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Design and estimation RCC overhead water tank

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ABSTRACT

Storage reservoirs and overhead tank are used to store water, liquid petroleum, petroleum products and similar liquids. The structure analysis of the reservoirs or tanks is about the same irrespective of the chemical nature of the product. All tanks are designed as crack free structures to eliminate any leakage.

This project gives in brief, the theory behind the design of liquid retaining structure (Elevated circular water tank with domed roof and conical base) using working stress method. Elements are design in limit state method.

Liquid tanks and especially the elevated tanks are structures of high importance which are considered as the main life line elements that should be capable of keeping the expected performance. Earlier design of water tanks being done using the working stress method given in IS 3370: 1965. This method leads to thicker and heavily reinforced section. The use of limit state method of design has been adopted in received code IS 3370:2009 and provision for checking the crack width is also included in this code.

Keywords: *Convective hydrodynamic pressure, Elevated water tank, Impulsive hydrodynamic pressure, Soshing wave height, STAAD pro.*

1. INTRODUCTION

A water tank is used to store water to tide over the daily requirement. In the construction of concrete structure for the storage of water and other liquids the imperviousness of concrete is most essential .The permeability of any uniform and thoroughly compacted concrete of given mix proportions is mainly dependent on water cement ratio .The increase in water cement ratio results in increase in the permeability .The decrease in water cement ratio will therefore be desirable to decrease the permeability, but very much reduced water cement ratio may cause compaction difficulties and prove to be harmful also. Design of liquid retaining structure has to be based on the avoidance of cracking in the concrete having regard to its tensile strength. Cracks can be prevented by avoiding the use of thick timber shuttering which prevent the easy escape of heat of hydration from the concrete mass .the risk of cracking can also be minimized by reducing the restraints on free expansion or contraction of the structure.

However, a general-purpose structural analysis program generally exists in every engineering office. So, the evaluation of the applicability of these structural analysis programs in the design of elevated tanks is important from an engineering point of view and it will be helpful to present the application and results to designers. There is a second important reason that should be considered. That is, simplified models are used for a straightforward estimate of the seismic hazard of existing elevated tanks. Only if the estimated risk is high, it is convenient to measure all the data (e.g. geometry of the tank, material properties) that are required by the general finite element codes and to spend time and money to prepare a reliable general model.

1.1 OBJECTIVE

- To make a study about the analysis and design of water tanks
- To make a study about the guidelines for the design of liquid retaining structure according to IS Code.
- To know about the design philosophy for the safe and economical design of water tank
- To develop programs for the design of water tank of flexible base and rigid base and the underground tank to avoid the tedious calculations.
- In the end, the programs are validated with the results of manual calculation given in Concrete Structure.

1.2 SCOPE

- In design of an intze tank varying seismic, wind zone and the results
- Seismic effect considered in the software are based on IS code. Due to the recent occurrence earth quake zone, detailed analysis of such soil may be required for safe design of such tanks
- In this study RCC structure have been considered. The study can be extended to steel structure.
- The seismic forces remain constant in a particular zone provided the soil properties remain same.

2. LITERATURE REVIEW

Recognizing the limitations and shot comings in the provision of IS:1893-1984, Jain and Medhekar, Jain and Sameer a set of provisions on aseismic design of liquid storage tanks, the author has given some recommendations –

- Design horizontal seismic coefficient given in revised IS: 1893(Part-1)-2002 is used and values of response reduction factor for different types of tanks are proposed.
- Different spring-mass model for tanks with rigid & flexible wall are done away with; instead, a single spring-mass model for both types of tank is proposed.
- Expressions for convective hydrodynamic pressure are corrected.
- Simple expression for sloshing wave height is used.
- New provisions are included to consider the effect of vertical excitation and to describe critical direction of earthquake loading for elevated water tanks with frametype staging.

This paper is related with the soil & water behavior of elevated concrete water tank under seismic load. An artificial seismic excitation has been generated according to Gaspariniand Vanmarcke approach, at the bedrock, and then consideration of the seismic excitation based on one dimension nonlinear local site has been carried out. Author has chosen seven cases to make comparisons with direct nonlinear dynamic analysis, mechanical models with and without soil structure interaction (SSI) for single degree of freedom (SDOF), two degree of freedom (2DOF), and finite element method (FEM) models. The analysis is based on superposition model dynamic analysis. Soil structure interaction (SSI) and fluid structure interaction (FSI) have been accounted using direct approach and added mass approach respectively. The result shows that a significant effect obtained in shear force, overturning moment and axial force at the base of elevated tank.

Earthquake response of elevated liquid storage steel tanks isolated by the linearelastomeric bearings is investigated under real earthquake ground motion. Two types of isolated tank models are considered in which the bearings are placed at the base and top of the steel tower structure. The continuous liquid mass of the tank is modeled as lumped mass known as sloshing mass, impulsive mass and rigid mass. The corresponding stiffness constant associated with these lumped masses have been worked out depending upon the properties of the tank wall and liquid mass.

The mass of steel tower structure is lumped equally at top and bottom. Since the damping matrix of the isolated tank system is non-classical in nature, the seismic response isobtained by the Newmark's step-by step method. The response of two types of tanks, namely slender and broad tanks, is obtained and a parametric study is carried out to study the effects of important system parameters on the effectiveness of seismic isolation.

The various important parameters considered are the tank aspect ratio, the time period of tower structure, damping and time period of isolation system. It has been shown that the earthquake response of the isolated tank is significantly reduced. Further, it is also observed that the isolation is more effective for the tank with a stiff tower structure in comparison to flexible towers.

In addition, a simplified analysis is also presented to evaluate the response of the elevated steel tanks using two degree of freedom model and two single degree of freedom models. It is observed that the proposed analysis predicts the seismic response of elevated steel tanks accurately with significantly less computational efforts.

3. METHODOLOGY

A. Structural Layouts

Each of the propped cantilevers was made rigid fixed to its base slab and was expected to be drawn inward at the top by the wall/top slab connecting reinforcements, in response to the outward hydrostatic loading on the wall. That was providing in view based on the fact that continuity reinforcement must be provided at corners and at memberjunctions to prevent cracking. The base slabs was typically a double overhanging single-spanned continuous slab, with wall point load and its applied fixed end moment at each overhang end. And the top slabs was laid out to be either two-way spanning or simply supported as stated by Anchor (1992 and 1981). The tank dimensions was deduce by application related to the formula for solid shapes volume calculations, Therefore (π x R2 x H) for cylinder was applied for the circular water tank; where, H and R, Breadth, Height and Radius respectively.

B. Wall Loading

The average water force and load, P in kN / meter width of the rectangular tank walls under flexural tension was derived as a point concentrated load by calculating the areas of the pressure diagrams of the water tank content on the walls, to be (ρH) x H/2, where ρ is the water density. By the centroid consideration of loading of the pressure diagram, one-third distance from the base, up each wall, was chosen as the point of application of the concentrated load. The circular water tank wall would be clearly in a state of simple hoop tension and its amount in kN per meter height of wall would be (ρH) x D/2. And it would still act at one-third distance from the base up each wall. The wall total working loads for both options were assumed purely hydrostatic. And the inclusion of wind load in the working load was purely made to be dependent on tank elevation above the ground level, but would always be applicable in the design of its support. The wind loads application point, if considered, would be at one-half the tank"s height and acting against the lateral water force. Hence, the resultant lateral force, from the combination of the water force and wind force; if applicable, would be one-half way between the two forces, that is, five-twelfth of the tank"s height.

C. Base Slab Loading

For every of the elevated water tank options, the base slab characteristic serviceability uniformly distribute load in kN/m per meter was the sum of its dead load, thyself-weight concrete and its finish, and its live load, that is, the weight of water to be contained. And the serviceability point load in kN / meter, acting on each of the base slabs, at the extremes of the overhangs was derived by adding up the wall dead load that is the base projection weight and a calculated fraction of the top slab load. But some notice difference may be experience in the calculations of the fractions of the loads from the circular water tank top slabs.

D. Top Slab Loading

The top slab uniformly distributed load, in kN/m per meter run is calculate by adding up its combination of dead load, that is self weight concrete, waterproof finish and its live load, to derive the characteristic serviceability load. Factors of safety of 1.4 and 1.6 was apply to the combination of dead and live loads respectively before their sum is make to achieve the require ultimate design load of top slab.

The methodology includes the selection of type of water tank, fixing the dimensions of components for the selected water tank and performing linear dynamic analysis (Response Spectrum Method of Analysis) by IS: 1893-1984 and IS: 1893-2002 (Part 2) draft code. In this study, various capacity circular and rectangular overhead water tank is considered for analysis. It is analyzed for four different zones (zone-II to V), and for two tank-fill conditions, i.e. tank full and tank empty conditions. Lastly, the results of the analysis of tanks performed on the basis of IS: 18931984 and IS: 1893-2002 (Part 2) draft code have been compared by using the software STAAD PRO software.

4. CONCLUTION

Storage of water in the form of tanks for drinking and washing purposes, swimming pools for exercise and enjoyment, and sewage sedimentation tanks are gaining increasing importance in the present day life. For small capacities we go for rectangular water tanks while for bigger capacities we provide circular water tanks.

Design of water tank is a very tedious method. Without power also we can consume water by gravitational force.

5. REFERENCE

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