Comparative study of Elevated Rectangular Water Tank by Seismic Load: A Review

Kishor S. Kulal[1], Prof. J.S. Kanase[2], Prof. Tiwari R.K.[3]

[1]M.tech Student, JSPMs RSCOE, Tathawade, Pune,

[2]Professor, JSPMs RSCOE, Tathawade, Pune,

[3] Professor, JSPMs RSCOE, Tathawade, Pune,

ABSTRACT:- Seismic force is a critical load component while analyzing and designing water tank as it results in horizontal displacement. Horizontal Displacement in water tank due to seismic force results in displacement and additional vibrations in whole structure.. Hence there is a need to investigate various methods to minimize this horizontal displacement. Hence the objective of the work is to understand the structural behavior of water tank subjected to seismic force with software an manual calculation. This thesis analyzes different water tanks with different forces with some analytical and experimental projects.

1.INTRODUCTION

Water is basic and Primary need for survival of human being. Human civilization has developed on the fertile banks of rivers and large natural lakes. Liquid storage tanks are used extensively by municipalities and industries for storing water, inflammable liquids and other chemicals. Thus water tanks are very important for public utility and for industrial structure having basic purpose of to secure constant water supply at the longer distance with sufficient static head to the desired destination under the effect of gravitational force. The overhead tanks which have been the inevitable part of water. supply system, by the help of which the required water head can easily be achieved to erecting it on purpose made supporting towers and water can be made available to all by the action of gravity. It is also essential to ensure that, requirements such as water supply is not hampered during an earthquake and should remain functional in the post-earthquake period. The forces due to earthquake-induced sloshing in fluid-filled water tanks are important considerations in the design of civil engineering structures. Seismic safety of elevated liquid-filled containers is of great concern because of the potential adverse economic and environmental impacts associated with failure of the container and liquid spillage on the surrounding area. As a result, a considerable amount of research effort has been devoted to a better determination of the seismic behaviour of liquid tanks and reservoirs and the improvement of associated design codes. In spite of this, there have been relatively few studies on the influence of simultaneous vertical, horizontal and rocking excitations with respect to the hydrodynamic problem of liquid sloshing. The traditional approach to estimating earthquake-induced hydrodynamic loads as outlined for example, by Housner (1957) involves the use of an impulsive, or high frequency, effective fluid mass which accelerates with the container, together with an additional effective fluid mass which undergoes resonant motions at the lowest natural frequency of sloshing. The traditional approach is based on a number of assumptions which may not be applicable to the general case. Hence, the present study aims at understanding the basic mechanism of liquid sloshing in elevated water tanks according to traditional approach, studying the available standard methods of analysis and their comparison.

For seismic loading, provisions in IS: 1893 (Part 2). A strength analysis of a few damaged staging clearly shows that all of them either met or exceeded the strength requirements of IS: 1893-1984, however, they were all found deficient when compared with requirements of the International Building Code. So, staging requires such special attention towards selection of staging configuration, analysis and design to make elevated water tank structure live at the time of earthquake hazards. Over period of times failure of large number of tanks has attributes the need of more clear understanding and assessment of behaviour of tanks during an earthquake ground motion. Reinforced concrete circular shafts type support (staging) is also widely used for elevated tanks of low to a very high capacity for its ease of construction and more solid form.

2.LITERATURE REVIEW

1. **Mr.Er.R.Ramakrishna & Mrs.Kode v l swarupa (2017)** has conducted an extensive research on structural behavior of water tank with straight and inclined legs subjected to wind speeds up to 200 kmph was studied using STAAD.Pro. And they concluded that There is a Decrease of displacement for Inclined Leg Water Tank by 11.1% when compared to Vertical Leg Water Tank for all wind loads while no change was observed for displacement in y direction. There is a Decrease of about 29% displacement was observed in z direction for Inclined Leg Water Tank compared to Vertical Leg Water Tank Subjected to same wind loads. There is a a Decrease of about 3 to 5% in Axial thrust, Shear force and Bending moment was observed for Inclined Leg Water Tank compared to Vertical Leg Water Tank Subjected to same wind loads. There is a Decrease of Torsional moment for Inclined Leg Water Tank by 18 to 24% for when compared to Vertical Leg Water Tank subjected to same wind load. There is a Decrease in Concrete Quantity for Inclined Leg Water Tank by about 21 % when compared to Vertical Leg Water Tank Subjected to same wind loads. There is a Decrease of Steel Quantity for Inclined Leg Water Tank by about 29% when compared to Vertical Leg Water Tank subjected to same wind load.

2. M.Reza Kianoush (2009) has conducted an analysis on seismic design of water retaining structure using National Building Code of Canada (NBCC) for serviceability and level of performance Criteria, and conclude that design of water tank should ensure the required safety during major earthquake. Four different level of damaging for concrete retaining wall were identified on basis of serviceability criteria. The comparison between the different design method showed in the NBCC and can be used to determine design forces fairly accurate.

3. Vladimir Vukobratović , Đorđe Lađinović (2017) has analyse the ground supported circular water tank against different earthquake zones in Serbia, and conclude that All of the obligatory provisions of Eurocode 8 were fully taken into account, while some of the informative ones were substituted with similar provisions defined by IITK GSDMA and ACI provisions. The effect of both the impulsive and the convective component was considered in the model and the influence of both horizontal and vertical seismic action was taken into account. A comparative analysis of the total seismic response of tanks with various geometrical properties was conducted through a parametric study. Since the seismic response of ground-supported concrete circular tank is primarily influenced by its geometrical properties, the ratio of the liquid height and the inner radius of a (H/R) was the main parameter in the analysis. The study showed that the impulsive period of vibrations, base shear force and overturning moments increase almost linearly with the increase of the ratio H/R, whereas the convective period of vibrations is practically a constant value for the H/R>1.5. It was therefore concluded that the seismic response of a tank structure mainly depends on the response in the impulsive mode. In addition, it should be noted that the increase of base shear force and overturning moments controlled by the increase of the ratio H/R directly influences the detailing demands.

4) Uma Chaduvulaa , Deepam Patel a , N Gopalakrishnan (2013) has carried out experiment on Fluid-Structure-Soil Interaction Effects on Seismic Behaviour of Elevated Water Tanks using model of water tank and consider the horizontal and vertical forces due to earthquake and conclude that The available literature supports behaviour of elevated steel water tank under pure rocking, but no study is done on water tanks with horizontal and vertical earthquake excitation, along with rocking motion. The problem is understood as a FluidStructure-Soil Interaction problem, with Soil-Structure interaction causing rocking motion and Fluid Structure interaction causing the hydrodynamic behaviour of water tank. A synthetic spectrum was applied and following observations were made. The high frequency impulsive mass behaviour and low frequency convective modes behaviour under earthquake excitation was studied after filtering high and low frequencies. The base shear and base moment values for impulsive modes were found to be higher (increased) in rocking excitation. Whereas, the convective base shear and base moment values were found to be lower (decreased) during increasing angular motion. This happens due to cancelling out of convective waves already produced due to pure horizontal excitation with waves produced by increased rocking motion of the tank under consideration. Impulsive pressure decreased with increasing base acceleration, whereas the convective pressure increased with increased base acceleration. Impulsive pressure decreases due to the non-linearity in the structure. The pressure variation along tank height due to vertical excitation increased with increasing acceleration, and increased furthermore with added rocking. Moreover, the stiffness of staging plays an important role in tank acceleration in magnifying the acceleration at the tank level. All the codes discussed in this paper suggest higher design seismic force for tanks by specifying lower values of the response modification factor or its equivalent factor in comparison to the building system. There are substantial differences, however, in the manner and extent to which design seismic forces are increased in various codes. American codes and standards provide a detailed classification of tanks and are assigned a different value of the response modification factor. In contrast, Eurocode 8 and NZSEE do not have such detailed classification, although NZSEE has given classification for ground supported steel tanks. Provisions on soil-structure interaction are provided in NZSEE and Eurocode 8 only.

5. M.Bhandari[1], Karan Deep Singh[2](2015) have analyse the different shapes of water tank for and design economic water tank on basis of IS 3370:2009 by manual calculations they conclude that As the capacities increase, the amounts of materials for the structure also increases. But, a rather non-perfect proportionality resulted; that is, a proportional increase in the capacity would not, necessarily lead toa proportional increase in any of the materials required.

The quantities of materials needed for the rectangular water tank were constantly more than those needed for square tank which is more than the quantity required for the circular water tank, at each varied capacity.
It can be clearly seen from the results that the formwork required for the construction of water tank is minimum for circular shaped tank as compared to square shaped and rectangular shaped tanks.
Generally, the construction material-outputs for all water tank capacities would be based on the choice of the design considerations and from the results obtained here points out that the circular shaped tank is the most economical among other two shapes considered for study as per IS3370.
6. Dr. O. R. Jaiswal, Dr. Durgesh C Rai Dr. Sudhir K Jain (2013) has provided the code on Seismic Analysis of Liquid Storage Tanks by different codes, and conclude that various codes revealed that ACI 350.3 which is the most recent code, is quite comprehensive and simple to use. In this code parameters of mechanical model are evaluated using rigid tank model. The flexibility of tank is considered in the evaluation of impulsive time period. In

contrast to this, Eurocode 8 and NZSEE guidelines use separate models to find parameters of rigid and flexible tanks. Such an approach makes these codes more cumbersome to use, without achieving any significant improvements in the values of parameters. Effect of vertical ground acceleration is considered in IITK-GSDMA-EQ04-V1.0 14 various codes with varying degree of details. In AWWA codes, hydrodynamic pressure due to vertical acceleration is taken as a fraction of that due to lateral acceleration. ACI 350.3, Eurocode 8 and NZSEE guidelines suggest more rational approach to obtain hydrodynamic pressure due to vertical acceleration, which is evaluated based on time period of breathing mode of vibration. All the codes suggest, quite similar expressions for evaluating maximum sloshing wave height. For Indian code IS 1893, the provisions for seismic analysis of tanks suggested by Jain and Medhekar (1994a, 1994b), need to be modified. These modifications are particularly needed to include simplified mechanical models for flexible tanks, to include the effect of vertical acceleration, and to include simple expressions for sloshing wave height.

7. Dr. Sudhir K Jain discussed on his paper about seismic design of the structure by different types of method and carried out the manual design calculations on different structure by various methods also given explanatory examples on IS1983.

8. J. Rosart (2015) has analyse the Seismic Design of Elevated Slurry Storage Tanks for AS/NZS 1170 by the Australian code. An alternative design code commonly referred to is API 650, “Welded Steel Tanks for Oil Storage”. This code refers to ASCE 7 for methodology but explicitly excludes elevated tanks when evaluating seismicity. It also assumes a homogenous liquid, but process tanks can contain mixtures of liquids, slurries and solids. The American ASCE 7 code, “Minimum Design Loads for Buildings and Other Structures” has seismic design actions for many non-building structures, including elevated storage tanks. Fluid properties and tank shapes are not restricted. This paper will present a methodology for applying AS1170.4 seismic parameters to ASCE 7 for seismic design of elevated slurry storage tanks. The seismic loads calculated are for limit states design and are therefore compatible for load combinations to AS/NZS 1170.0 and concluded that The ASCE 7 loading code was chosen as it covers the scope limitations of AS 1170.4. Guidelines for implementation were given. For large diameter, low aspect ratio tanks such as thickeners, assumptions about the slurry properties can change the seismic loads dramatically. A conservative approach is recommended.

9. Samer A. Barakat ,Salah Altoubat (2010) has discussed about the Application of evolutionary global optimization techniques in the design of RC water tanks, evolutionary-based optimization procedures for designing conical reinforced concrete water tanks. The material cost of the tank that includes concrete, reinforcement, and formwork required for walls and floor was chosen as the objective function in the nonlinear optimization problem formulation. The wall thicknesses (at the bottom and at the top), base thickness, depth of water tank, and wall inclination were considered as design variables.

Three advanced optimization techniques to solve the nonlinear constrained structural optimization problems were investigated. These methods are: (1) Shuffled Complex Evolution (SCE), (2) Simulated Annealing (SA) and Genetic Algorithm (GA). Several tests were performed to illustrate the robustness of these techniques and results were encouraging for SCE Method. The SCE method proved to be superior to the SA and GA methods in obtaining the best discovered solutions. The paper concludes that the robust search capability of SCE algorithm technique is well suited for solving the structural problem in hand. They concluded 1. For the conical water tank design, meshes of square finite elements with side length less than 50 mm at the corner and near the axisymmetric and 100 mm elsewhere produce reasonably accurate results. 2. The governing criterion that determines the optimum design based on working stress design method is the shear strength and crack width requirements whereas the crack width is the governing requirements in the strength-based formulation. 3. The angle of wall inclination α of the optimum design of the conical water tank is found to be in the range between 15◦ and 33◦ based on the WSD method, and between 14◦ and 26◦ for the SD method. 4. For cylindrical water tanks, the total costs are more than that for conical water tanks of the same capacities by 20%–30% when using the WSD method and by 18%–40% when using SD method. 5. The integration of the optimization techniques and FE analysis is successfully demonstrated. Therefore, the proposed constrained optimization formulation provides improved designs in terms of safety, serviceability and economy, which lead to cost-effective products.

10. D. L. Beneke1 ; J. R. Thumkunta2 ; and D. J. Koen(2011) has analyse the Optimal Structural Design of Circular, Rotationally Molded, Above-Ground Polyethylene Water Storage Tanks. Rotationally molded polyethylene water storage tanks have been produced since the 1950s when the technology became available for this manufacturing process. For circular tanks manufactured in this way, the traditional method of design has been based on hand calculations considering internal hydrostatic pressure from the stored liquid as the primary applied load. This study presents the results of the optimal structural design of 16 circular polyethylene water tanks of various sizes. Based on the results derived, optimal design recommendations for these tank structures are provided when both hydrostatic pressure and wind loads are applied. The conclusion of analysis is A series of FEA simulations and ensuing design optimizations have been undertaken on 16 circular, above-ground, rotationally molded LLDPE water storage tanks. The tanks were subjected to hydrostatic pressure loads from potable water as well as to wind loads under domestic circumstances. Effects of changes in geometry on the optimal constant wall thickness were investigated as well as the effect of variable wall thickness. The conclusions drawn from this study are as For tanks with a constant wall thickness, the optimal height to diameter ratio of a tank is around 1.0 for tanks with domed roofs and around 1.1 for tanks with a domed roof and ribbing; For tanks with either constant or variable wall thickness, a tank with a shallower wall-rib depth will tend to use less LLDPE material; and A tank with a variable wall thickness will generally use around 10% less LLDPE material than for a tank with a constant wall thickness. The optimization process demonstrated is one which can be readily adapted to any vessel which must hold a stored material (either liquid or bulk solid, for instance) and be exposed to wind loads. Careful examination of load codes of practice would be required, however, to ensure consistency. The limitation of the optimization process is that it does not consider any other environmental effects such as seismic and/or snow loads and as such, the process would need to be modified if the structures being optimized were exposed to such effects.

11. *Prof.R.V.R.K.Prasad ,Akshaya B.Kamdi (2012)** has discussed about the EFFECT OF REVISION OF IS 3370 ON WATER STORAGE TANK, they have publish paper about the theory behind the design of circular water tank using working stress method and limit state method. In the end comparative result of IS 3370 (1965) and IS 3370 (2009) is given. The conclusion of above research is The thickness of wall and depth of base slab is comes to different for IS 3370:(1965) and IS 3370:(2009) because of the value of permissible stress in Steel (in direct tension, bending and shear) IS 3370:(1965) value of σst is 150 N/mm2 and in IS 3370:(2009) σst is 130 N/mm2 . Design of water tank by Limit State Method is most economical as the quantity of material required is less as compared to working stress method Water tank is the most important container to store water therefore, Crack width calculation of water tank is also necessary.

12. MEDHAT A. HAROUN* AND MAGDY A. TAYEL (2000) has calculated the RESPONSE OF TANKS TO VERTICAL SEISMIC EXCITATIONS, also A method for analysing the earthquake response of elastic, cylindrical liquid storage tanks under vertical excitations is presented. The method is based on superposition of the free axi symmetrical vibrational modes obtained numerically by the finite element method. The validity of these modes has been checked analytically and the formulation of the load vector has been confirmed by a static analysis. Two forms of ground excitations have been used: step functions and recorded seismic components. The radial and axial displacements are computed and the corresponding stresses are presented. Both fixed and partly fixed tanks are considered to evaluate the effect of base fixation on tank behaviour. Finally, tank response under the simultaneous action of both vertical and lateral excitations is calculated to evaluate the relative importance of the vertical component of ground acceleration on the overall seismic behaviour of liquid storage tanks. This Conclude that Axial stresses developed in an anchored tank shell due to the vertical component of earthquake excitation are much smaller than those due to the horizontal components of ground motion which are believed to be the cause of the elephant foot buckling of the bottom course of the shell. On the contrary, the values of the dynamic hoop stresses due to vertical excitations are comparable to the hydrostatic hoop stresses. Since steel cylindrical shells offer considerable resistance in the circumferential direction, it may be concluded that the effect of vertical excitations on the response of anchored steel tanks is not significant when compared to the effects of horizontal excitations. However, the 'elephant foot bulge' failure of tanks is sometimes attributed to over-stressing of the shell beyond the yield limit. It should be noted that vertical excitation is important in seismic analysis of reinforced concrete tanks since these structures are more susceptible to the increase in hoop stresses.

13. R. L. C. SILVA, G. B. MARQUES, E. N. LAGES, S. P. C. MARQUES (2019) has carried out an analytical procedure on cylindrical tanks including soil-structure interaction also they mansion The soil under the tanks is modeled as an elastic linear medium. The cylindrical wall is considered rigidly connected to the plate foundation. Here, concrete tanks are emphasized, although the study can be extended to other construction materials. For the analysis of the design forces acting on the tanks, efficient and simplified approximate expressions are derived based on rigorous analytical theories for thin shells and circular plate on elastic foundations. To verify the proposed approximate expressions and investigate the influence of the foundation deformability on displacements and design forces, parametric analyses of concrete tanks with different soil stiffness values are presented. The results illustrate the strong influence of the foundation stiffness on the tank design quantities and a very good performance of the simplified expressions. And conclusion of the analysis is An analytical study aiming the design of liquid storage circular tanks resting on deformable foundation has been developed. The procedures accounted for the soil-structure interactions. The soil behavior has been modeled by a continuous set of elastic vertical springers. An exact analytical formulation expressed in terms of complex Bessel functions was used as basis for derivation of simplified and efficient approximate expressions to evaluate mechanical quantities which are important for the structural design of the mentioned tanks. Comparisons of results showed that the simplified approximate expressions allow obtaining the displacements, forces and moments along the tank wall with an excellent accuracy in relation to the exact solution. For the analyzed tank, the largest relative difference between corresponding extreme values of displacements and forces in the wall, computed by using the exact and approximate solutions, was 0.143%. To evaluate the displacements, shear forces and bending moments along the plate foundation, the study used approximate expressions for the real and complex parts of the Bessel functions. The analyses demonstrated that such approximations provide very good results for the important mechanical quantities for the plate design and their unrealistic values are concentrated in a small region near the plate center. A largest relative difference of approximately 3.15% between the corresponding extreme values of displacements and forces, computed by exact and approximate solutions, was observed for the maximum radial shear force in the plate. Comparative analyses of a cylindrical tank rested on soils with different levels of stiffness (soft, medium, stiff and very stiff) demonstrated that the effects of soil-structure interaction have crucial importance for the tank design. The results showed that the critical design forces of the tank are very sensitive to differential settlements of the plate foundation and that even for soils usually classified as rigid the actual resultant forces in the wall can be very different from those obtained through the simplified design procedures in which the soil-structure interactions are neglected.

14. Hamdy M. Mohamed1 and Brahim Benmokrane (2013) has undergo the case study Design and Performance of Reinforced Concrete Water Chlorination Tank Totally Reinforced with GFRP Bars. They stated that Reinforced-concrete (RC) tanks in water and wastewater treatment plants (WWTPs) experience severe corrosion problems resulting from the application of specific treatment methods or chemicals. Municipalities around the world spend hundreds of millions of dollars annually to replace and repair corroded RC tanks. Designing these tanks requires attention not only to strength requirements, but also to durability and crack control. This paper presents the design procedures, construction details, leakage testing, and monitoring results for the world’s first RC water chlorination tank totally reinforced with glass-fiber-reinforced polymer (GFRP) bars. The project is located in Thetford Mines, Quebec, Canada. The tank is considered one of the most important components in the city’s new water treatment plant. The tank has a volume of over 2,500 m3 and its walls are 4,650 mm high. The foundation, vertical walls, and cover slab were totally reinforced with GFRP bars. The tank was designed to satisfy the serviceability and strength criteria in CAN/CSA S806-12 (CSA 2012), ACI 440.1R-06 (ACI 2006), and ACI 350/350R-06. The tank is fully instrumented at critical locations with fiber-optic sensors to collect strain data. Site inspection showed that the tank performed very well and was able to withstand applied loads without problems or leaking during the leakage test and after eight months under the service condition. The Conclusion for the report are The GFRP bars provided an efficient way to overcome the expansive steel-corrosion issues and related deterioration problems in the water chlorination tank. The design provisions used in the water chlorination tank showed that the proposed reinforcement ratios adopted by building codes and guidelines (CAN/CSA S806-12; ACI 440.1R-06, and ACI 350/350R-06) are adequate to meet serviceability and strength criteria. No obstacles to construction resulting from the GFRP bars were encountered throughout the tank's construction. The GFRP bars withstood normal on-site handling and placement with no problems. The FRP-RC water tank performed very well and was able to withstand the applied loads or leaking during the leakage test. The GFRP reinforced-concrete walls, foundation, and slab showed normal structural performance in terms of strain and cracking throughout 10 months of real service conditions. The cost-effectiveness of using GFRP bars in the tank was optimized by using Grades II and III in the longitudinal and transverse directions, respectively, and by using a small bar diameter rather than using a larger diameter with smaller spacing. Finally, this successful field application demonstrated the effective use of GFRP bars in an RC tank for a water treatment plant for the first time. The structural performance of this first application of its type and scale, based on the monitoring and continuous observations, was anticipated. This application opens the door to a major application of FRP reinforcing bars in RC water tanks in North America and across the world. RC water tanks with GFRP bars would extend the life of such structures to 100 years or more compared to steel-RC tanks, which needs major restoration after 25 years.

15. Shraddha Mandar, Joshi, Dr.S.K.Deshmukh (2014) has carried out Dynamic Analysis of Elevated RCC Circular Liquid Storage Tank, they states that It is well recognized that liquid tanks possess low ductility and energy absorbing capacity as compared to the conventional buildings. Seismic safety of liquid storage tanks is of considerable importance. As known from very upsetting experiences, elevated water tanks were heavily damages or collapsed during earthquake Due to the fluid-structure interactions, the seismic behaviour of elevated tanks has the characteristics of complex phenomena. Water storage tanks should remain functional in the post earthquake period to ensure potable water supply to earthquake affected regions. The main aim of this study is to analyze the Elevated Circular RCC Liquid Storage Tank by using Response spectrum method (IS 1893 method). And Conclusion for the analysis is the Base shear and Base moment for the example in paper has effect on the elevated circular reservoir. The structure should be design according to IS code for the given results.

3.CONCLUSION

- It is observed that the elevated water reservoir has heavy effect of seismic forces on the structure hence the design and analysis for the reservoir must be appropriate according to given IS code.
- The Seismic coefficient and the different zones should be select accordingly and software as well as manual calculation should verify
- The design of water tank should ensure the required safety during major earthquake. Four different level of damaging for concrete retaining wall were identified on basis of serviceability criteria.

4.REFERENCES

- KODE V. L. SWARUPA1 , ER. R. RAMAKRISHNA, Performance of Elevated Circular Water Tank in Different Wind Zones, ISSN 2319-8885 Vol.06,Issue.11 March-2017,
- M.Reza Kianoush ,Seismic design of concrete water retaining structures,6th Canadian Conf. earthquake Engineering/Toronto, May-2009
- Vladimir Vukobratović , Đorđe Lađinović , ground supported circular water tank against different earthquake zones,-2017
- Uma Chaduvulaa , Deepam Patel a , N Gopalakrishnan, Fluid-Structure-Soil Interaction Effects on Seismic Behaviour of Elevated Water Tanks, Non-Circuit Branches of the 3rd Nirma University International Conference on Engineering,-2013
- M. Bhandari[1], Karan Deep Singh, different shapes of water tank for and design economic water tank on basis of IS 3370:2009, EARTHQUAKE ENGINEERING AND STRUCTURAL DYNAMICS, VOL. 13, 583-595 (2015)
- *Prof.R.V.R.K.Prasad ,**Akshaya B.Kamdi, International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622, Vol. 2, Issue 5, September-October 2012
- Howarfd I .Epstein, M. ASCE (1976) “Seismic Design of Liquid-storage Tanks”, Journal of the structure Division, American society of Civil Engineers, Vol. 102,No. ST
- Laurent M. Shirima”Reinforced block water storage tanks”:22 WEDC conference New Delhi, India 19
- Durgesh C. Rai1 “Review of code Designing Forces for Shaft Supports of Elevated Water Tanks
- Mark W.Holmberg,P.E(2009)” Structure magazine”
- Ajagbe, Adedokun and Oyesile W.B.,” Comparative Study on the Design of Elevated Rectangular and Circular Concrete Water Tanks”, International Journal of Engineering Research and Development ISSN: 2278-067X Volume 1, Issue 1 (May 2012), PP 22-30.
- Bojja.Devadanam, Ratnam, Ranga Raju,” Effect of Staging Height on the Seismic Performance of RC Elevated Water Tank”, International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization)Vol. 4, Issue 1, January 2015
- Bhandari1, Karan Deep Singh,” Comparative Study of Design of water Tank With Reference to IS: 3370”, International Journal of Emerging Technology and Advanced Engineering (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 1,1, November 2014)
- Chirag N. Patel and Patel,” Supporting Systems for Reinforced Concrete Elevated Water Tanks: A State-OfThe-Art Literature Review”, International Journal of Advanced Engineering Research and Studies, IJAERS/Vol. II/ Issue I/Oct.-Dec.,2012/68-71
- Hamdy M. Mohamed1 and Brahim Benmokrane, Design and Performance of Reinforced Concrete Water Chlorination Tank Totally Reinforced with GFRP Bars:case study, n. DOI: 10.1061/(ASCE)CC.1943-5614.0000429. © 2013 American Society of Civil Engineers.