An Informative Review on Underground Storage Reservoir System

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Abstract: Underground Water Tank had been the main and the most essential part of almost every project. Due to increase of population every day, it is necessary to provide water demand for the various purposes such as industrial use, farming, domestic use, for drinking purpose etc. The storage of water is foremost done by providing underground water tank. The weight is directly transferred underground because of its location beneath the ground level. The rate of land has been seen increasing day by day over a period of time and it is necessary to efficient use of most of its part within the boundary that is a major issue. Different works based on different storage tank criteria along with the views of various researchers are mentioned in literature survey part. The paper contributes by analyzing the previous work done with the comparative analysis of cost effectiveness with linkage to parametric analysis and design by both traditional as well as software approach that leads to the conclusions provided with the outline of proposed work.

Index Terms - Limiting Standards, Sub grade modulus, Tank Efficiency, Tank Size, Underground Storage Reservoir System

I. INTRODUCTION

The water supply demand has now increased when compared to previous year data. Due to increase of population and shifting of people day by day leads to increase the water demand for drinking, domestic use, industrial along with commercial use. The water tank has now become the essential component of every structure just because to fulfill the water needs. Water tanks are classified based on its shape, materials and location.

Four types of water tanks are classified based on its size are as follows:-
1. Rectangular water tanks
2. Circular water tanks
3. Spherical water tanks
4. Intz water tanks

Six types of water tanks are classified based on its material are as follows:-
1. Steel water tanks
2. Composite alloy based water tanks
3. R.C.C. water tanks
4. P.S.C. water tanks
5. Traditional brick wall type water tanks
6. Plastic water tanks

Three types of water tanks are classified based on its location are as follows:-
1. Overhead water tanks
2. Tanks resting on ground
3. Underground water tank

Since underground water tank has many advantages are as follows:-
1. To store different types of liquids.
2. To store liquid products that contains high vapor pressure.
3. To store a huge amount of water.
4. To collect, save and store runoff water from channels connected from large catchment areas.
5. To transfer inside water pressure directly to the soil.
6. It can easily be cleaned and maintained.
7. The space above the water tank can be utilized hassle free.
II. LITERATURE SURVEY

The study of literature review enlightens the efforts made by the author to obtain the result which provides constructive behavior for any kind of changes. Various papers are studied and compared the sole effect of underground water tank and all the statistics were represented as well as various situations were analyzed the outcomes were exceptionally good.

The finite element method has been used in the parametric evaluation of results of underground water tank is the major part of their study. In introduction, they have provided information about underground water tank used for various purposes tot store water for waste water rainwater collection and roof catchments are the best practice to store water in underground tanks by channeling. The shear stresses in tank wall is less when L/B ratio of tank is more, hence shear stresses in X direction is also less, same pattern observed in Y direction. Principal bottom stresses are less at L/B of value 3 up to sixty percent. Similarly for top stresses, 10% rate of decrease has observed by increasing L/B ratio. Von miss and Tresca top and bottom also get lessen up to 10 percent. No change in nodal displacement is observed due to pressure of water that retains its position and earth pressure that gives a better reaction forces. They conclude for both full and empty conditions. L/B less than 2, the parameters shows negligible values but showing variations when there has an increment of L/B ratio (Anshuman Nimade et al. 2018).

Tapering of elevated water tank is mentioned in their work by concluding the diameter side walls and by using staging. They have considered their research as per Gujarat disaster management authority. Mass dashpot model is the perfect way describe the water tank, hence they used this mass dashpot model in their work. For staging’s, they used various levels with spacing’s between them to support the water tank. Results and conclusion part have merged to describe the spot work. When there has an increment of tapering of staging, the axial tension decreases and the diameter of staging also decreases. When tapering increases, the minimum pressure decreases, but the maximum pressure will increase along with 3 degree and 6 degree taper results with stability requirements. 6 degree with 6.28 m diameter of staging, raw uplift and tension in column and foundation has observed which was 70% at that time and with 0 degree inclination, 8.04 m diameter of staging, the value observed is 80% (Chirag Patel et al. 2012).

Using software tool, the major part of their work was successfully completed consist of analysis work, designing work with comparison of underground rectangular water tank. In introduction part, they have shown the importance of water tank and their 3 types of classifications with the use of each of them. Tank with staging are used and analyzed with the help of Staad Pro software. Two design cases have used in underground water tank. They concluded concrete tanks that can be replaced by plastic tanks. Dead loads should be greater than uplift loads during maintenance work concluded by their uplift check. Allowable stress should be greater than stress on soil just after construction work concluded by observing stress on soil. Uses of tension piles, PCC beneath the RC slab, using toe, use PCC just above RC slab and increment of floor thickness criteria should be used when the above stated criteria shows unsafe. This is just to increase the part or thickness or dimension of member to increase its weight to bear the unsafe criteria to make the underground tank safe (Issar Kapadia et al. 2017).

The main and the major coefficient of sub grade reaction were evaluated by the author. He made an assumption that Hook’s law obeyed by sub grade and the centrally loaded plate which is rigid rested on horizontally plane; the reaction of sub grade at every point of base has a same value. The deformation criteria of sub grade material along with the loaded area dimensions should be matched with the coefficient of sub grade reactions. This coefficient using rules have been described in the work presented. The main point observed that the sub grade reaction theories should not be used for the evaluation of settlement or displacements. These coefficients should be numerical error free and satisfy the elastic properties of sub grade material and its reaction to the area of the project surface acted upon it (Karl Terzaghi 1995).

Using the software tool, elevated water tank has design and analyzed. They used their work to apply seismic loading for all the four Indian Seismic Zones and find out the varying dimensions of member of tank for different zones. After analysis, they found the water that above the ground design has same for Zone 2, Zone 3 and Zone 4. But for Zone 5, it was less expensive. Design results for Zone 4 can easily to apply to any Zone. The circular water tank analysis and design results mentioned separately. Results including reactions are shown in the paper for all different zones separately (M. Ravikanth et al. 2019).

The major and the main criteria of their work is to determine cost of over overhead water tank foundation typically Intz water tank foundation was used. The main point that they have highlighted was soil depth which was varying above the footing was determined and compared. They used and compared total 10 different cases with a range of soil above footing from 800 mm to 7775 mm respectively. 18 lakh liter capacity of Intz water tank has used. The comparative results used are dressing, excavation, RCC, PCC, reinforcement, shuttering and overall cost analysis. For economy of the project, they suggested restrict the depth of soil above foundation by 4m since the cost of footing lessen by 8.11 percentage when 1 m of increment of depth of soil (Niraj Soni et al. 2018).
Elevated Storage Reservoir (ESR) has analyzed and designed in their work and the main and most important point was they compared the manual and software approach. The software used was Staad Pro and the suggestions applied in the work to eliminate working stress method of design and to introduce limit state method of design. 1.21 lakh liter capacity of tank has selected with a wind speed of 39 m/sec and the location of tank is the Pune city where seismic zone appears to be Zone III. Medium type soil with a dimension of tank 4m x 5.5m x 5.5 m was selected and continues their work. The main conclusion which they found out was by the help of software, we can save up to 15 to 20% of steel in the entire structure design and construction process as compared by manual approach (Rashadus Sadain et al.).

The most important point to be noted in their work that they case studied the design of the tank at Phule Nagar, Ambernath with a view of Elevated Storage Reservoir (ESR). Firstly, they collected data for 1000 cubic meter capacity tank for earthquake Zone IV. The manual design of all the components has described in the work with limit check. The seismic effect check has also a major part conducted in the work. After then Staad Pro software has used to analyze the entire structure and compare its results with manual design results. The conclusion includes that flat bottom needs more amount of reinforcement and the junction of ring beam. The Intz type water tank is more economical that suggested and applied lesser steel requirement that any other heavily capacity tank. Per capita demand should be calculated as per the area so that the final design output should be based on it. Working stress method is more costly, hence limit state method should be preferable (Sagar Mhamunkar et al. 2018).

U.K. based rainwater harvesting system has modeled and evaluation of its design was discussed in their work. The demonstration of catchment size and its importance has discussed, also simulation modeling by state of the art continuous usage approach has the main criteria of the work to fulfill the WC demand concerning 36 percent to 46 percent. A total of 10 models which has existed are compared and shown each of its importance and weather it can be used as RWH only or not. Total two sites are selected and approach to fulfill the need and the demand has discussed. They conclude as per case study, EA approach design tanks are big in size. Demand from domestic system to commercial system ranges between 36 to 46 percent can be fulfilled by RWH system approach and by creating and linking RWH systems, the average needs can be fulfilled between domestic and commercial use. Their work is based on the actual case study with the efficient and economical use of underground water tanks (S. Ward et al. 2008).

The work is solely based on design manually and compared with software Staad and SAP 2000. He discussed the objectives based on Indian standard guidelines with analysis and its design. Axial forces and deflection has analyzed with an approach to get and make safe RCC water tank. Dynamic type of water tank loading has discussed full and empty conditions. After discussing the classifications, the author summarized the steps involving selection of tank size, calculation of shear forces, bending moment, deflection and axial forces in the tank. Results involved in the work concludes that it has not possible to get the deflection manually, it has only to be done by software approach and both the software values are nearly same. The permissible value of 7000 KN/ sq. m has made in empty and full water condition as per shell stresses. Checks are also discussed in this work (Suraj P. Shinde 2018).

The work is based on water tanks analyzed and designed economically. Working stress method is used and detailed analysis of overhead tanks, underground tanks and tanks resting on ground. Various types of tanks has discussed thoroughly and clearly mentioned the basic sources of water supply demand. After then quality of water has discussed and the procedure of estimation has done. After then design of each of three water tanks has discussed. Then tank size is selected and the comparison of different size with steel reinforcement has discussed. The first conclusion drawn is for selection of safe and economical design, H/D ratio to be maintained at 0.45. Due to implementation of new IS code, the thickness of components of Intz tank has increased with earthquake forces. Comparatively LSM method has been proved more economical than WSM method. Section 8m x 5m x 2.5m seems to be more economical when tanks resting on ground and same with 8m x 5m x 2.5m tank with 10m x 1.25m x 6m for underground water tanks (Thalapathy M. et al. 2016).

The work on underground water tank that has designed and analyzed in the case of fully submerged by using principle of beam resting on elastic foundation has been discussed in this work. MESDA Pro analysis program has used and with the help of spread sheet, this principle has applied and analysis has done thoroughly. Case study of 3 Australian cities was investigated first then literature survey work has done. Manual analysis has also put an extra effort in the work leads to comparison of moment in different water tanks with modulus of sub grade reaction, moment in different tanks with height of tank. Their recommendation, suggests it should be cost effective along with its size selection and the modulus of sub grade reaction should be determined in lab first before its construction procedure (W. O. Ajagbe et al.).

The work suggests design and analysis of overhead water tank and sump with a case study view of a residential apartment at Nanganallur city, located in Chennai, India. The use of sensors in the apartment puts an extra effort in the analysis and design procedure. To avoid vast calculation approach and to design of cost economical tanks, they suggest to use the sensors and to develop the automatic program for flexible and rigid base water tanks. Their flow chart clearly explains its importance widely with per capita demand formulation approach. Manual calculations based on the software and sensor result conclude their work that, the predetermination of per capita demand is very essential in the analysis and design of economical water tanks (Yashwwanth Krishna Gunasekaran et al. 2016).
III. CONCLUSIONS

After reviewing the previously work done on water tank, it has been concluded that the various works belongs to different research approaches that applicable manually, by software and together by manually and software. The following conclusions evolved during the previously work done are as follows:-

1. The FEM method is the best method to know the exact stress theory and provides the exact location of various types of stresses.
2. Software analysis and design method approach has been proved to be a best and economical approach by comparing the manual traditional approach to design a water tank.
3. The tank should be cost effective; for that the optimum dimension of the different components of the same should be provided.
4. Pressure inside and outside the tank leads to varying dimensions of the tank.
5. The case study reflects the exact situation of the location where the tank made, the intensity of exact soil pressure at that location and measures leads to cost reduction can be determined not theoretically but practically as well.

IV. OUTLINE OF THE PROPOSED WORK

Cost of the land is the major issue and has now the chief factor that concludes this work that for underground water tank, if the economical size of tank should be provided, the usage of the land area is less which is directly proportional to the cost reduction. The proposed work will be based on parametric analysis and design factors of different sizes of the underground water tank that will bear the pressures more economical and the comparative analysis that will make the best size of underground storage reservoir system will be discussed in the upcoming analytical papers.

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