Sloshing & Earthquake Effect On Water Tank

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Abstract- *Fluid stockpiling tanks is an imperative segment of life line frameworks, for example, water dissemination framework, oil plants and so on. Seismic outline of fluid stockpiling tanks requires learning of hydrodynamic weight following up on the divider and sloshing recurrence. For such a reason it requires legitimate investigation of liquid tank collaboration under seismic excitation. In the outline codes, mechanical analogs of tank-liquid framework are ordinarily used to acquire the hydrodynamic weight, sloshing recurrence and plan seismic powers. Such mechanical analogs are and produced for basic geometries, as rectangular and circular water tanks. Nonetheless, for tanks of different shapes and for tanks with inward obstacles, there are a not very many investigations on the mechanical analogs. In the present paper, exploratory and numerical investigation is taken up to get the sloshing recurrence of fluid contained in rectangular tank with or without astound divider. The exploratory examination is done on research facility models of tanks, which are energized utilizing an Electro-Magnetic Shake Table. The numerical investigation is finished with the assistance of limited component model of tank-liquid framework utilizing ANSYS programming. An examination of test and numerical outcomes is given.*

Keywords- Fluid-tank interaction, Sloshing frequency, tanks with obstruction, tanks of other shapes, ANSYS

I. INTRODUCTION

Water is an essential component in human life line, so the storage of water is very important phenomenon. For such a purpose term of design of water tank is implemented in civil engineering. While designing of water tank there are some important factors should be considered. Sloshing is the one of the important factor while designing of water tank. Sloshing is defined as the free motion of water inside the water tank. There are two types of water tanks like elevated storage water tank and ground storage water tank are commonly used to store the water. In major cities and rural areas elevated storage water tank and ground storage water tank are generally use. In case of elevated storage water tank it forms an integral part of water supply scheme and these tank must remain functional to meet the demand in any extreme and hazard situations like earthquake, fire etc. While designing the elevated storage water tank and ground storage water tank, it is very important to study the seismic behavior, safety with respect to water tank and sloshing effect of water inside the tank. The design and construction of water tank is such that it should remain functional in the post-earthquake period to ensure potable water supply to earthquake-affected regions. During the earthquake the sloshing effect inside the water tank increases and numbers of large elevated storage water tank and ground storage water tank are severely damaged where as others severely without damage. An analysis of the dynamic behavior of such a tank must take into account, the motion of the water relative to the tank as well as the motion of the tank related to ground. Numerous scientists have been done on the conduct, examination and plan of ground tanks. Indian subcontinent is exceedingly defenseless against cataclysmic event like seismic tremor, drafts, surges, tornados and so on. Lion's share of states or association domains are inclined to one or different calamities. These normal disasters are causing numerous setbacks and endless property misfortune consistently, According to seismic code IS: 1893 (Part 1): 2000, over 60% of India is inclined to quakes. The fundamental explanation behind life misfortune is fall of structure. It is said that seismic tremor itself never executes individuals; it is gravely developed structures that murder. Thus it is essential to investigation the structure legitimately for quake impacts. Sloshing waves have been examined numerically, hypothetically and tentatively in the previous quite a few years and numerous noteworthy marvels have been considered in those contemplated, particularly the direct and nonlinear impacts of sloshing for both in thick and gooey fluids. When the water tanks are used in seismic active regions, seismic behavior of them has to be investigated in detail to prevent the damage of such a structure and maintain the stability of structure. So there is need to focus on seismic safety of life line structure with respect to dynamic and sloshing study and find out the remedial measures which provide safety to the structure during the earthquake and also to withstand more design forces.

II. SLOSHING EFFECT OF TANKS

Sloshing is free motion of water inside the water tank. Sloshing is directly proportional to the acceleration of the water inside the tank. When earthquake is occurs the sloshing inside the water tank increases. It provides hydrostatic pressure distribution, force moments and natural frequencies of the free liquid surface. These parameters have a direct effect on the dynamic stability of structure and reduce the stability and strength of overall structure and structure damaged. That's why to maintain the strength and stability of water tank the study of sloshing effect and earthquake effect is important.

III. OBJECTIVE OF INVESTIGATION

- To conduct a study about the Static and Dynamic analysis of water tanks rest on ground
- To study about the behavior of water tank under earthquake load.
- To carry out the time history analysis of the water tank for tank is not fully filled with water level conditions.
- To compare seismic force for tank without baffle and tank with baffle wall.

IV. PROBLEM STATEMENT

A) A Rectangular Tank resting on ground of 54,00,000 liter capacity has plan dimensions of 45m x 30m and height of 4.6 m (including free board of 0.6 m). Wall has a uniform thickness of 400 mm. The base slab is 500 mm thick. There is no roof slab on the tank. Tank is located on hard soil in Zone V. Grade of concrete is M30.Analyze the tank for seismic loads

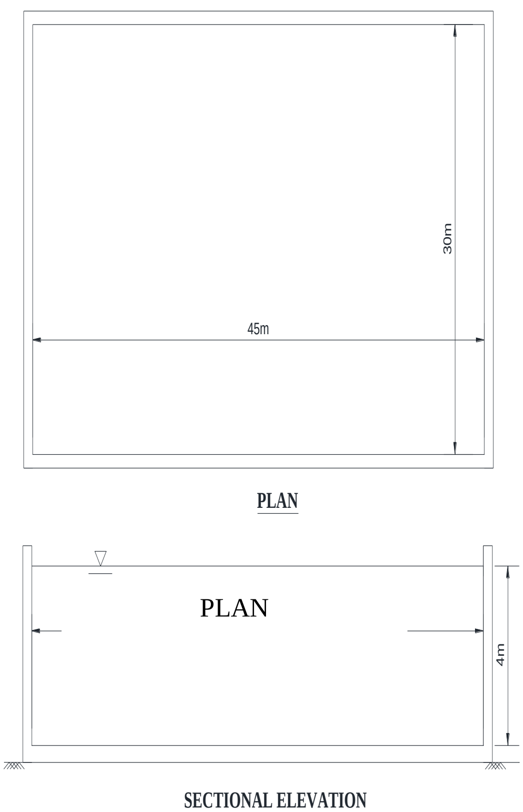


Fig.1. Plan Dimension of Tank

Summary of Hydrostatic Pressure & hydrodynamic Pressure Acting In X Direction

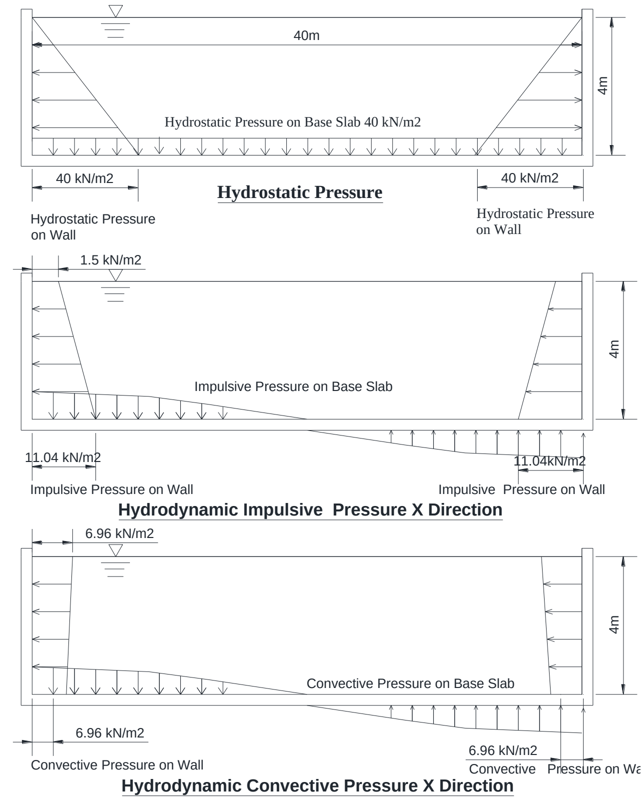


Fig.2. Hydrostatic and Hydrodynamic pressure acting in X Direction

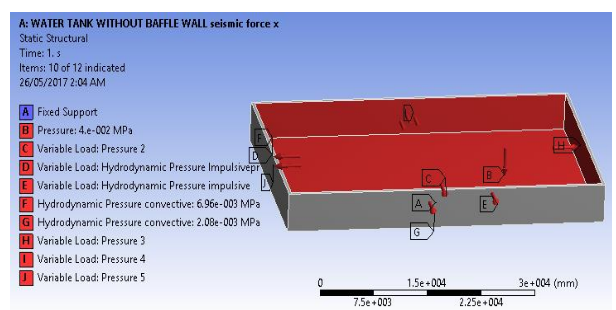


Fig.3. Hydrostatic and Hydrodynamic pressure acting in X Direction

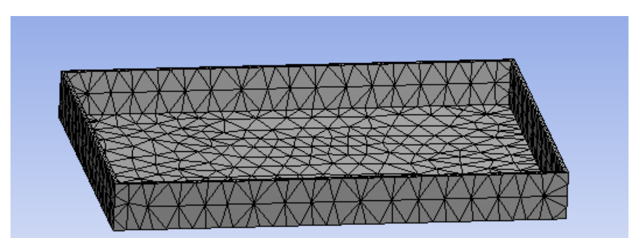


Fig.4. Meshing in Ansys Workbench16

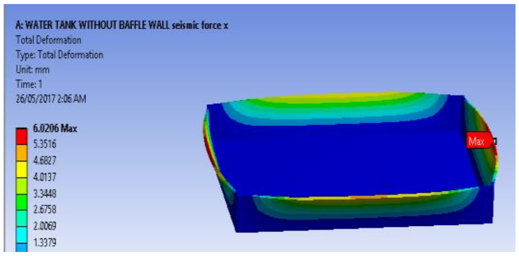
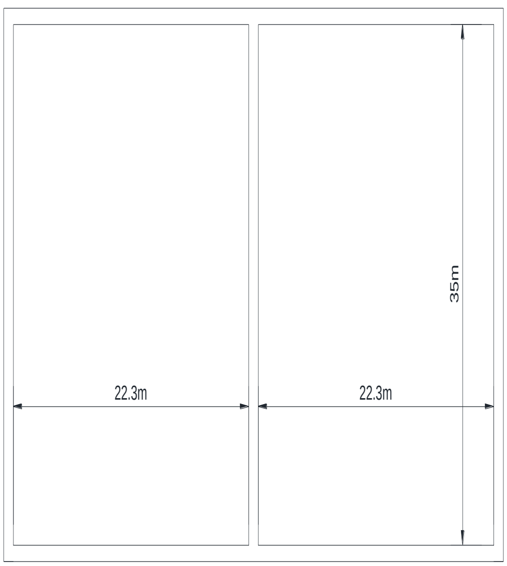
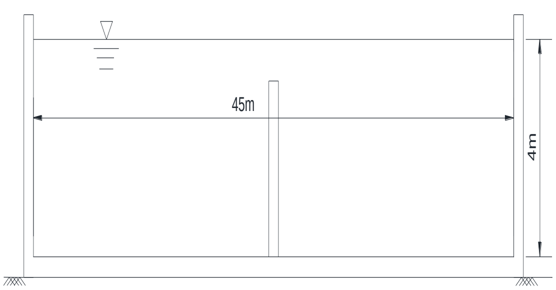


Fig.5. Total deformation of Tank without baffle wall

B) A Rectangular baffledTank resting on ground of 54,00,000 liter capacity has plan dimensions of 45m x 30m and height of 4.6 m (including free board of 0.6 m). Wall has a uniform thickness of 400 mm. Single baffle wall placed at the center of tank.The base slab is 500 mm thick. There is no roof slab on the tank. Tank is located on hard soil in Zone V. Grade of concrete is M30.Analyze the tank for seismic loads



PLAN



SECTIONAL ELEVATION

Fig.6. Plan Dimension of Tank

Summary of Hydrostatic Pressure & hydrodynamic Pressure Acting In X Direction

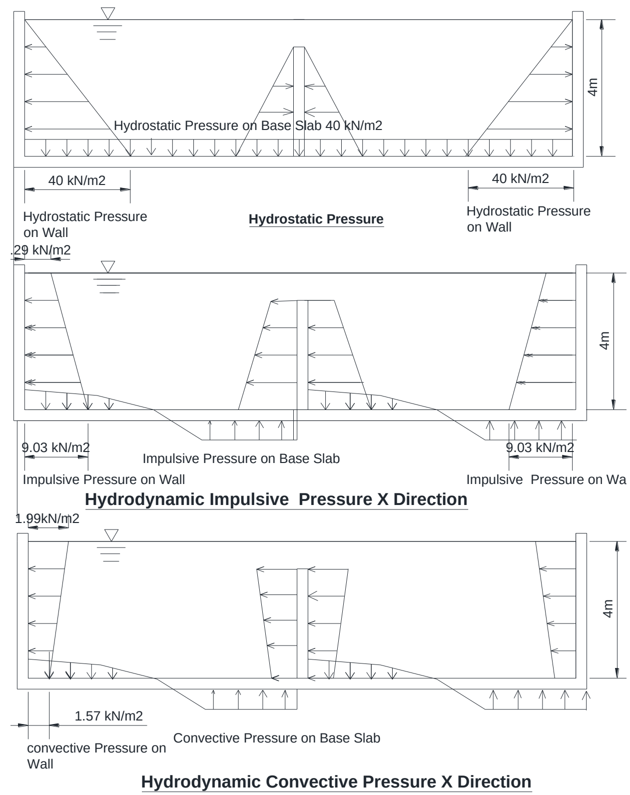


Fig.7.Hydrostatic and Hydrodynamic pressure acting in X Direction

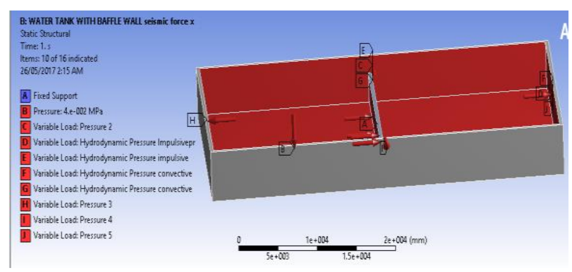


Fig.8.Hydrostatic and Hydrodynamic pressure acting in X Direction

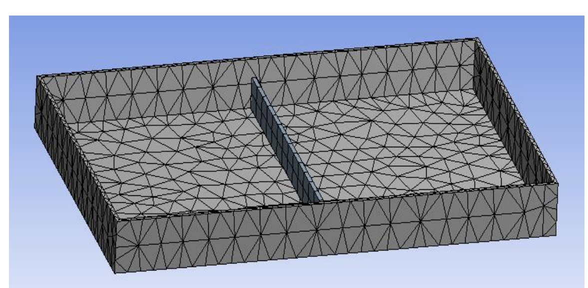


Fig.9.Meshing in Ansys workbench

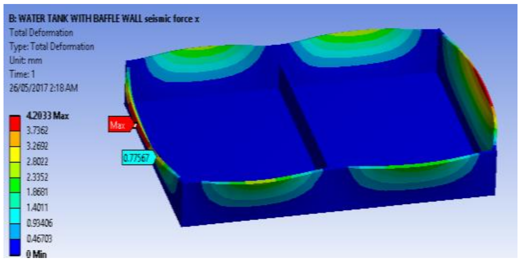
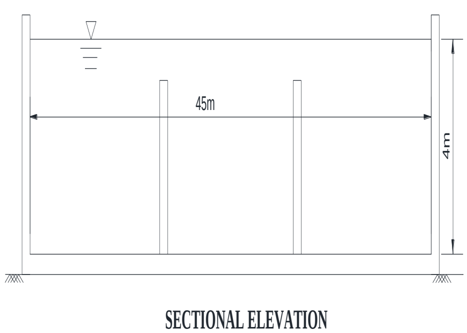


Fig.10.Total Deformation of Tank

C) A Rectangular baffled Tank resting on ground of 54,00,000 liter capacity has plan dimensions of 45m x 30m and height of 4.6 m (including free board of 0.6 m). Wall has a uniform thickness of 400 mm. Double baffle wall equally placed at the centre of tank.The base slab is 500 mm thick. There is no roof slab on the tank. Tank is located on hard soil in Zone V. Grade of concrete is M30.Analyze the tank for seismic loads

PLAN



SECTIONAL ELEVATION

Fig.11.Plan Dimension of Tank

Summary of Hydrostatic Pressure & hydrodynamic Pressure Acting In X Direction

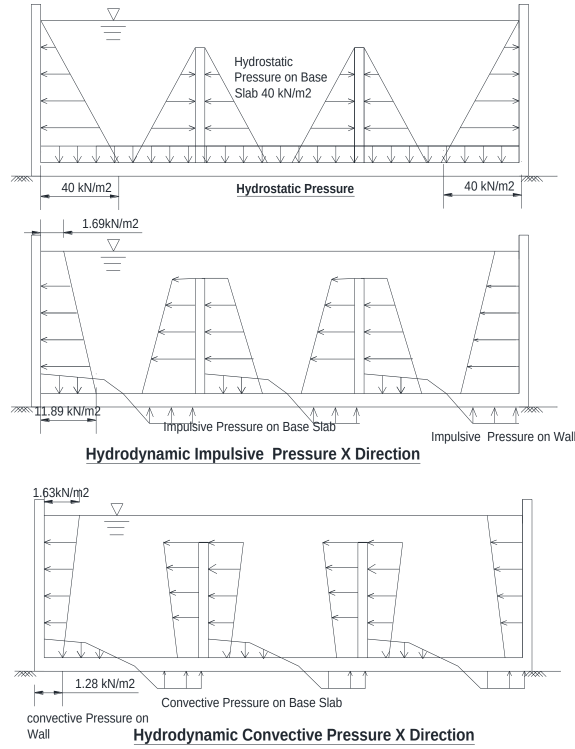


Fig.12.Hydrostatic and Hydrodynamic pressure acting in X Direction

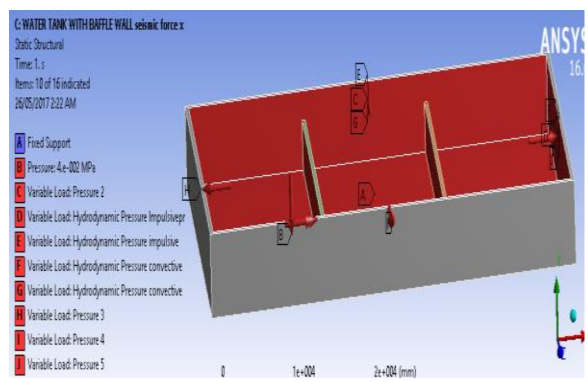


Fig.13.Hydrostatic and Hydrodynamic pressure acting in X Direction

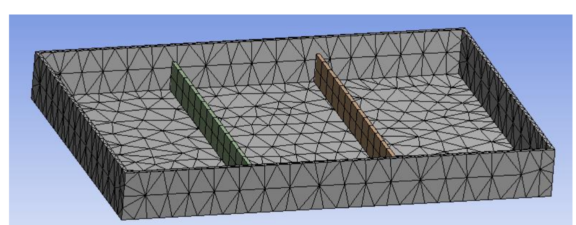


Fig.14.Hydrostatic and Hydrodynamic pressure acting in X Direction

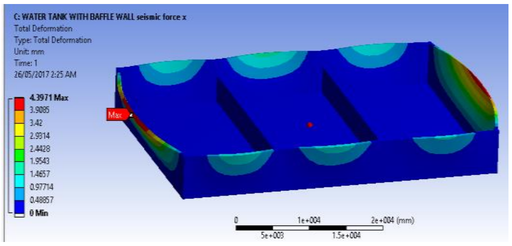


Fig.15.Hydrostatic and Hydrodynamic pressure acting in X Direction

V. EXPERIMENTAL IMPLEMENTATION AND RESULTS

1. COMPARISON OF SEISMIC FORCE FOR TANK WITHOUT BAFFLE AND TANK WITH BAFFLE WALL

Table I. Comparison For Tank With And Without Baffle Walls

Title	**Tank without baffle wall**	**Tank with single baffle wall**	**Tank with double baffle wall**
Impulsive mass of liquid	5,40,000kg (10% participates in Convective mode)	5,35,200kg (20% participates in convective mode)	548700kg (31% participates in convective mode)
Convective mass of liquid	44,82,000kg (83% of liquid participates in impulsive mode)	20,87,280kg (78% of liquid mass participates in impulsive mode)	1203600kg (68% of liquid mass participates in impulsive mode)
Time Period for Impulsive mode	0.075sec	0.075 sec	0.083sec
Time Period convective mode	15.63 sec	7.538sec	5.15sec
Base shear at bottom of wall	3653kN	2358kN	2777kN
Equivalent Impulsive pressure – X Direction	T=1.57kN/m ^{2} B=11.04 kN/m^2	T = 1.3kN/m^2 B=9.03kN/m ^{2}	T = 1.7kN/m^2 B=11kN/m^2
Equivalent linear convective pressure- X Direction	T=6.96kN/m^2 B=6.96kN/m^2	T=1.9kN/m^2 B=1.5kN/m^2	T=1.6kN/m^2 B=1.3kN/m ^{2}
Sloshing Height	1.71m	0.66m	0.43m

2. TIME HISTORY ANALYSIS

The behavior of water tank is carried out using time history analysis. It is carried out by two ways likes the behavior of water tank under EI centro, earthquake acceleration-time records and using ANSYS software with transient dynamic analysis. The ANSYS program works under the Newmark's time integration method. In this method dynamic equations are solved. Integration time steps are an important phenomenon work in it. It is define as the time increment between successive time points. There are three methods to do a transient dynamic analysis are full method, mode supervision method and reduced method. In present work transient analysis is carried out by using full method. In this method full system matrix is used to calculate the transient response. It is the most general method because it allows all types of nonlinearities to be included like plasticity, large deflection, large strain etc. the following are the ANSYS result models which showing the sloshing effect on rectangular water tank when it is not fully filled with water.

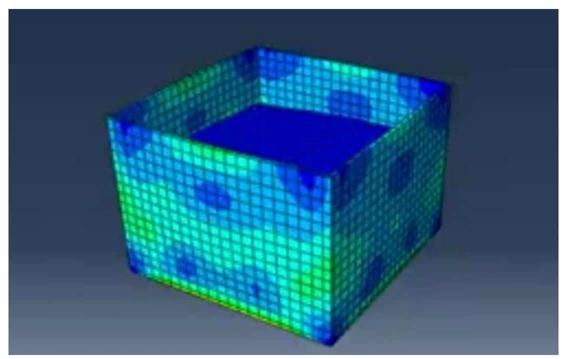


Fig.16.Sloshing effect on rectangular water tank when it is not fully filled with water

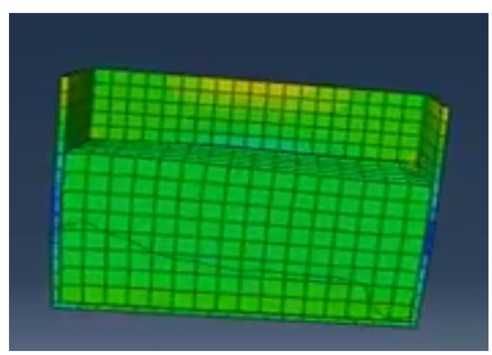


Fig.17.Cross-section of Sloshing effect on rectangular water tank when it is not fully filled with water

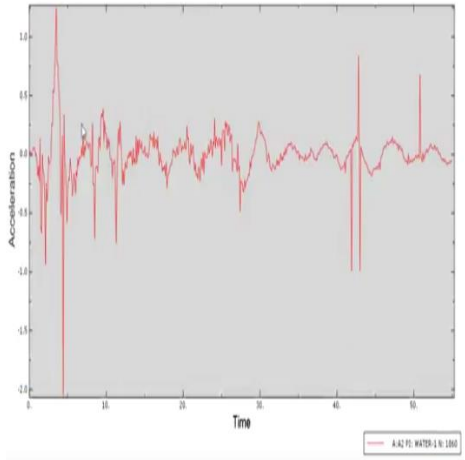


Fig.18.Time history analysis graph for sloshing effect on rectangular water tank when it is not fully filled with water

VI. CONCLUSIONS

Tanks with and without baffle having same geometric size, seismic parameter, water height, from above calculation and analysis the following conclusion is made for sloshing in tank with and without baffle wall

a) Time Period calculated for tank without baffle is more than the time period for tank with baffle which means sloshing is more in case of tank without baffle as compared to tank with baffle walls.
b) The Sloshing height calculated for tank without baffle wall is more than the sloshing height calculated for tank with baffle wall.

c) Sloshing height is considerable reduced for tank with multiple baffles when the seismic forces is acting in perpendicular direction to baffle wall

d) Base shear calculated at bottom of wall for tank without baffle is slightly more as compared to base shear calculated for baffled tank.

e) The equivalent convective pressure reduces with an introduction of single and multiple baffle in tank i.e it reduces with reduction in aspect ratio of tank

f) The hydrostatic force acting on baffle wall gets nullified for baffled tank when both the tank compartments are equally filled.

g) The hydrodynamic force acting on the baffle wall is doubled as per the codal calculations as there is no specific clause mentioned for baffle wall.

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