= 0.5 M
Total Height of the Cylindrical Portion (h)	= 7.5 M

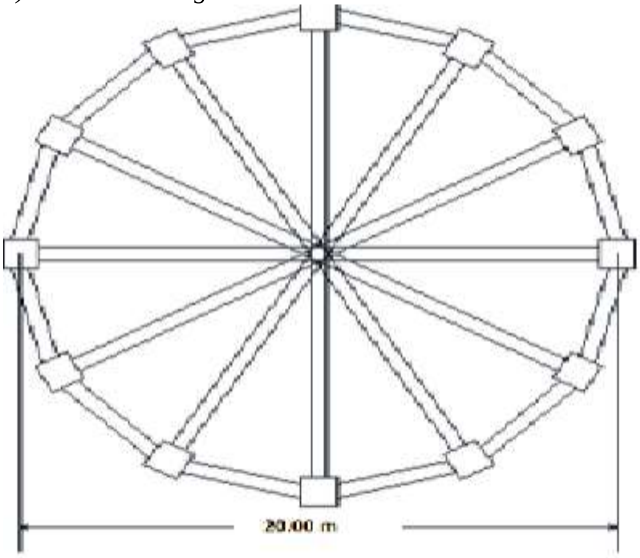
C. *Dead storage Calculation:*

Height of Bottom of Outlet from junction of Conical dome and

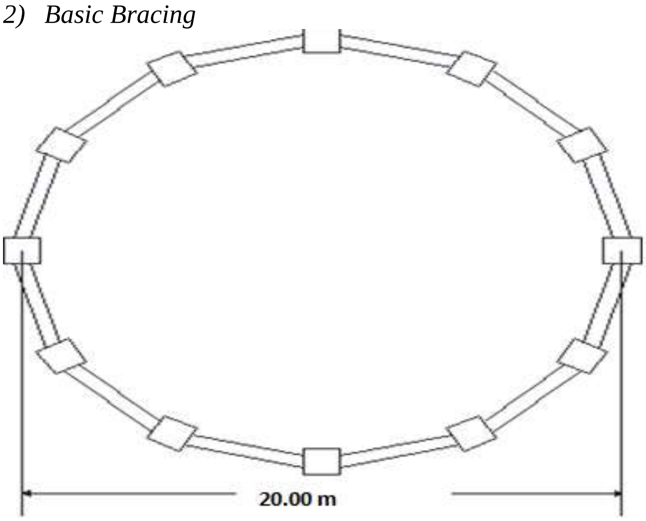
bottom dome (h')	= 0.4 M
Diameter of conical dome at 0.6m above base (D3)=	10+0.4x2 =10.8 m
Volume V4 = p/12xh'x(D3^2+D2^2+D3xD2) =3.14/12x0.4x(10.8^2+10^2+10.8x10)	= 34 m^3
Volume V3	= 82.7 m^3
Height of the apex of bottom dome above the dead storage h"	= 1.6 m
Volume V5 = p/3xh"2x(3xR1-h") = = 3.14/3x1.6^{2}x(3x7.25-1.6)	= 54.02 m^3
Total Dead Storage = 34-82.73+54.02	= 5.3 m^3
Effective Storage of the tank = 2806.0-5.29	= 2800 m^3

D. Staging Patterns:

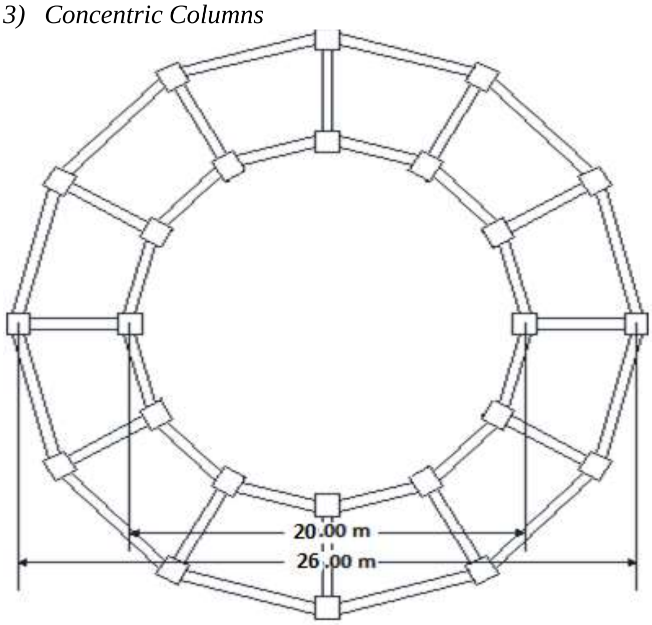
1) Radial Bracing with Central Column

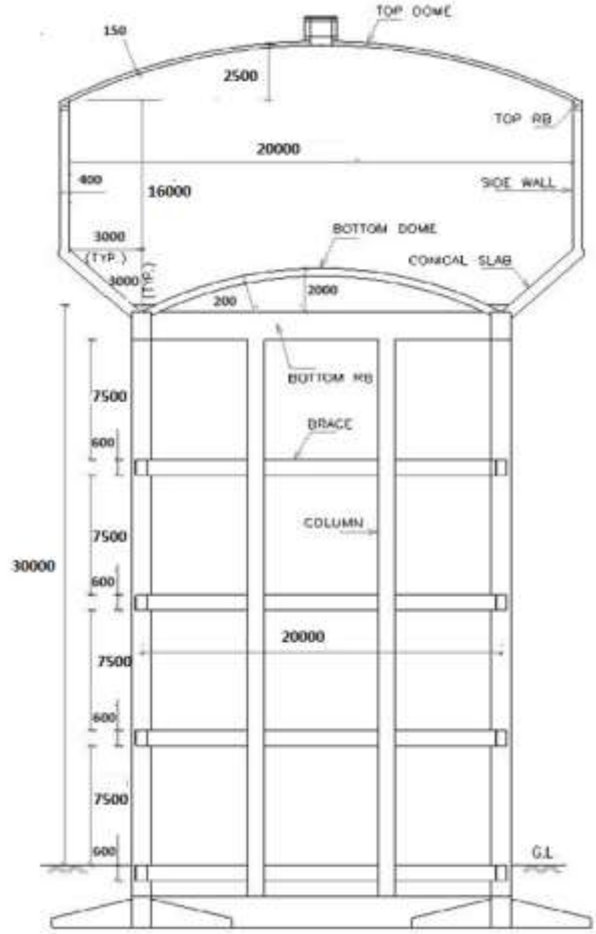


2) Basic Bracing



3) Concentric Columns





IV. LOADS CALCULATIONS ON ELEVATED WATER TANK

1) Dead loads

The Dead loads of an elevated water tank is its self weight which includes Staging and container portion. The total self weight of tank is applied in the Staad model in the Dead load case.

2) Imposed Loads

The top dome should be loaded with uniform pressure of 0.75kN/m² as an imposed load, because the no access is provide to roof except in the time of maintenance of the tank.

3) Water Loads

The water tank container is modelled with plate elements in STAADPro, and the water pressure will be applied on the bottom dome, and conical slab as a hydrostatic pressure vertically downwards, and the hydrostatic pressure applied on the side wall varies linearlywith the depth of the water (h), and it maximum at the bottom of the wall and it is zero at the top. The hydrostatic loads on tank are worked out in both Tank full and Tank half conditions.

Tank full condition (Height of water = 12.5m)

- The water pressure on Bottom dome = γw h = It varies from 85 kN/m^2 to 105 kN/m^2
  (105 kN/m^2 is at the lowest point and 85 kN/m^2 is at the highest points of the dome).
- The water pressure on Conical slab = γw h = It varies from 75 kN/m^2 to 105 kN/m^2(105 kN/m^2 is at the lowest

point and 75 kN/m^2 is at the highest points of the conical slab).

- The water pressure on the side wall = γw h = It varies from 0 kN/m^2 to 75 kN/m^2 (75 kN/m^2 is at the bottom of wall and 0 kN/m^2 is at the top of the wall).

Tank Half condition (Height of water = 6.25m)

- The water pressure on Bottom dome = γ_W h = It varies from 32.5 kN/m^2 to 52.5 kN/m^2 (52.5 kN/m^2 is at the lowest point and 32.5 kN/m^2 is at the highest points ofthe dome).
- The water pressure on Conical slab = γ_W h = It varies from 22.5 kN/m^2 to 52.5 kN/m^2 (52.5 kN/m^2 is at the lowest point and 32.5 kN/m^2 is at the highest points ofthe conical slab).
- The water pressure on the side wall = γ_W h = It varies from 0 kN/m^2 to 22.5 kN/m^2 (22.5 kN/m^2 is at the bottom of wall and 0 kN/m^2 is at the top of the wall).

B. Loads combinations

An elevated tank design shall be based on the most adverse load combinations given below using the safety factors prescribed as per IS: 1893 (Part-1): 2002. The elevated tank design shall be worked out for Tank empty, Tank half and Tank full conditions.

- Load Combination 1 (Tank Empty): Tank Self weight + Live load (No water in the tank)
- Load Combination 2 (Tank Half): Tank Self weight + Live load + Half tank of water
- Load Combination 3 (Tank Full): Tank Self weight + Live load + Full tank of water
- Load Combination 4: Combination 1 + Earthquake
- Load Combination 5: Combination 2 + Earthquake.
- Load Combination 6: Combination 3 + Earthquake.
- Load Combination 7: Combination 1 + Wind load.
- Load Combination 8: Combination 2 + Wind load.
- Load Combination 9: Combination 3 + Wind load.

C. Finite Element Model of Elevated Water tank

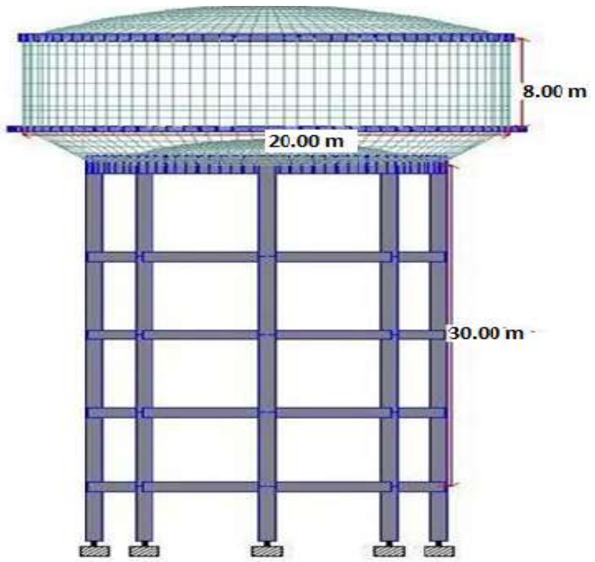


Fig. 4.5: FEM Model of Elevated Water tank

Finite element modelling procedure is adopted for analysis and finite element model is prepared in Staad Pro V8i software by using members and plane elements. The Figure: 4.4 shows the Columns, bracing beams, floor beams and finite element mesh generated to model tank portion. The diameter of the staging is 10m and height staging is 24m and 30m. The bottom dome, conical slab, side wall and top dome are modelled in staad pro with 4 noded plate elements.

The member specifications in terms of geometrical properties of the members are applied to the FEM model. The support condition of fixed is applied to the columns, because we are considering the foundation of tank as annular raft or combined raft. The loads and load combinations are applied to FEM model as considered in the chapter 4.2 & 4.3. The seismic force is applied at C.G of the tank as nodal forces on tank element nodes. The loads and load combination applied in the staad pro are as follows.

1) Primary Loads

1) EQ (+X)
2) EQ (-X)
3) EQ (+Z)
4) EQ (-Z)
5) WL (+X)
6) WL(-X)
7) WL(+Z)
8) WL(-Z)
9) Dead load (DL)
10) Live load (LL)
11) Water load (Full)
12) Water load (Half)

D. Load Combinations

1) Tank Full conditions

1) DL+LL+WATER FULL+EQ(+X)
2) DL+LL+WATER FULL+EQ(-X)
3) DL+LL+WATER FULL+EQ(+Z)
4) DL+LL+WATER FULL+EQ(-Z)
5) DL+LL+WATER FULL+WL(+X)
6) DL+LL+WATER FULL+WL(-X)
7) DL+LL+WATER FULL+WL(+Z)
8) DL+LL+WATER FULL+WL(-Z)

2) Tank Half conditions

9) DL+LL+WATER HALF+EQ(+X)
10) DL+LL+WATER HALF+EQ(-X)
11) DL+LL+WATER HALF+EQ(+Z)
12) DL+LL+WATER HALF+EQ(-Z)
13) DL+LL+WATER HALF+WL(+X)
14) DL+LL+WATER HALF+WL(-X)
15) DL+LL+WATER HALF+WL(+Z)
16) DL+LL+WATER HALF+WL(-Z)

3) Tank Empty conditions

17) DL+LL+EQ(+X)
18) DL+LL+EQ(-X)
19) DL+LL+EQ(+Z)
20) DL+LL+EQ(-Z)
21) DL+LL+WL(+X)
22) DL+LL+WL(-X)
23) DL+LL+WL(+Z)
24) DL+LL+WL(-Z)

E. Finite element model of different staging patterns

The staad modelling for Concentric columns, Radial bracing and Basic bracing staging patterns and are shown in Figures: 4.6, 4.7 & 4.8.

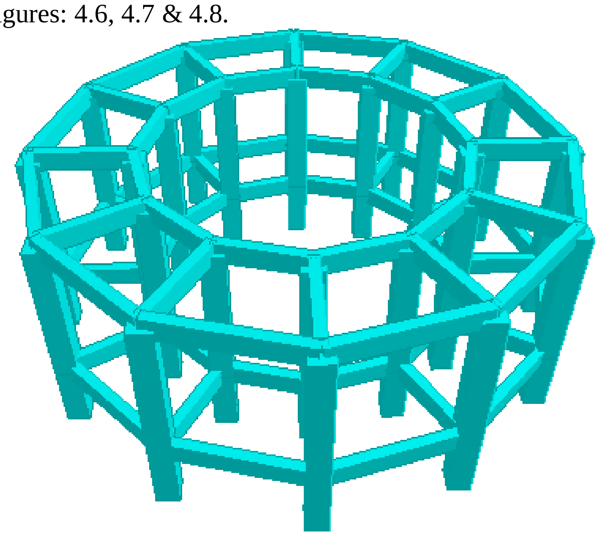


Fig. 4.6: Concentric columns type of staging

Fig. 4.7: Radial Bracing with central column type of staging

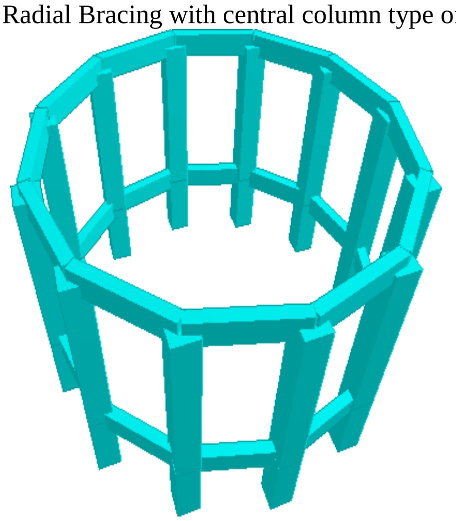


Fig. 4.8: Radial Bracing type of staging

V. SUMMARY

In the present study an elevated water tank of capacity 1800m3 with staging heights of 24m and 30m is considered. These tanks are analyzed for different types of staging patterns namely Basic, Radial systems and Concentric columns in various earthquake zones Zone-III zone IV and Zone-V as per IS 1893 (Part-2) codes. In this analysis Finite Element Model is generated by Staad pro structural software and the Seismic forces are applied to the model for various tank filling conditions, such as Tank empty, Tank half and Tank full conditions.

- The staging performance of a tank with various earthquake appearances in various tank filling conditions are studied.
- A proportional study of various patterns of staging are Radial and basic type bracings and concentric columns in Zones-IIIrd or Vth with 24metres ht. of staging.
- A proportional study of various pattern of staging are Basic and radial type bracings and concentric columns in Zone-V with 30m height of staging and collective number of bracing bays.

VI. CONCLUSIONS

In this demonstration the substantial change in seismic behaviour of tanks along with the concern responses such as base moment, stiffness, displacement, base shear, etc. For appropriate modifications supporting system is used. Finally study reveals the eminence of appropriate supporting conformation to resist the heavy damage/failure of an elevated water tanks during earthquake.

Earthquake features in various zones, which is the main cause of the excitation of responses like overturning moment, roof displacement and base shear force, are equated and compared.

1) In IIIrd zone 1st case study of storage tank having 24metres staging ht., in this case Basic bracing (Ks= 26315.79kN/m) is satisfactory or much more suitable in comparison to radial (Ks= 35087.72kN/m).
2) In Zone-V for the same Case study-1 of fluid (water) storage tank having 24 metres staging ht., the roof displacements for Basic (70mm), Radial (62mm) type of bracings are exceeding the limiting value (54mm).
3) In Case study-1 and 2 fluid (water) storage tank having 24 & 30metres ht., in the Radial type the Base shear & Base moments are comparatively greater than the Basic bracing which may distress the reinforcement scheme of staging members.
4) In Zone-V for the same Case study-2 of fluid (water) storage tank having height of staging, after amendment of bracing beam sizes, it is observed that, the minimum value of staging stiffness (Ks) should be less than 11013kN/m to make roof displacements in the permissible limits.

A. Future Scope

As per the above case studies, frame type staging with a single row of columns placed along the tank periphery, are suitable for low to medium range of storage capacity.

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