

Estimation of Structural Strength of Tanks under Sloshing Loads

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ABSTRACT: Sloshing refers to the movement of liquid inside another object which is typically undergoing motion. When sloshing occurs, there will be dynamic pressure due to fluid interaction with the walls of the tank causing large deformation in the tank as well as the supporting structure. A computational fluid dynamics (CFD) simulation gives a realistic picture of the sloshing phenomenon in the inner portion of the tanks. This thesis focuses on the dynamic effects of sloshing phenomenon by coupling CFD and structural solver. Here the use of baffles inside the tanks is also studied and compared with those tanks without baffles. The structural deformation of the tanks is studied and the results are verified.

KEYWORDS: Sloshing, CFD, Waffles, Dynamic pressure, Deformation, Structural solver

I. INTRODUCTION

A. General

Storage tanks are important components in water distribution systems, ships, petroleum plants etc. During earthquakes, due to the seismic excitations the tanks will get damaged which in turn damages life and property. In the case of ground supported tanks earthquake causes heavy sloshing in water resulting in hydrodynamic pressure in the walls of the tank. In the case of ship tanks the heavy sloshing will cause the tank fluid to interact with the water outside. As a result pollution of ocean or sea water occurs, which in turn destroys the overall ecological system? The liquid sloshing may cause huge loss of human life, economic and environmental resources due to failure of the container. The expulsion of toxic components stored in tanks in the industries can be the reason of soil contamination and can create adverse effect in environment. Thus sloshing will not only affect the structure but also the environment in which they are provided. Thus there is a need to estimate the hydrodynamic pressures as well as the proper analysis of fluid tank interaction under seismic excitations. Thus, understanding the dynamic behaviour of liquid free-surface becomes necessary. Due to this many engineers and researchers are aiming to understand the complex behaviour of sloshing and finding ways to reduce its impact on structures and trying to develop structures to withstand its effect.

Sloshing, the term refers to the movement of liquid inside another object which is typically undergoing motion. It is also defined as the periodic motion of the free surface of partially filled tank or container. Sloshing is important in various engineering disciplines such as propellant slosh in spacecraft tanks and rockets, cargo slosh in ships and trucks transporting liquid (for example oil and gasoline), oil oscillation in large tanks, water oscillation in a reservoir due to earthquake, sloshing in pressure-suppression pools of boiling water reactors and several others. Liquid sloshing and free surface motion not only affects the dynamics of flow inside the container, but also the container itself. The containers having tanks used to store liquids have to withstand the complex dynamics of the transportation system, different ground motions. This unavoidable motion of the container and the forces associated on the liquid inside it results in mostly violent and disordered movement of the liquid/gas (mostly air or vapour) interface or free surface. ANSYS fluent is used for dynamic analysis of the structure.

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B. Workflow

Figure 1 given below represents the various processes involved in this work. Different purposes of ANSYS software is described in the workflow. The steps involved during the execution of this work can be obtained from the figure.

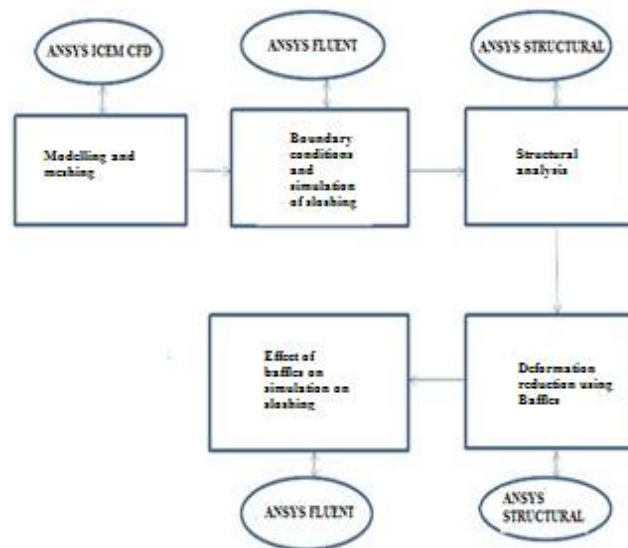


Fig. 1: Diagram showing various processes involved

C. Significance of Numerical Analysis

Study of sloshing is indeed complex. The experimental set-up entails a shake table to produce oscillations to the tank in the desired direction. However capturing of free-surface profile using conventional techniques is not feasible. Moreover particle induced velocimetry (PIV) methods are prohibitively expensive. Hence the need for Computational Fluid Dynamics (CFD) based numerical methods. CFD simulations are carried out in three stages viz. preprocessing, solution and post-processing. In the present work, modeling and meshing, a part of the preprocessing has been carried out using ANSYS ICEM CFD. The rest of the preprocessing, solution and post processing have been carried out using ANSYS Fluent. Later structural analysis for estimating strength of the tanks has to be carried out using ANSYS structural.

II. RELATED WORKS

1. Haroun and Abou-Izzeddine, (1992), describes the parametric study of seismic soil-tank interaction in Horizontal excitation. The moment and hydrodynamic forces exerted on a tank structure is caused by the dynamic soil tank interaction under horizontal seismic excitations. In this paper the analytical mechanical models for flexible cylindrical tanks which accounts for rigid base rocking motions and lateral translation used with a lumped-parameters idealization of foundation soil is explained.
2. Issacson and Ryu, (1998), focuses on the earthquake induced sloshing in a vertical container of arbitrary section subjected to both harmonic and regular base motion. Linearized flow theory is used for solving the harmonic base motion and the boundary value problem in the case of inviscid fluid.. Excellent agreement is obtained when compared with results based on closed form solution for circular and rectangular tanks.
3. Malhotra et al, (2000), suggests a simple procedure for seismic analysis of Liquid-Storage tanks. The convective and impulsive actions of the liquid for flexible steel or concrete tanks fixed to rigid foundations for cylindrical ground-

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supported tanks were studied. By simple calculations, base shear, overturning moment and sloshing wave height were calculated. This paper explains An example to illustrate the procedure, and compared with that of the detailed modal analysis procedure. An SDOF system represents the convective and impulsive modes of vibration of the tank liquid system. In this paper the results obtained from the proposed procedure were compared with the detailed procedure. The sloshing wave height obtained were 12-18% higher than those of the detailed modal analysis, results were close to those from modal .analysis. Eurocode 8 was used for the design.

4.Faltinsen and Rognebakke, (2003), focus on the coupled effect between ship motions and sloshing. Two dimensional hull sections containing tanks filled with different levels of water excited in sway by regular waves are taken into account. Assuming linear external flow, simulations of the modeled case are performed using a linear and non linear sloshing model. For steady state motion, a convolution formulation does not improve the results relative to using constant coefficient in the equation of motion. When non linear sloshing model is used, satisfactory agreement between theory and experiments is achieved.

5.Papaspyrou *et al*,(2004), describes the sloshing effects in half-full horizontal cylindrical vessels under longitudinal excitations. The sloshing effects are studied in detail and a mathematical model is developed. The objective of this paper is the solution of externally induced liquid sloshing in half-full cylinder under longitudinal excitation through semi-analytical manner without the use of finite difference or finite element approximation Finally this paper concludes that for engineering purposes the equivalent rectangle may be used for approximating half-full cylinder since the results are comparable.

6.Jaiswalet *al*,(2008), suggests a study on sloshing frequencies of fluid –tank system. The important lifeline systems like water distribution system, petroleum plants etc is highly affected by the sloshing phenomenon. The knowledge of sloshing frequency of the liquid and hydrodynamic pressure on the wall is important in the design considerations. As per the design codes, mechanical analogs of tank fluid system are commonly used to obtain those values.. They suggests further extension for obtaining hydrodynamic pressure on the walls of the tanks with different shapes.

7.Hopfinger and Baumbach, (2009)focused liquid sloshing in cylindrical fuel tanks. Asymmetric sloshing with geyser formation with sudden change in bond number is taken into account. Three parameters in which axisymmetric sloshing is related to be focused. The lateral forcing experiments, impulsive forcing and axisymmetric sloshing s were explained. The result of dam breaking experiment explains the formation of geyser followed by violent sloshing with gas entrainment when there was a step change in surface height.

8.Koli *et al*,(2010), studied the simulation of fluid sloshing in a tank and the design modification using baffle plate to minimize the sloshing phenomena using ALE method. ALE method is used create new undistorted mesh for the fluid domain. Fluent slosh is an important phenomenon for both fuel tanks as well as for the supporting structure. Fluent slosh can be generated by braking, changes in highway exit ramp. This paper suggests the future scope of optimization of the shape of the tank as well as baffle arrangements.

9.Brar and Singh,(2014), in their present study focused on the sloshing effects oil transportation tank with 2D nonlinear CFD analysis were carried out and the validation was done using experimental results. COSMOL multi-physics software is used for simulations in partially filled tanks. The tanks with and without baffles are analysed. Results shows that baffles will reduce the pressure exerted on the walls of the tank and the combination of horizontal as well as vertical baffles will reduce the sloshing effectively.

10.Wackchaure and Sonal,(2014), discusses about the behaviour of elevated water tanks under sloshing effects. The main objective of this paper includes the comparison between static and dynamic analysis of elevated water tanks, the study of dynamic response of elevated water tanks, behaviour of water in different state with different water depths (15%,30%,50% and 75%), response spectrum analysis of elevated reservoir. It can be concluded that elevated water tanks with compartment reduces the sloshing effect and stress, deflection and deformation of the tank

III. OBJECTIVES AND SCOPE

A. Objectives

1. To study the structural behaviour and response of the tanks filled with fluid under earthquake loads and wave loads.
2. To study the effect of baffles on the structural strength and sloshing phenomenon.

B. Scope

1. Numerical computation of sloshing loads using CFD method.
2. Use of structural solver with CFD output as input for the computation of structural behaviour.
3. Verification of CFD results.
4. Design baffles and study effect on structural deformation due to sloshing loads.
5. Study the effect of baffles on sloshing pattern.

IV. METHODOLOGY

1. An extensive study of literature is carried out to comprehend the present advances in the computation of sloshing loads.
2. ANSYS fluent is used for CFD computations of sloshing.
3. ANSYS mechanical /workbench is used for structural behaviour and deformations.
4. Baffles are designed to induce the forces and moments in extreme cases of earthquake and wave excitations in ANSYS workbench.

V. 3D SIMULATIONS AND VALIDATION OF CFD RESULTS

A. General

The tank in 3D is having 5m x 3m x 4.5 m and is modelled in fluent as shown in the figure 2 below. The tank is surrounded by the walls on all sides. Tank is then divided into two portions i.e; air and water. An air water interface is also present to separate the two portions.

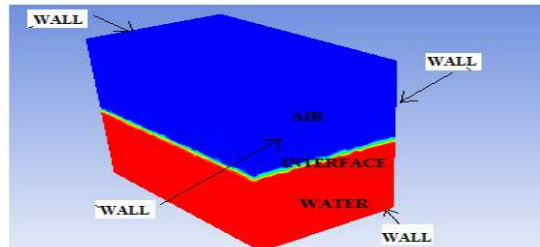


Fig. 2: Boundary conditions of 3D tank

B. Rough sea conditions

The pressure distributions due to sloshing of ship tanks under rough sea conditions in 3D were obtained using ANSYS Fluent-15. Here t refers to the time period of oscillation of the wave. Under rough sea conditions, frequency (ω) of the wave is assumed to be 6.28 rad/s, amplitude of oscillations = 0.35m and total time period $t = \frac{2\pi}{\omega} = 1$ seconds. Thus the 3D simulations for different time periods ($t=0$ seconds, 0.25 second, 0.5 second, 0.75 second and 1 second) were given in the figures 3 through 7. Figure 3 indicates the pressure distribution at the starting time. In the case of figure 4, at 0.25 sec the pressure distribution is shown. The values of the pressure distribution are obtained from ANSYS fluent (left portion of the figures).

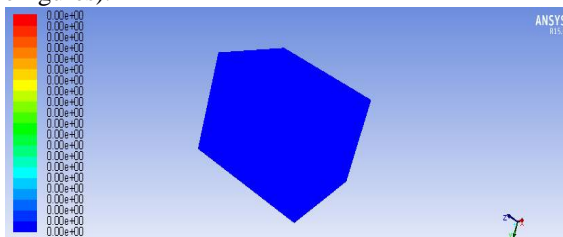


Fig. 3: Pressure distribution of the tank at $t = 0$ sec

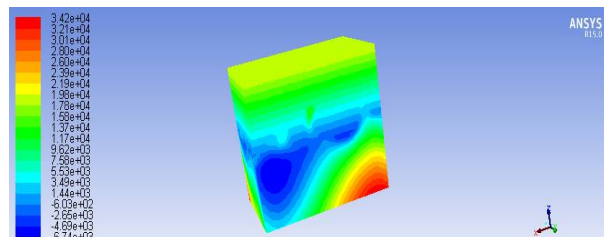


Fig. 4: Pressure distribution of the tank at $t = 0.25$ sec

The figures 5 and figure 6 indicates the pressure distribution of the 3D tank at 0.5 sec and 0.75 sec respectively. Figure 7 clearly depicts the pressure distribution at 1sec ie;the final time .The colour distribution can clearly depicts the variation in pressure in the tank.

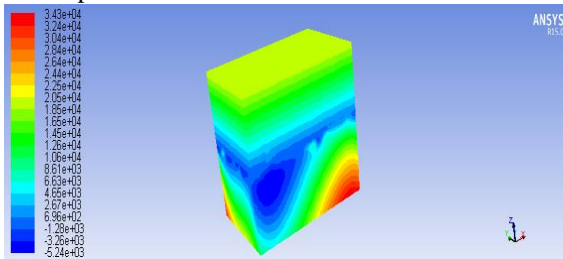


Fig. 5: Pressure distribution of the tank at t = 0.5 sec

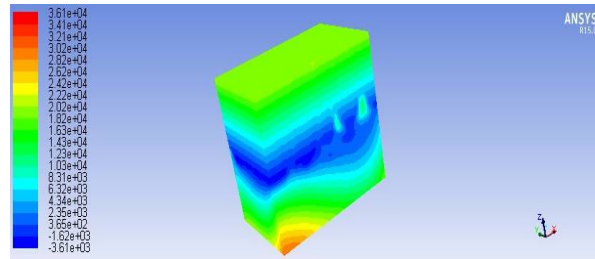


Fig. 6: Pressure distribution of the tank at t = 0.75sec

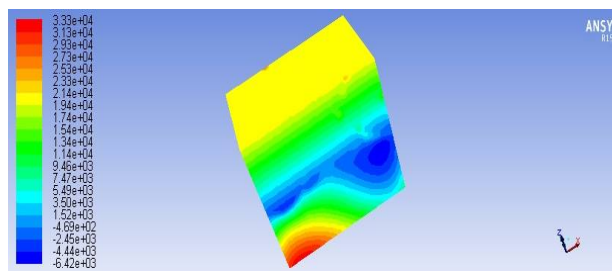


Fig. 7: Pressure distribution of the tank at t = 1 sec

C. Earthquake motions

For earthquake motions, the pressure contours were found out and the figures are shown below. The total pressure contours of sloshing of water tanks under a velocity amplitude of 628 m/s was obtained using ANSYS Fleuent-15. Here t refers to the time period of oscillation of the wave. Under normal sea conditions, frequency (ω) of the wave is assumed to be 628 rad/s, and total time period $t = \frac{2\pi}{\omega} = 0.01$ seconds. Thus the total pressure contours of sloshing for different time periods (t = 0 seconds, 0.0025 seconds, 0.005 second, 0.0075 seconds and 0.01 seconds) were given in the figures 8 through 12. Figure 8 indicates the pressure distribution at the starting time. In the case of figure 9, at 0.0025 sec the pressure distribution is shown. The values of the pressure distribution are obtained from ANSYS fluent (left portion of the figures).

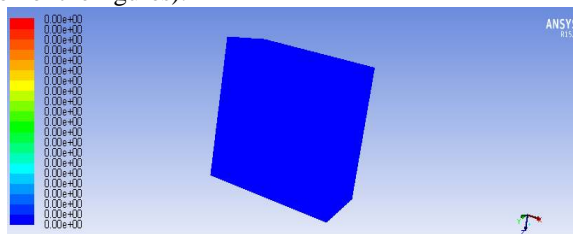


Fig. 8: Pressure distribution of the tank at t = 0 sec

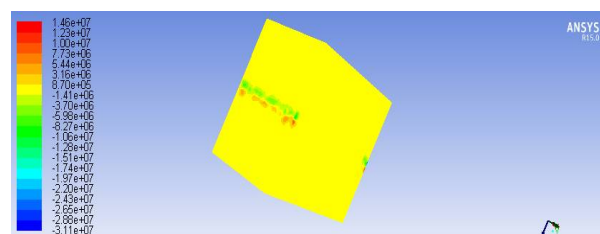


Fig. 9: Pressure distribution of the tank at t = 0.0025 sec

The figures 10 and figure 11 indicates the pressure distribution of the 3D tank at 0.005 sec and 0.0075 sec respectively. Figure 12 clearly depicts the pressure distribution at 0.01sec ie;the final time .The colour distribution can clearly depicts the variation in pressure in the tank.

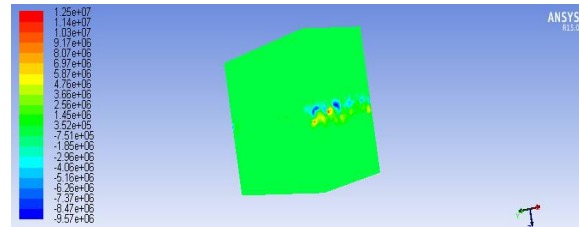
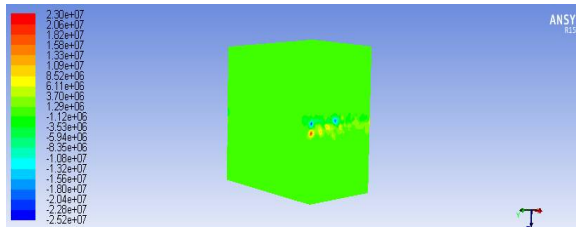


Fig.10: Pressure distribution of the tank at t = 0.005sec Fig. 11: Pressure distribution of the tank at t = 0.0075sec

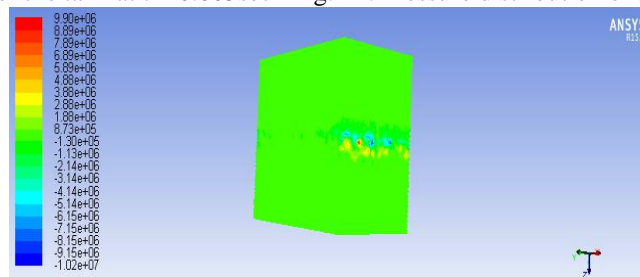


Fig. 12: Pressure distribution of the tank at t = 0.01 sec

D. Validation of CFD results (Rough sea conditions)

a. Theoretical validation

The figure 13 as shown below depicts all about the wave parameters by small wave amplitude theory. Figure shows the water wave profile and particle in motion. The total pressure at any instant is then calculated by relating this theory to the results obtained from fluent.

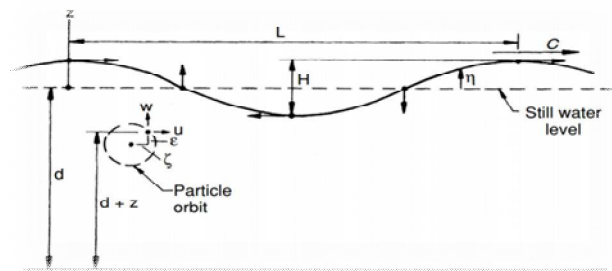


Fig. 13: Definition of progressive surface parameters

By small amplitude wave theory, the total pressure at any instant of time was computed using the equation given below which is the combination of static pressure as well as hydrodynamic pressure.

$$P = -\rho g z + \frac{\rho g H}{2} \left[\frac{\cosh k(d+z)}{\cosh kd} \right] \cos(kx - \omega t)$$

Where,

P = Total pressure in Pa

ρ = Water density = 998.2 kg/m³

g = Acceleration due to gravity = 9.81m/s²

z = Vertical ordinate (positive upwards) = 0.9 m

x = Horizontal ordinate (positive rightwards) = 3.7 m

H = Height of the wave = 0.5 m

L=Wave length = 3.5 m

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t = Time at any instant in seconds = 30.9 seconds

d = Depth of the wave (positive upwards) = 2.25m

ω = Wave angular frequency = $\frac{2\pi}{30.95} = 0.2033$ rad/sec

k = Wave number = $\frac{2\pi}{3.5} = 1.795$ rad/m

Substituting above obtained values for deep water we get,

$$F = 5.345 \times 10^3 F_0$$

Figure 14 shows the pressure distribution of the tank at 30900th time step in case of rough sea. The values are obtained at the left side. Comparison with the theoretical value is made.

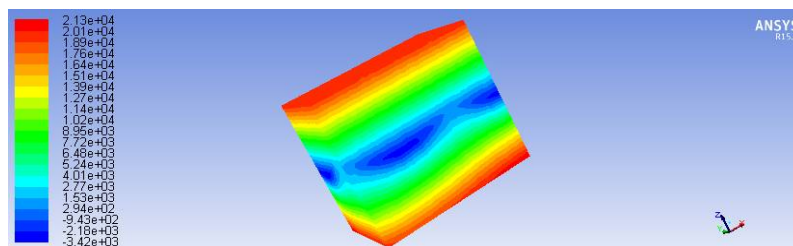


Fig. 14: Pressure distribution of the tank 30900th time step in case of rough sea

From the figure it is clear that the total pressure obtained at 30900th time step is approximately the same pressure (Green – Blue region) calculated from theoretical calculations. Hence the CFD simulations are correct.

E. Experimental validation

The sloshing experiment is carried out in Dunkerley's apparatus. Figure 15 shows a cylindrical model of following dimensions is considered for the experiment

- Top diameter (Inner) = 11.5 cm
- Bottom diameter (Inner) = 11 cm
- Height = 17 cm
- Thickness = 2mm

The model is of plastic material. By giving vibrations, the water inside the vessel experiences oscillations. Thus this is a simple experiment which represents the occurrence of sloshing in a tank. Figure 16 represents the Dunkerley'sVibration Measuring Apparatus. The cylindrical vessel is fitted in a small metal beam in the apparatus. The readings are taken by using a pen – paper mechanism that is attached to the beam.



Fig.15: Model of the tank



Fig.16: Dunkerley'sVibration Measuring Apparatus

The vibrations that are recorded from the experiment is shown in the figure 17. When the vessel is made to vibrate ,the pen attached in the apparatus records the vibratiom as shown in the figure 17.18 oscillations occur during the experiment and thus the time period of oscillation is 3.6 seconds and the frequency is 1.74rad /sec.

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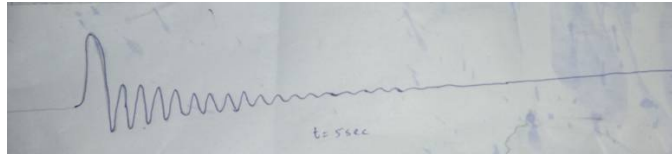


Fig. 17: Recording of vibrations using Dunkerley's Apparatus

In the figure 18 the comparison of the free surface profiles are shown. The first part represents the experimental result obtained and the second portion indicated the result obtained from ANSYS Fluent. Then the results are compared.



Fig. 18: Comparison of Free Surface Profiles at $t=2 \text{ sec}$ ($\omega = 1.74 \text{ rad/sec}$)

From the figure 18 by using ANSYS fluent the water profile same as that by experiment is obtained. Thus it can be concluded that the CFD simulations is correct by experimentally also as shown.

VI. STRUCTURAL ANALYSIS OF TANKS

A. General

Structural analysis is carried out using ANSYS workbench. Transient analysis is carried out in the case of fluid flow conditions since it is time varying.

B. Sloshing in ship tanks due to wave loads

The modeling of tank was done by using ANSYS structural solver having 5m x 3m x 4.5 m dimensions. For stainless steel tanks the thickness are ranging from 25 mm to 90 mm. In the case of sloshing due to wave tanks stainless steel is using and in the case of sloshing due to earthquake motions the structural steel material is used. The pressure distribution of the tank is found out by using fluent up to 30 seconds. Table 1 shows the different values obtained from the fluent. From these values 8 largest values are taken into account and is given in the table. The unit of pressure distribution is pascal.

Table 1: Pressure distribution values from fluent

SI No.	Pressure (Pa)
1	4.74×10^4
2	4.93×10^4
3	5.35×10^4
4	4.7×10^4
5	4.74×10^4
6	4.78×10^4
7	4.16×10^4
8	5.39×10^4

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These values are given as input to the structural solver and the various responses are found out. Thus the graph showing the thickness versus deformation is shown in the figure 19. thickness is given in x axis upto 90mm. Deformation is along y axis upto 160 mm.

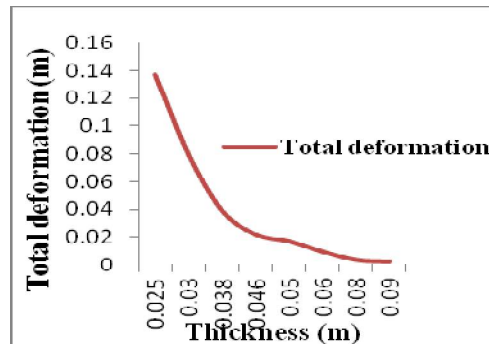


Fig. 19: Thickness vs total deformation plot

From the graph it is clear that there is no abrupt change in deformation after 50mm. So adopt thickness of 50 mm to the tank. The tanks with and without baffles are modeled by using ANSYS. Then the comparisons of results are made.

a. Structural analysis of tank without baffles

The modeling was done by using ANSYS structural solver. The tank of size 5m x 4.5m x 3 m having a thickness 50 mm thickness are modeled using ANSYS structural solver. Figure 20 shows the pressure distribution of the tank from ANSYS fluent. The values are given along the walls. In figure 21 the output after analysis is obtained. Total deformation of the tank is obtained from structural solver.

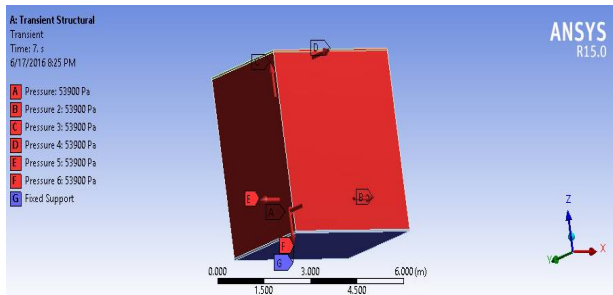


Fig. 20: Pressure distributions in the tank

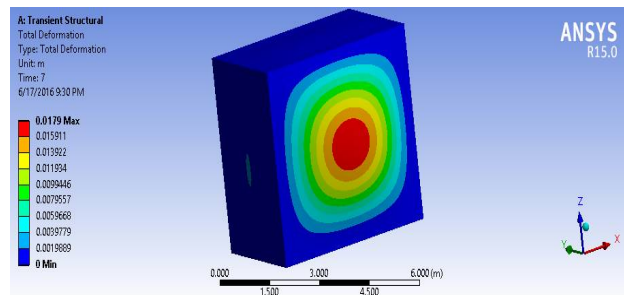


Fig. 21: Total deformation of the tank

The structural analysis is carried out by using the pressures shown in the figure above and different structural responses such as deformation, von-Mises stress and von-Mises strain are found out in the figures 22 and 23. The different colours indicates the variation in the tank.

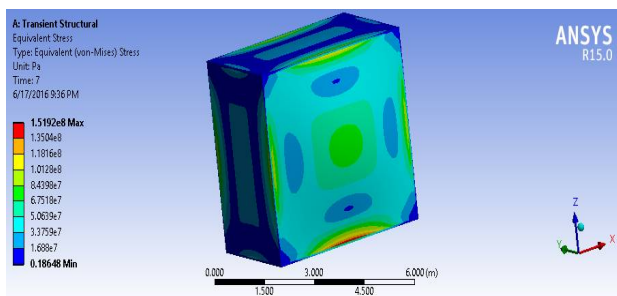


Fig. 22: von-Mises stress of the tank

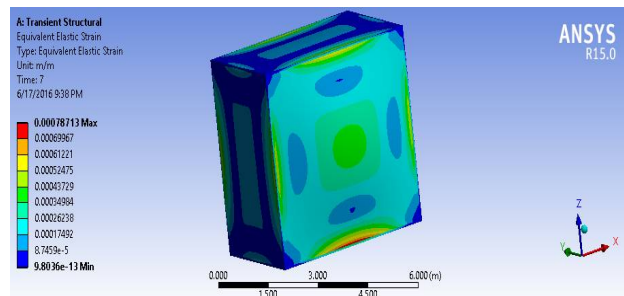


Fig. 23: von-Mises strain of the tank

b. Structural analysis of tank with baffles

Tanks having 5m x 3m x 4.5 m having thickness 50mm and a baffle of thickness double as that of thickness of the tank are provided .The baffles are provided to reduce the effect of sloshing in the tanks. Figure 24 shows the pressure distribution of the tank from ANSYS fluent. The values are given along the walls. In figure 25 the output after analysis is obtained. Total deformation of the tank is obtained from structural solver

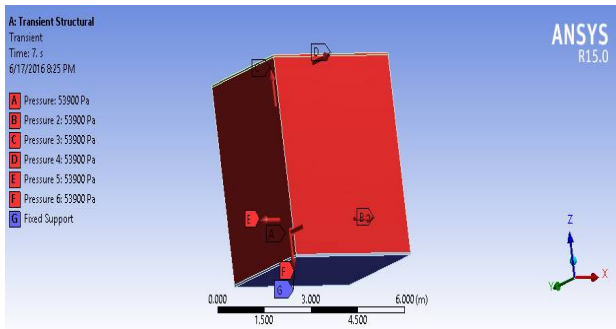


Fig. 24: Pressure distributions in the tank

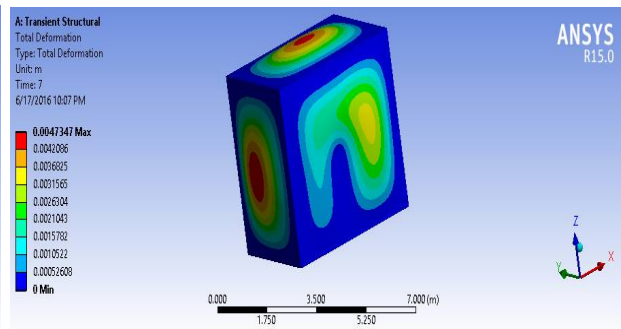


Fig. 25: Total deformation of tank

The structural analysis is carried out by using the pressures shown in the figure above and different structural responses such as deformation, von-Mises stress and von-Mises strain are found out in the figures 26 and 27. The different colours indicate the variation in the tank.

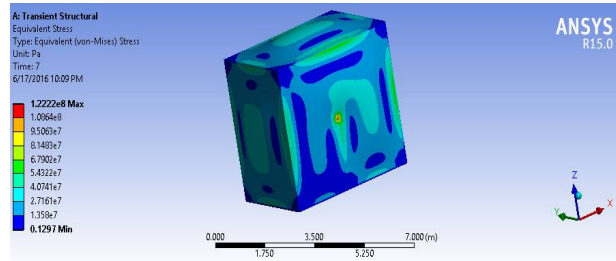


Fig. 26: von – Mises stress

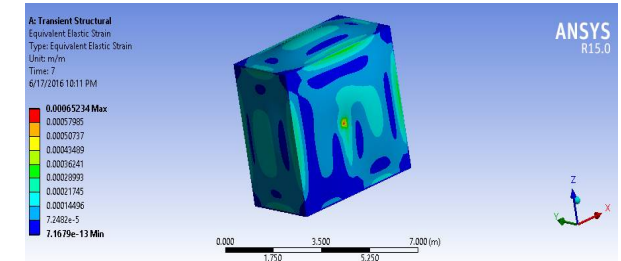


Fig. 27: von-Mises strain

When the two cases are considered, the reduction in deformation with baffles in case of earthquake motions are 21.64%. Thus it can be concluded that the use of baffles will be useful in reducing the sloshing effect on the tanks and thereby increasing the efficiency.

B. Sloshing in water tanks due to earthquake motions

Sl No.	Pressure (Pa)
1	2.43×10^7
2	2.31×10^7
3	2×10^7
4	1.6×10^7
5	1.5×10^7
6	1.45×10^7
7	1.2×10^7

Table 2: Pressure distribution values from fluent

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In the case of earthquake motions, the tank having dimensions 5m x 3m x 4.5 m is taking into account. Structural steel is used as the material of the tank. The thickness ranges are 50 mm to 200 mm. But the deformation is large since the earthquakes loads are very high, use of baffles are encouraged. Different pressure variations at different time steps are found out from the fluent introduced into the structural solver (ANSYS Workbench). The structural responses of the tank are given by the structural solver. Table 2 shows the different values obtained from the fluent. From these values 7 largest values are taken into account and is given in the table.

These values are given as input to the structural solver and the various responses are found out. Thus the graph showing the thickness versus deformation is shown in the figure 28. thickness is given in x axis upto 190 mm. Deformation is along y axis upto 4 m.

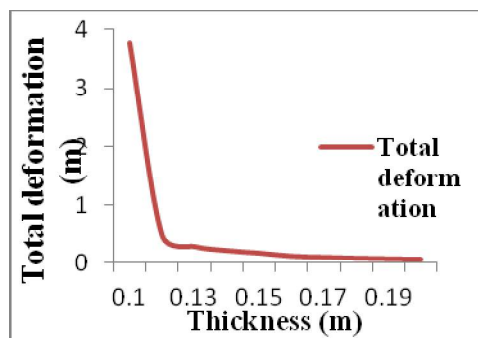


Fig. 28: Thickness vs total deformation plot

From the graph it is clear that there is no abrupt change in deformation after 170 mm. So adopt thickness of 170mm to the tank.

c. Structural analysis of tanks without baffles

The modeling was done by using ANSYS structural solver. The tank of size 5m x 4.5m x 3 m having a thickness mm thickness are modeled using ANSYS structural solver. Figure 29 shows the pressure distribution of the tank from ANSYS fluent. The values are given along the walls. In figure 30 the output after analysis is obtained. Total deformation of the tank is obtained from structural solver

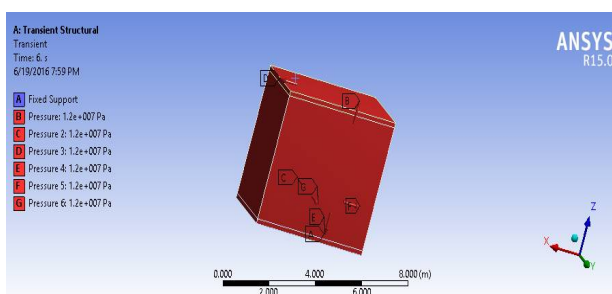


Fig. 29: Pressure distributions in the tank

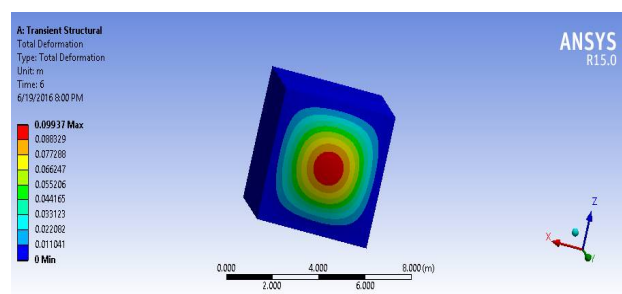


Fig. 30: Total deformation of tank

The structural analysis is carried out by using the pressures shown in the figure above and different structural responses such as deformation, von-Mises stress and von-Mises strain are found out in the figures 31 and 32. The different colour indicates the variation in the tank.

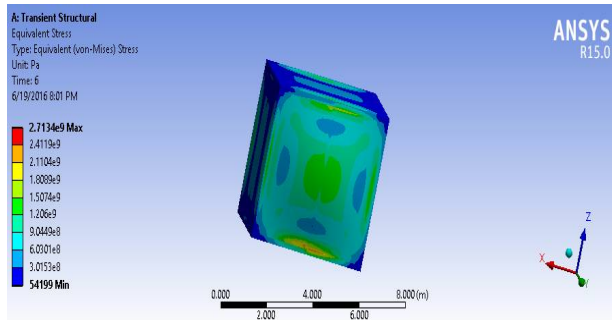


Fig. 31: von – Mises stress

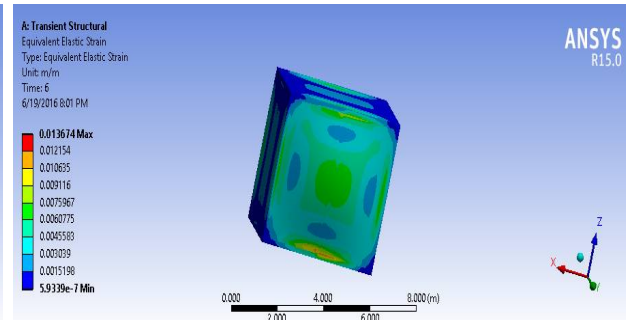


Fig. 32: von-Mises strain

d. Structural analysis of tank with baffles

Tanks having 5m x 3m x 4.5 m having thickness 170mm and a baffle of thickness double as that of thickness of the tank are provided. The baffles are provided to reduce the effect of sloshing in the tanks. Since the pressure distribution in the case of earthquake is very high to reduce the effect of sloshing, the baffles are provided. Thus the reduction in the deformation can be clearly obtained. Figure 33 shows the pressure distribution of the tank from ANSYS fluent. The values are given along the walls. In figure 34 the output after analysis is obtained. Total deformation of the tank is obtained from structural solver

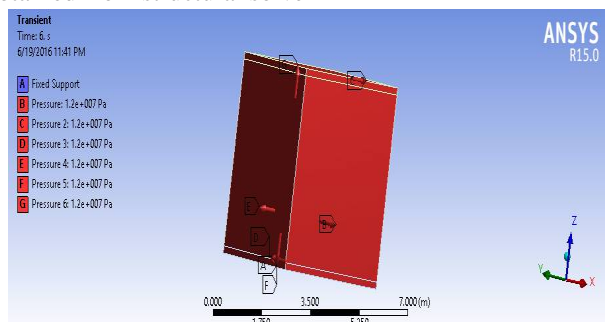


Fig. 33: Pressure distributions in the tank

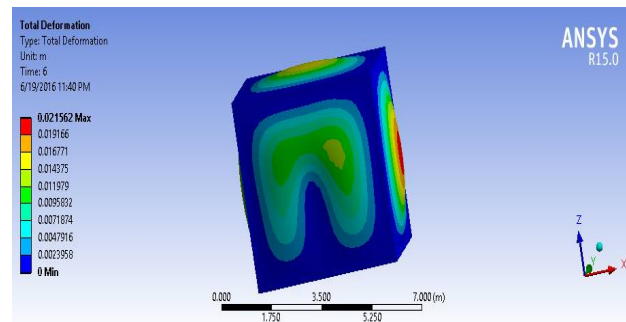


Fig. 34: Total deformation of tank

The structural analysis is carried out by using the pressures shown in the figure above and different structural responses such as deformation, von-Mises stress and von-Mises strain are found out in the figures 35 and 36. The different colours indicate the variation in the tank.

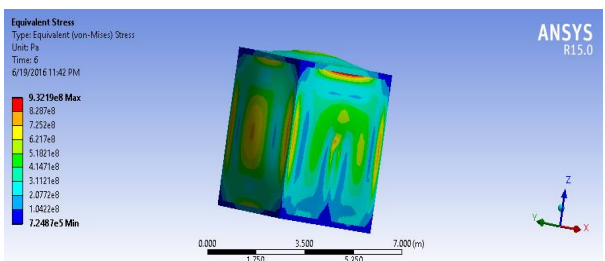


Fig. 35: von – Mises stress

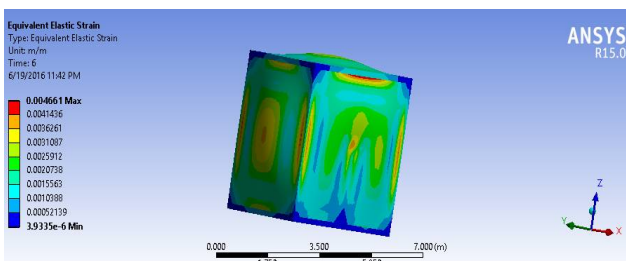


Fig. 36: von – Mises strain

When the two cases are considered that is tanks with baffles and without baffles, the reduction in deformation with baffles in case of earthquake motions are 26.46%. Thus it can be concluded that the use of baffles will be useful in reducing the sloshing effect on the tanks and thereby increasing the efficiency.

VII. 2D SIMULATION OF TANKS WITH BAFFLES

A. Rough sea conditions

The pressure distributions due to sloshing of ship tanks under rough sea conditions with baffles were obtained using ANSYS Fluent-15. Here normal sea condition is taken into account. Thus the 2D simulations for different time periods (t=0 seconds, 0.5 seconds, 1 seconds, 1.5 seconds and 2 seconds) were given in the figures 37 through 41. Figure 37 indicates the simulation of tank at the starting time and we can see no fluctuation in the water level here. The baffles are provided at the mid way of the tank with height same as that of the water level. Figure 38 indicates the simulation of tank at 500th time step. A small change in water profile can be seen.

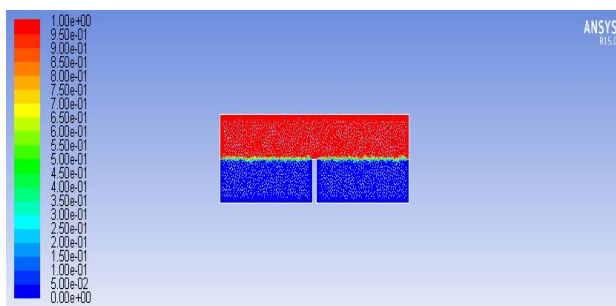


Fig. 37: 2D simulations of sloshing at 0th time step

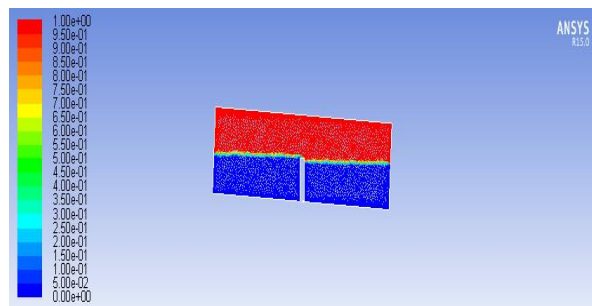


Fig. 38: 2D simulations of sloshing at 500th time step

Figures 39, 40 and 41 represent the 2D simulation of tank at 1000th time step, 500th time step and 1500th time step respectively. From these figures the fluctuations in the water profile can be easily seen, hence the comparisons are made with that of the one with baffles.

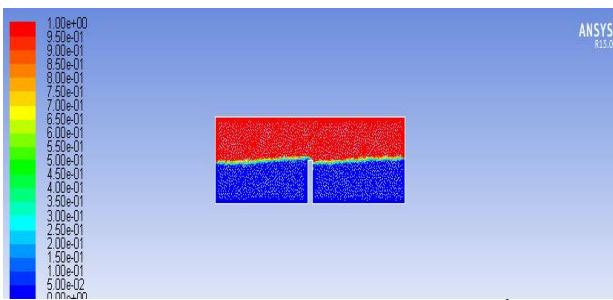


Fig. 39: 2D simulations of sloshing at 1000th time step

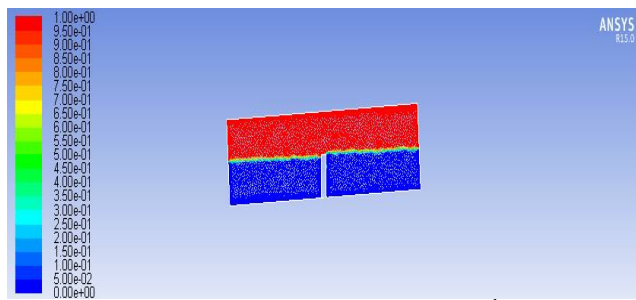


Fig. 40: 2D simulations of sloshing at 500th time step

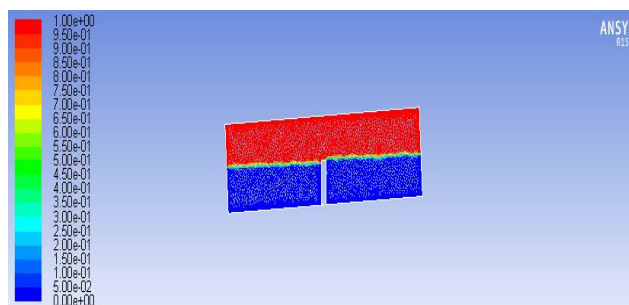


Fig. 41: 2D simulations of sloshing at 1500th time step

When the baffles are provided the figures indicate that the sloshing is effectively reduced.

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VIII. CONCLUSION

The effects of sloshing due to wave loads in ship tanks as well as earthquake forces in case of water tanks are best studied in this thesis. From the studies carried out in the present work it can be concluded that, Sloshing is a dynamic phenomenon which can be aptly studied using dynamic simulations using commercial CFD package ANSYS Fluent with UDF's .Sloshing loads depend on the grid size which has been suitably selected here. Deformations of the structure under sloshing loads have been well captured using ANSYS workbench. The dependency of the deformations on the thickness of the structure and from this the selection of optimum thickness has also been clearly obtained. Baffle thickness has been calculated from the maximum or extremum motion case using structural solver. The inclusion of baffles in the tanks not only reduced the magnitude of deformations but also the sloshing pattern of liquid inside the tank. The method used here ie; a combination of CFD and structural analysis is quite effective in predicting sloshing loads and their deformations on the structures. On the whole the work finds its success in moulding the commercial codes ANSYS fluent and workbench for solving a dynamic problem in structures.

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