"Literature Review on Dynamic Behavior of Elevated Conical Water Tank"

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ABSTRACT
A water tank is a container which is used for storing water. They are used to provide storage of water for various uses such as drinking purposes, irrigation, agricultural, fire suppression, chemical manufacturing, food preparation as well as many other uses. Storage reservoir & overhead tank are used to store water. Elevated water tank are also known as a water tower, constructed at certain height so as to create sufficient pressure in the water distribution system, this tanks are consider as important town services in many cities. Their safety performance during the strong earthquakes is of critical concern. They should not collapse during and after the earthquake, so that they can be used in meeting the essential requirements like drinking water and extinguish fire. Many studies focused on the seismic behavior, analysis and design of elevated water tanks considering the dynamic analysis.

General Terms
Water Tank, Dynamic analysis, conical tank, meridional stress, etc

1. INTRODUCTION
Literature survey is essential part of research to review the work done in the area of performance based design and analysis of the structure. To take up a specific need to analysis and design, the literature survey in the form of papers, journals, books and IS code need to referred, to determine the scope of work and understand the present status of proposed study. The brief review of various works by different researchers on water tanks are discussed below. This report on research on the seismic behavior of water tanks structure which is used for the storing the various materials and the earthquake effect on water tanks structure.

2. RESEARCH WORK OF DIFFERENT LITERATURES
El Damatty A.A et al. [1] have studied the stability of imperfect steel conical tanks under hydrostatic loading. It is analytically based & involves nonlinear stability analysis of liquid filled conical steel vessels possessing geometric imperfections and residual stresses. A finite-element formulation based on a newly developed consistent shell element that includes both geometries and material nonlinearities is used. Conical steel tanks with cylindrical upper section caps are widely used as containment vessels for elevated water tower structures. A typical cross section of a raised conical tank is shown in Fig. 1.1. The conical steel vessel is typically welded on-site to a cylindrical component on the top and to a steel circular plate at its bottom. The latter is in turn anchored to a reinforced concrete slab, which is supported by a reinforced concrete tower. The steel vessel is normally constructed from curved panels, but welded together along circumferential and longitudinal edges.

Figure-1. Cross section of elevated conical tank
And finally he concluded that elastic stability analyses of perfect vessels show localized buckling near the bottom of the shell due to the effect of high compressive meridional stresses. The limit or buckling loads are found to be in excellent agreement with the corresponding numerical results available in the literature. The elastic analyses of conical vessels, with different imperfection patterns, indicate that the presence of an axisymmetric imperfection shape leads to the lowest limit load for hydrostatically loaded conical vessels. By including a strain-hardening plasticity model, the inelastic stability analyses reveal that for tanks that have practical dimensions, yielding precedes the elastic stability limit. Therefore, inelastic behavior has to be considered when studying the stability of such structures. The effect of the meridional and hoop residual stresses due to welding was investigated. It was found from the inelastic stability analyses undertaken that the limit load of hydrostatically loaded conical shells is reduced by the presence of hoop residual stresses resulting from circumferential welding. Longitudinal welding has no appreciable effect on the limit loads. The inelastic stability analysis of imperfect tanks having initial displacement of the order of unit thickness shows very good agreement with the results obtained from the experimental investigation carried out by Vandepitte. Comparison of the numerical results indicates that such a magnitude of imperfections leads to a reduction of 35-40% in terms of the limit load. Analyses also show that the reduction in the buckling strength due to the presence of geometric imperfections is more pronounced in a tall tank than in a broad one. Furthermore, the smaller the thickness of a conical tank, the more sensitive is the structural response to geometric imperfections.
El Damatty A.A et al. [2] have studied the spring less stability of conic tanks and also the aim of this investigation is to check the result of various state shapes on the spring less stability of liquid-filled round shape tanks and to see the important state shape that might result in the minimum spring less limit load. Round shape formed steel vessels having cylindrical higher section caps are wide used as superstructures for elevated water tanks. After a look spring less stability analysis of liquid-filled round shape tanks underneath hydrostatic loading was performed mistreatment the consistent shell part. The results of stability analyses of small-scale tanks are compared to those of the obtainable experimental work. The results obtained from the on top of analyses are shown to be inside they vary of earlier experimental results. A procedure has been adopted to see the state form that's most important. This was achieved by presumptuous associate degree state form within the style of a Fourier growth having equal coefficients, and so activity an analysis for the buckling mode ensuing from the spring less stability analysis. Results obtained from the analysis result in the conclusion that the spring less instability of liquid-filled round shape tanks is most sensitive to axisymmetric imperfections. Compared to alternative non-axisymmetric functions, the sin 20 state form has conjointly a major contribution to the spring less stability of the tanks. However, it's a lot of conservative to contemplate the axisymmetric imperfections only conducting spring less stability analysis of round shape tanks. Results of the varied analyses conducted on skinny walled round shape tanks indicate that yielding sometimes precedes elastic buckling. As such, these structures can typically fail by spring less buckling.

El Damatty A.A et al. [3] have studied the behavior of stiffened liquid-filled conic tanks. The investigation is disbursed numerically mistreatment associate in-house developed shell part model that features the consequences of geometric and material non-linearities and accounts for geometric imperfections. The study focuses on two cases of tanks strengthened by longitudinal stiffeners within the lower region: the case of stiffeners free at their bottom edge, which might correspond to the retrofit of existing tanks; and therefore the second having stiffeners anchored to the lowest block of the tank, which might duplicate the case of a replacement style. An intensive constant study is conducted to assess the standard behavior of the two cases and to work out the important imperfectness form that ends up in the minimum buckling capability of such kind of stiffened steel structures. Finally, a comparison between the buckling capability of unstiffened and lengthways stiffened conic tanks that have constant volume of steel is conducted, revealing a serious advantage of together with stiffeners.

After the study the author concluded that the addition of stiffeners leads to a significant reduction in the meridional displacements and the local meridional bending stresses in the regions surrounding the stiffeners and for both the unstiffened and the stiffened cases, the maximum values of meridional stresses occur at the internal fibers of the walls of the tanks. As a result of adding stiffeners, the high values of meridional stresses become localized in between the stiffeners rather than being spread around the whole circumference as for the case of unstiffened tanks. A similar observation was found for the distribution of the hoop stresses, which have maximum values at the exterior fibers. This explains the increase in limit loads achieved by adding stiffeners.

El Damatty A. A and Marroquin E [4] have studied the design procedure for stiffened water-filled steel conical tanks and he observed that the procedure is based on the orthotropic shell theory and on design equations for unstiffened tanks previously developed by Vandepitte. The procedure can be used to design new structures as well as to retrofit existing tanks. The applicability of the orthotropic shell procedure depends on the width to thickness ratio \( (bl)/(t) \) of the shell panel located in-between the stiffeners. Using detailed finite element analysis, upper bound values for this aspect ratio that assures that newly designed stiffened tanks, where the stiffeners are anchored at their bottom edges, can carry the hydrostatic pressure magnified by a factor of 1.4 were established both for a 16 and 20 stiffener configurations.

El Damatty A.A et al. [5] has had experimental study on dynamic characteristics of combined conical-cylindrical shells. For the study he considers the truncated round shape having a superimposed high cylindrical cap is wide used as a containment vessel for elevated water tanks. The analysis of the wind and unstable responses of those tanks needs the data of the dynamic characteristics of the vessels. This study reports the results of the primary experimental and numerical investigation conducted to assess the dynamic behavior of combined cone-shaped vessels. He compare the experimental and numerical results and eventually all over that smart and honest decent agreement between the through an experiment expected and therefore the numerically evaluated basic frequencies among 100 percent distinction and an awfully good agreement within the circumferential and meridional variations of the elemental mode form is shown between the experimental and numerical results.

El Damatty A.A, et al. [6] had work on experimental study conducted on a liquid-filled combined cone-shaped tank model. And he discovered that the basic free surface sloshing frequency is far less than the frequency of vibration of the liquid-shell system. A really sensible agreement is shown between the experimental prediction and also the elementary sloshing frequency evaluated supported a antecedently developed analytical model. The walls of the tank were assumed to be rigid during this analytical model. The experimental results justify this assumption. And also the initial 2 modes of vibration of the liquid-shell system are shown to own a cos (nθ), n >1, circumferential variations. These modes manufacture a localized impact however don't cause base shear or overturning moment. a wonderful agreement in terms of values and shapes is shown between the numerical prediction of those modes supported a antecedently.

![Figure-2:Typical Elevated conical tank with cylindrical cap](image_url)
developed finite-boundary part model and also the experimental results.

Sweedan A.M.I and El Damatty A.A [7] have studied the equivalent models of pure cone like tanks beneath vertical ground excitation and also the purpose of this study is to ascertain an easy procedure that may be wont to estimate the unstable forces functioning on a cone like tank subjected to vertical ground accelerations. The study is conducted employing a numerical model that's supported a coupled finite-boundary part formulation antecedently developed for the analysis of this fluid-structure interaction drawback. First, the numerical model is employed to develop charts that may be wont to establish the basic frequency of the axisymmetric vibrations of cone like tanks. Then, identical mechanical model during which the fluid mass is simulated as rigid and versatile mass elements is developed.

Figure-3 Equivalent model for vertical forces at the bottom section of the tank walls

In this vertical load can be resolved into a radial component causing tensile hoop stresses and a meridional component causing compressive meridional stresses. By lowering this cross section, the supported weight will increase while the radius of the cross section will decrease leading to a state of high compressive meridional stresses, especially at the base of the tank. The axisymmetric hydrodynamic pressure, \( p_r \) associated with a vertical excitation \( G_x (t) \) will have exactly the same effect as the hydrostatic pressure although its distribution along the height of the tank is not linear (as in the case of hydrostatic pressure). At an arbitrary point of the vessel, this pressure can be resolved into a vertical component, \( p_r = p \gamma \sin \theta \nu \), and a radial component, \( p_r = p \gamma \cos \theta \nu \). The integration of the vertical component along the surface of the vessel leads to a normal force \( N(t) \).

The present study is considered by evaluating the seismic response of a water-filled conical steel tank subjected to the vertical component of a real earthquake using the equivalent mechanical model. The author concluded that the comparison between results obtained using the proposed model and those predicted by the finite-boundary element code shows excellent agreement. For this particular tank, it is found that the maximum seismic normal force induced at the bottom section of tank’s walls represents about 35% of the forces developed at the same section due to the effect of hydrostatic pressure. Such a conclusion emphasizes the importance of considering the vertical component of ground acceleration when analyzing and designing this special type of water-storage structures.

Sekhar Chandra Dutta et al. [8] have studied the dynamic behavior of R/C elevated tanks with soil-structure interaction and he work the results of earthquakes has long been recognized as a necessary step to grasp the natural hazards and its risk to the society within the long-standing time. A

speedy assessment of general injury survey and documentation of initial necessary observations, besides facilitating in emergency management and rehabilitation activities, identifies the requirement of follow-up areas of analysis. However, semi-permanent preparation needs in-depth analysis on the known problems with suggestions for preparation. At this background, the injury survey conducted following couple of severe Indian earthquakes like 2001 Bhuj earthquake, 2005 geographical region earthquake etc. square measure critically examined. The scrutiny of such injury histories unconnected injury/failure of ferroconcrete (R=C) elevated water tanks of low to high capability important lifeline facility and damage of constant usually ends up in vital hardships even within the post-earthquake state of affairs, claiming human casualties and economic loss to make setting.

Figure-4 Collapsed 265 kL water tank in Bhuj 2001.

In the present paper author attempts to examine the failure/damage of little reinforced concrete elevated water tanks consequent upon the occurrence of the same in the event of moderate to severe seismic shocks. The present study, in the initial phase, evaluates primary dynamic characteristics, viz. impulsive lateral period and impulsive torsional to lateral period ratio of such system incorporating the effect of soil-structure interaction. The soil-structure interaction may considerably change impulsive lateral period and impulsive torsional-to-lateral period ratio of elevated tanks. Incorporation of this effect increases the first parameter and decreases the second one. The soil-structure interaction increases the impulsive lateral period and decreases the impulsive torsional-to-lateral period ratio strongly for elevated tanks supported by shaft staging with lesser heights, larger staging radius, thicker shaft wall, smaller ratio of the radii of foundation and staging and softer subgrade medium. Thus, consideration of soil-structure interaction effect, at least for the design of these categories of tanks, seems to be extremely essential. In the context of failure of a few reinforced concrete shaft supported tanks, the present investigation identifies that it is the tank-empty condition that regulates the possibility of generation of axial tension in the tank staging, though base shear is primarily governed by tank-full condition.

M. Moslemi et al. [9] has studied the unstable response of liquid-filled elevated tanks and during this study author targeted to gauge the performance of elevated tanks underneath unstable loading.

In this study, the finite component (FE) technique is employed to research the unstable response of liquid stuffed tanks. The fluid domain is shapedly mistreatment displacement-based fluid parts. Each time history associated modal analyses area unit performed on an elevated tank. Mistreatment the FE
technique, impulsive and convective response parts area unit obtained singly.

The fundamental mode shapes (both impulsive and convective) of the tank aren't typically influenced by the form of the tank’s floor. The properties of the elemental impulsive mode area unit chiefly obsessed on the pure mathematics and stiffness properties of the supporting shaft. As compared, the elemental convective mode is especially full of the pure mathematics (aspect ratio) of the highest cylinder and to a lesser extent by the pure mathematics of the round shape portion of the vessel. As a result, such associate assumption may solely end in a small increase on the peak of the contained water and as a result a small reduction within the convective mass magnitude relation (WC/WL). What is more, since the overall response is especially dominated by the impulsive part, the results of such associate assumption on the overall response of the model are going to be negligible. The following are the dimension of the water tank such as
- Side shell thickness = 8.8 mm
- Cone thickness = 24.5 mm
- Tank floor thickness = 330 mm
- Shaft thickness = 380 mm.

In this study, free vibration as well as time history analyses were carried out on the three-dimensional elevated tank model.

El Ansary A.A and El Damatty A.A [10] have studied the behavior of elevated liquid-filled concrete cone like tanks within the current study; a nonlinear finite part model is developed for the analysis of ferroconcrete cone like tanks. A physical property model for concrete is developed for a homogenous degenerated shell part. The model is capable of capturing the precise options of concrete like compaction dilatancy transition, sensitivity of fabric to confining pressure, and hardening/softening behavior.

The author detected that the placement of most displacement rises because the angle \( \theta \) will increase. To boot, one will see that the displacement at heart of the tank is zero because the boundary conditions square measure assumed to be hinges at this location. One will deduce that the most displacement doesn't happen at the highest of the tank as a result of it's the minimum liquid pressure at this location. The concrete cone like tanks' behavior will be accurately captured by considering the fabric nonlinearity victimization the acceptable elasto-plastic essential model. The most displacement initially cracking will increase because the tank height will increase. Increase within the maximum displacement percentages square measure 100%, 19%, and one year for the tanks with \( \theta \) of 30°, 45°, and 60° severally.

In the gift study, an in depth finite part technique was utilized to check the fluid–structure interaction for liquid-filled conic elevated tanks. The liquid within the tank was sculptural to check the fluid

figure-5. actual model, equivalent cylindrical model and equivalent DOF model.

The author also observed that the maximum deflection of the concrete conical tank wall occurs at approximately the middle one-third of the height of the tank. For tanks with \( H = 6 \) m, the cracking load decreases by 40% and 66% when the angle increases from 30° to 45° and from 45° to 60°, respectively. Absolute values for meridional stresses at cracking increase as the height of the tank increases. For tall tanks with height (\( H = 9 \) m), hoop stresses at first cracking are larger than those for short tanks with height (\( H = 6 \) m) with percentages of increase of 51%, 65%, and 89% for tanks with \( \theta \) of 30°, 45°, and 60°, respectively. Hoop stresses at cracking increase as the height of the tank increases for \( \theta \) larger than 37°. For tall tanks with height (\( H = 9 \) m), hoop stresses at first cracking are larger than those for short tanks with height (\( H = 6 \) m) with percentages of increase of 4%, and 17% for tanks with \( \theta \) of 45°, and 60° respectively. The first cracking of conical concrete tanks is governed by the exceedance of the hoop stresses to the concrete tensile strength. The maximum hoop stress occurs at approximately 1/5 to 1/6 of the height of the tank.

Pallavi S.Dhamak, et al. [11] has studied the dynamic response of an elevated water tank to understand interaction.
of soil and structure in dynamic analysis of tanks. In this study three dimensional FEA is carried out using Abaqus software. A structure interacts with its surrounding soil and this causes changes in effect of seismic waves. In seismic analysis, interaction of structure and soil should be considered. Dynamic response of soil-structure system is a function of three factors, dynamic parameters of site, forces and excitations and dynamic model of the system when it is affected by a dynamic loading. Dynamic parameters of the site include soil modulus of elasticity, soil Poisson coefficient, and damping in soil.

After study the author seen that for respective levels almost all columns shows same displacement for corresponding modes. As per the computer technology concern Abaqus software has various capabilities to analyses the structure with SSI. He also observed considerable variation in displacement in the structure with and without SSI. For mode no 1 displacement of structure without SSI is more as compare to displacement with soil. For mode no 2 and 4 displacements of structure with SSI are almost same. Displacement of structure without SSI is decreasing from mode 1 to mode 2 and in case of with SSI it is increasing. From the obtained results it may be concluded that for relatively heavy structures on soft soil SSI analysis must be carried out.

ABAQUS software can be used efficiently to investigate the effect of SSI on the structures, further different soil and structural models can be incorporated to improve the accuracy. Conclusions drawn from present study will be beneficial in understanding the effect of dynamic SSI on the structure.

Donarose K.J. et al. [12] have studied the overhead water tanks subjected to dynamic masses that embody large water mass at the highest of a slender staging that square measure most crucial thought for the failure of the tank throughout earthquakes. During this study the time history analysis technique is employed of the cistern for 0.5 tank level and full water level conditions by victimization El Centro earthquake time acceleration records and compares the response histories like displacement and base shear.

The peak displacements from the time history analysis beneath El Centro earthquake records square measure below the most permissible displacement for various water levels. The height displacement from the time history analysis will increase with staging heights. However the displacement 1st decreases so will increase with capacities. The displacement for half-filled tanks is lesser than the displacement for tanks with full capability. The bottom shear values from time history analysis were will increase as staging height will increase. Also, the bottom shears decreases so will increase with capability. Base shear for 0.5 capability tanks square measure lesser than that for full capability tanks beneath same staging condition.

Ahmed A. Elansary et al. [13] have studied the nonlinear behavior of ferroconcrete round shape tanks beneath hydrostatic pressure during this study finite component model (FEM) created, that accounts for material nonlinearity tough in ferroconcrete, is developed. This nonlinearity is taken into account by implementing a concrete malleability essential model within the developed FEM. There are twelve tanks with completely different sensible dimensions is analysis of beneath hydrostatic water pressure. And at last the author terminated that beneath operating hundreds, the quantitative relation between the most cross displacements from the linear analyses to the nonlinear analyses is some zero.9 for all of the studied tanks. However, beneath final hundreds, this quantitative relation is three.1, 2.4 and 1.8 for the tanks with associate inclination angle of 30˚, 45˚ and 60˚, severally. The cross displacement of a tank will increase with the rise within the inclination angle thanks to each operating and supreme hundreds. The most displacement thanks to operating hundreds happens at zero.3, 0.5 and 0.6 of a tank’s height for the tanks with associate inclination angle of 30˚, 45˚ and 60˚, severally, whereas the most displacement thanks to final hundreds happens at zero.3, 0.4 and 0.5 of a tank’s height for the tanks with associate inclination angle of 30˚, 45˚ and 60˚, severally. The conventional strain within the meridional direction and therefore the shear strain distributions through the wall’s thickness are parabolic. However, insignificant amendment happens within the traditional strain distributions through the wall’s thickness within the hoop direction. Most hoop stresses in concrete occur at (0.15 - 0.3) of the tank’s height thanks to each operating and supreme hundreds. Hoop stresses don't amendment considerably through the tank’s wall for those tanks with associate inclination angle of 30˚ and 45˚;
but, this variation is important for those tanks with associate inclination angle of 60˚. Most meridional stresses occur among zero.1 of the tank’s height at rock bottom fringe of the tank’s vessel for each the steel and concrete thanks to each the operating and supreme hundreds. a big variation is ascertained within the meridional stresses on the tank’s thickness thanks to bending effects. All of the studied tanks have some constant malleability.

Moslemi M et al. [14] have studied the parametric study based on design of liquid-filled elevated tanks. In this following are the parameters selected for this study shown in Fig. 1.9 and the parameters are defined as follows:

- $r_t$: radius of the cylindrical steel shell
- $R_{root}$: radius of the supporting shaft
- $h_{top}$: freeboard (distance between the water free surface and the roof)
- $h_3$: height of water in the cylindrical portion of the tank
- $h_c$: height of the conical portion of the tank
- $h_{shaft}$: height of the supporting shaft
- $t_{cyl}$: average thickness of the cylindrical portion of the tank
- $t_{con}$: average thickness of the conical portion of the tank
- $t_{floor}$: thickness of the tank’s floor
- $t_{shaft}$: thickness of the concrete shaft wall
- $\theta$: cone angle

![Figure 9. Parameters defined for the parametric study.](image)

The author demonstrated that independence of the proposed normalized pressure quantities from the variations of tank’s floor thickness. Thus, it was concluded that the sensitivity of the hydrodynamic pressure to the floor and plate thickness variations can be removed by normalizing the hydrodynamic pressure with respect to the spectral accelerations.

Also he observed the results of this verification study, the proposed normalized pressure graphs could be utilized with high level of accuracy for seismic design of liquid-filled conical elevated tanks.

Ahmed A. Elansary et al. [15] have studied the assessment of equivalent cylinder method and development of charts for analysis of concrete conical tanks because the current codes of practice do not provide any provisions or guidelines for designing reinforced concrete conical tanks under hydrostatic loading. Available provisions are limited only to cylindrical and rectangular tanks. In this paper, a nonlinear Finite Element Model (FEM), based on shell element discretization, is used to analyze hydrostatically loaded reinforced concrete conical tanks.

Author observed that a nonlinear Finite Element Model (FEM) is used to analyze a set of 40 cylindrical tanks and 120 pure conical tanks under hydrostatic water pressure. The effect of considering shrinkage and effect of changing in concrete strength on the designed wall’s thickness are determined. For all studied tanks, the ratio between the thicknesses considering shrinkage to those neglecting shrinkage is found to be 1.3. It is also concluded that increasing the concrete strength significantly reduces the calculated tank’s thickness. The ratio between thicknesses of the tanks with $f_c = 30$ MPa to those with $f_c = 40$ MPa can reach up to 1.5.

Ahmed A. Elansary and Ashraf A. El Damatty [16] have studied the behavior of composite conical tanks under pressure and he presents the first comprehensive study conducted on liquid-filled composite tanks.

![Figure 10. Elevated conical tank.](image)

In this study the author compare the CFEM and ESM can predict the stresses and forces at the concrete wall and steel shell, separately. The displacements obtained from the CFEM are significantly larger than those resulting from the ESM because the CFEM accounts for the concrete cracking. Both the CFEM and ESM predict that the failure criterion in the steel shell is reached. Insignificant relative transverse displacements are observed between the concrete wall and steel shell due to the full contact existed between two walls.

![Figure 11. Layout dimensions of the studied elevated composite conical tank.](image)

A ratio of 3.1 is observed between the maximum transverse displacements obtained from the CFEM to those resulting from the ESM. This difference occurred due to including the material nonlinearities in the CFEM and adopting failure criteria different than that used in the ESM.

The locations of maximum displacements, stresses, and forces along the vessel’s height obtained from both the CFEM and ESM are identical. The meridional stresses at the inner and outer faces of the concrete wall obtained from the ESM are smaller than their counterparts resulting from the CFEM.
by 25% and 28%, respectively. These ratios are found to be 33% and 37% at the same load level of p = 1. The CFEM predicts constant distributions of both the hoop and meridional stresses through the thicknesses of the steel shell. In the steel shell, the ratios between the maximum meridional and hoop stresses resulting from the CFEM to those obtained from the ESM are 1.3 and 0.5, respectively. In both the concrete wall and steel shell, the maximum meridional axial force and bending moment occur at the vessel’s base and at an elevation of 0.5 m, respectively.

3. CONCLUSION
In the present paper some author compare the numerical results with experimental analysis indicate that such a magnitude of imperfections leads to a reduction of 35-40% in terms of the limit load. Analyses also show that the reduction in the buckling strength due to the presence of geometric imperfections is more pronounced in a tall tank than in a broad one. And some author concluded that the addition of stiffeners leads to a significant reduction in the meridional displacements and the local meridional bending stresses in the regions surrounding the stiffeners and for both the unstiffened and the stiffened cases. Some author conclude that the soil-structure interaction increases the impulsive lateral period and decreases the impulsive torsional-to-lateral period ratio strongly for elevated tanks supported by shaft staging with lesser heights, larger staging radius, thicker shaft wall, smaller ratio of the radii of foundation and staging and softer subgrade medium. And some author concluded that increasing the concrete strength significantly reduces the calculated tank’s thickness. Some author compare the concrete wall and steel shell, the maximum meridional axial force and bending moment occur at the vessel’s base and at an elevation of 0.5 m, respectively.

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