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Design Analysis and Comparsion of Over Head Water Tank for Different Wind Speed and Seismic Zones as Per Indian Standard Codes

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ABSTRACT:

As to IS standards of Practices, A few designing of Tanks is subjecting to Dead + Live Loading, Wind Load, or Seismic Load. Tanks are frequently designing for W.F. and don't yet examined for Earthquake Load, thinking that once constructed for wind forces, Tanks would be safer underneath seismic forces. Wind and seismic forces acts on Intze type tank examined in this research work. Because wind flowing relatively to ground surface and exerts loads on structures located on the ground, Wind affects on elevated structures is critical. The wind influence is taking majority of designers, however seismic consequence on building is often overlooked. The Elevated Structure is designing for a variety of Wind Forces, such as 39 metres/second, 44 metres/second, 47 m/s, and 50 m/s, and cross-checked with different Seismic Zones, such as Zone-II, Zone-III, Zone-IV, and Zone-V, using the 'Response Spectrum Method,' with max. Governing state from both forces being used for staging design and analysis. The research reveals that for Case-1, Case-2, Case-3, and Case-4, total loading, Moments, Reinforcement in staging (columns, braces, and raft foundation) vary.

KEY WORDS: Wind Loading, Seismic Load, Intze Tank, I. S. Codes, Response Spectrum Method, Raft foundation.

INTODUCTION:

Water is life line for every kind of creature in this world. Municipalities and enterprises use liquid storage tanks for water delivery, firefighting systems, inflammable liquids, and other chemicals all around the world. Thus, water tanks playing a vital element in public utility and industrial structures, with the primary goal of ensuring a consistent supply of water across a longer distance with sufficient static head to the target site underneath the pressure of gravity. The demand for drinking water has risen dramatically in response to population growth. Pumping water at peak hours is also impossible due to electrical shortages in many parts of India and around the developing world. Elevated water tanks become an integral element of living in such conditions. Natural calamities earthquakes, draughts, floods, and cyclones are all common in India. India having several disasters. They showing causalities and enormous properties loss each year.

India having more than 60% prone to earthquakes, according to the seismic code IS 1893(Part-1):2000. The greatest cause of death is the collapse of structures. Natural disasters, it is believed, never kill people; it is poorly constructed structures that do. As a result, it's critical to assess the structure for earthquakes, cyclones, floods, and typhoons.

ELEVATED WATER TANK, AND EARTHQUAKE INFLUENCE

Water supply is a critical capability that must be maintained after a disaster. Many Indian states have different water supply systems that rely on raised tanks for capacity. It has a big elevated storage container that can hold enough water to pressurise a water dispersion system. Individual supply frameworks of organisations and mechanical residences, of which elevated tanks are a basic portion, augment the basic supply plan in significant metropolitan communities. The tank's features include strengthening and durability; the problem of leakage should also be prevented by identifying acceptable construction techniques. Regardless, these constructions do not consistently last as long as they were designed to. Because of the enormous absolute mass aggregated at the highest point of the slim supporting structure, these constructions are particularly vulnerable to lateral forces such as seismic tremor and wind. As a result, it is necessary to assess the significance of these powers for each area.

Water supply is essential for suppressing fires that can occur during seismic shocks, which can result in significant damaging and losses of life. As a result, tanks used in the post-tremor period to ensure that water is available in seismic tremor-affected areas. Water is also necessary for survival because it is used for drinking, thus elevated water tanks should continue to function even after cyclones and strong winds. Despite this, during previous earthquakes, fewer tanks were injured or buckled.

Water retaining structure distress has been detected in general much earlier in the administration's life, around the 9th to 10th year. Because of some concerns with supplementary views and an overabundance of seismic analysis, wind analysis in earthquake-prone and wind zones. We learned from previous scenarios that tanks have incurred varied degrees of damage, 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. Water makes up 72 percent of the Earth's surface, with the seas accounting for 96 percent, ice glaciers accounting for 3%, and pure drinking water accounting for barely 1%. So, rather than being a required, storing water is one of the major source to demanding for 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

HOW STAAD. PRO HELPS FOR THE DESIGNING OF WATER TANKS

Bentley's Structural Analytical and Design (Staad. pro) programme is a powerful and high-potential analysis tool. Staad pro creates a virtual 3D model and assigns multiple load factors to it. It makes bending moment shear force and deflection of structure elements with load combinations and Indian standard codes difficult to calculate. To begin, a design of a prototype model of a water tank is developed in a software interface with specified construction dimensions, material attributes, and load conditions. Defining the required parameters and loads. Finally, conduct model analysis to integrate structure evaluation and obtain detailed information about structural behaviour under load conditions. The fatigue process is commonly used in traditional methods of analysis.

LITERATURE REVIEW:

Khaza Mohiddin Shaikh and Prof. Vasugi K (2014): The relevance of seismic analysis and designing of tanks cannot be overstated. Even after an earthquake, these structures must continue to work. The majority of high water tanks are never entirely filled. As a result, a two-mass idealisation is preferable to a one-mass idealisation.

R.K.Prasad and Akshaya B. Kamdi (2012): BIS published the new version of IS 3370 (parts 1 and 2) in 2009, after a long hiatus from the 1965 original. This updated code is mostly for liquid storage tanks. The idea behind the design of a circular water tank utilising WSM and LSM is summarised in this paper. LSM's water tank design is the most cost-effective since the amount of material required is smaller than that of WSM's. Because the water tank is the most significant container for storing water, crack width calculations are also required.

Hasan Jasim Mohammed (2011): An optimization method is applied for structure designing of concrete rectangular and circular water tanks, with total cost of tank as the objective function and the tank's properties as design variables, which include tank capacity, width and length in rectangular tanks, water depth in circular tanks, unit weight of water, and tank floor slab thickness.

Pavan S. Ekbote and Dr. Jagdish G. Kori: Tanks were harshly damaged or toppled during the earthquake. This could be due to a lack of understanding of the manners of tank's supporting system in dynamic action, as well as an incorrect geometrical selection of tank staging patterns. The seismic manners of raised water tanks has complicated properties of fluid structural interactions. The primary goal of this research is to better understand the behaviour of a supporting system (or staging) that is more effective when using SAP 2000 software with varied response spectrum methods. Different supporting systems, such as cross and radial bracing, are investigated in this work.

Sezen et al. (2008) using simplest 3-mass models to perform dynamic analysis and The output of elevated cylindrical tanks smashed during Kocaeli earthquake in Turkey in 1999 was investigated.

Dutta et al. (2009) Investigated for dynamic property of RC tanks assisted by cylindrical shaft staging. Small-scale experimentation and FEM analysis were used to verify the findings.

Amani et al. (2010) The FEM using for calculating resonant frequencies of RC elevated spherical container half filled with water, and the results were confirmed experimentally. We investigated complete dynamical responses of spherical tanks loaded to horizontal base motion and free vibration and containing water at various levels. He discovered that for a spherical tank, 3 independent mass-motions required: structural translation, convective sloshing, and pendulum motions. As a result, the study requires three degrees of freedom.

Moslemi, M. et al. (2011) Seismic responses of liquid-filled elevated tank was discussed, as well as the complexities of modelling conical-shaped tanks. Fluid elements dependent on displacement are using for modelling fluid domain (D-Fluid element). An elevated tank was subjected to time history function or modal analyses.

Chaduvula, U. et al. (2013) 1:4 scale model of a 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 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 "DESIGNING AND ANALYSIS was completed through stadd pro. 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 various topics such as construction view, designing, formwork details, reinforcement details, water treatment plant method, and execution.

Thalapathy .M et al., "ANALYSING OR DESIGNING OF TANKS" was completed. According to the paper, this project provides complete information of designing a liquid-retaining system using the working stress process. This paper provides an idea for a safe tank design at a low cost, as well as designer relation curve b/w design variables. This paper aids in comprehending the design concept of tanks that is both stable and cost-effective.

Ankit Agarwal, Pooja Semwal This review paper provides the structural stability and behaviour of reinforced concrete cement overhead water tanks during the penetrable force like earthquake. The objective of this analysis to understanding shapes of water tanks as per different seismic zones IInd, IIIrd, IVth and Vth in India.

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

Dona Rose K J et al 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., 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 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., "Geotechnical exploration for Designing of Tank Foundation" was finished. The author of this publication did a geotechnical subsoil survey in order to determine what sort of tank would be appropriate for that location. He conducted several soil stability experiments, such as bearing capacity and conventional penetration tests, as part of this inquiry, and recommended using a shallow foundation that would be safe in the region.

Dr. Suchita Hirde et al., The author of this journal investigated the performance of tanks in seismic zones in India. She also conducted research into past earthquake damage to water tanks, after which she modelled and analysed 240 tanks for various characteristics in an earthquake zone.

B.V. Ramana Murthy, M Chiranjeevi 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, 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 strategy. As a result, a two-mass idealisation is preferable to the one-mass idealisation used in IS 1893: 1984. Housner (1963b) suggested two mass modelling for tanks.

CONCEPT OF DOMES

A dome can be defined as a shell formed by a curve rotating around a vertical axis. A spherical dome is generated when the arc of revolution around the vertical axis is a segment of a circle. As a resultIn a spherical dome, any vertical segment through the axis of revolution in any direction is basically an arc of a circle. A conical dome can also be made by rotating a triangle around a vertical axis. Spherical domes are the most common of the two types.

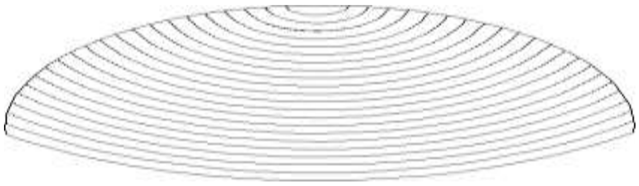

Fig: Spherical Dome

The domes are designed for the total vertical load only. The weight of the dome slab and any covering material, if any, over the slab; the weight of any other load suspended from the slab; and live load, among other things, are all included in the term total vertical load. Because wind load, shrinkage, and temperature changes are complicated in nature and difficult to quantify, no separate calculations are done. However, the effect is mitigated by assuming an additional live load of 1000 to 1500 N/sq. m on the dome's surfaces. Alternatively, the adjustment for wind load and other factors might be made by designing the dome with a lower allowed stress value. Whatever the design outcome, min. thickness of slab should be 80 mm, min. % of steel in both directions (Meridonial and along the latitude) shouldn't lesser than 2% of the concrete surface The minimal % of steel cann't be lesser than 0.3 percent.

INTZE TYPE WATER TANK DESIGN

It has been discovered that an elevated circular tank with a flat floor slab is an inefficient design for storing huge amounts of water. The main reason for this is because the floor slab becomes excessively thick for tanks with big diameters. In such cases, the Intze tank is the finest option. An Intze tank is made up of three parts: a top dome (roof), a cylinder wall, and a floor slab made up of a conical dome and a bottom spherical dome. Because the domical floor is exposed to direct compression, its thickness is significantly reduced, making it a cost-effective alternative to a flat slab floor. The conical dome and bottom dome are proportioned in such a way that the outward thrust from the bottom domed component of floor balances the inward thrust from the conical domed portion. The dia. of bottom dome should ideally be between 65 and 70% of the tank's diameter. The inclination of conical dome with the horizontal should be between 50 and 55 degrees for economic reasons. Figure 1 shows the proportions of various tank components under ideal conditions (2)

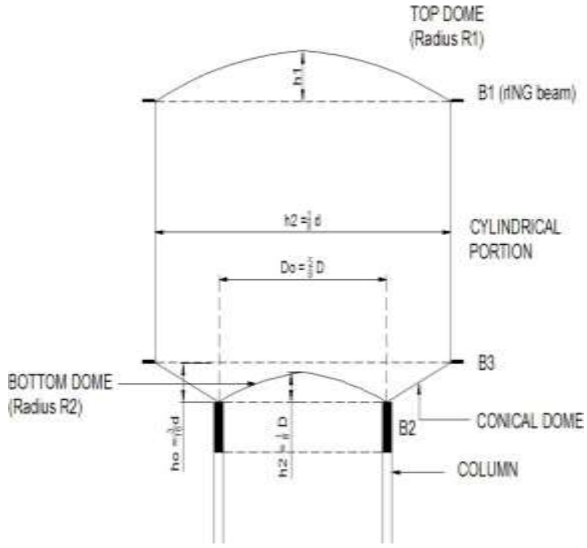

Fig: Components of Intze Tank

The Top Dome And Top Ring Beam:

With the use of a shear key, the dome and ring beam are supposed to be freely linked to cylindrical walls of tank. On the basis of membrane analysis, we will design the top dome and its ring beam, which will be independent of the tank wall, which will be assumed to be free at the top.

The Cylindrically Wall:

Let D be dia.of tank and H be ht. of cylindrical part. At top and bottom, the walls are believed to be free. As a result, tank walls will only be subjected to hoop tension, with no B.M. The maximum hoop tension will be at the base, with a magnitude of W.h.d/2 per unit height. Horizontal rings on both sides of the tank offer enough reinforcement. In addition to this, vertical reinforcement is provided on both the faces of distribution reinforcement.

Design Of Ring Beam At The Junction Of The Cylindrical Wall And Conical Dome:

Find hoop tension in the beam by the formula

$$\mathrm{H} = \mathrm{H}_1 \times \frac{D}{2} + \mathrm{H}_2 \times \frac{D}{2}$$

W2 is the load transmitted through the tank wall at top of conical dome, and H1 is the horizontal component of the thrust T

owing to w1. The value of $H_1 = w_1 \tan(\beta)$

H2 is the horizontal force at the top of the conical dome due to water pressure,

H_2 = w x h x d

d is assumed beam depth and h is the water depth up to the beam's centre.

The beam can be created in the same way as the top ring beam now that H has been calculated. It's preferable to keep the beam's depth low in order to gain greater breadth, which could be used as a walkway or inspection gallery around the tank.

DESIGN OF CONICAL DOME:

For conical dome designing following steps involved:

- Calculate the weight of water on the conical dome by multiplying the average diameter by the water depth. Add the conical dome slab's self-weight and the load (w1) transferred through the tank wall at top of conical dome to this value.
- For calculating load per metre run at the conical dome base, divide the total load obtained above by the perimeter of conical dome at base.
- Find Meridonial thrust in slab due to (w_2) by $T = \frac{w2}{\cos\beta}$
- Determine the hoop tension caused by water pressure and the conical dome slab's selfweight; we knowing pressure of water will acting normal to inclined slab surface. Assume "p" represent the intensity of water pressure at a depth of h metres above the conical dome base, and "Dh" represent dia. of conical dome at that depth. A general formula is then used to calculate hooptension,

$$H = (\frac{\rho}{\alpha\rho Q} + q.\tan\beta)\ \frac{DH}{2}$$

Where „q" is wt. of conical slab per square meter of the surface area.

- Using the aforementioned calculations, calculating hoop stress at bottom, midpoint, and top of the inclined conical dome slab and add hoop reinforcement as needed.

Design of Bottom Spherical Dome:

The bottom dome is designed in the similar manner as the top dome, except that the load of the water above the dome is added to self-wt. of dome slab to get design load for the dome.

Design of bottom ring beam:

For designing ring beam some steps involved:

- Find the net horizontal force (P) on ring beam given by the formula, P = T1 xcos $\alpha \sim \cos\gamma$
- If $T1 \cos\alpha > \cos y$ The force will be compressive in nature, resulting in net inward force per metre.
- Find hoop stress, = $\frac{PD}{2} \times \frac{1}{bd}$ (compressive)

Its effect can be overlooked because it is compressive in nature and usually has a minor magnitude. (In a well- proportioned tank the net horizontal force should be much less.)

- Find vertical load per meter run, is = $T1\cos\beta x T2 \sin\gamma$

Alternatively, the vertical load per metre can be calculated by dividing total vertical loads by the bottom ring beam's perimeter.

Design of Staging:

Design of columns: Let W be total vertical load (including live loads) due to tank and its contents above the staging. If n be no. of columns in staging:

Total load on each column = W/η Add to this vertical force Pω due to wind to which the column will be subjected to.When the wind blows, the windward columns on leeward side experience downward forces. The neutral axis is a line that passes through the centre of group of column circles and is perpendicular to the wind direction. Let, Mw = Moment due to wind regarding underneath of

columns and let „r" be the distance from any column to the neutral axis.

Σr^2 = Sum of the square of the distances of all columns from N.A. The vertical force in any column at a distance r from N.A. is given by the formula

$$Pw = \frac{\text{Mw} \times \text{r}}{\Sigma r^2}$$

Alternatively: The maximum force in the remotest or the extreme column can also be calculated from the following formula

$$Pw = \frac{\text{MWR}}{nxR}$$

Where, R = radius of the column circle The design of columns will obviously be governed by the farthest column or the extreme column on the leeward side. The column should be created with this in mind. Max. B.M. = ½ x Max. Horizontal shear X Distance b/w the bracing;

- Total vertical Load = P + Pw

Design of Foundations:

For Intze tanks, combined footing is commonly used to achieve rigidity at the column base. Depending upon the allowable soil pressure the combined footing may either be in form of solid circular raft or an annular circular raft.

CONCLUSION

The following are the results drawn from this project's design and analysis:

- For the same bearing capacity, the volume of concrete and the quality of steel both rise as the wind speed and seismic zone increase.
- We have seen that, speed of wind increases the wind force on staging goes on increasing for different cases.

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