A PARAMETRIC STUDY TO ANALYZE THE SEVERITY OF HYDRODYNAMIC PRESSURE FOR INTZE TANK

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Abstract—**Regarding seismic analysis, as per IS 1893:1984, provisions were given considering water tank as single degree of freedom system, whereas according to IS 1893:2002 (Part-2), impulsive and convective water masses of container water are considered. In the present study, efforts are made to understand the behavior of intze tank supported on circular shaft, when it is subjected to hydrodynamic pressure. Various parametric studies have been carried out to study the severity of hydrodynamic pressure by varying the tank capacities, height to diameter ratio of cylindrical wall, different seismic zones and soil types. It is observed that hydrodynamic pressure is not critical in case of intze tank.**

Key words—**intze tank, hydrodynamic pressure, hydrostatic pressure, parametric study, tank capacity, h/D ratio, seismic zone, soil type.**

I. INTRODUCTION

The importance of storing water is obvious, especially in the present scenario when water is becoming a scarce commodity. For storing water and its distribution, water tanks are largely used. For achieving the required head, elevated storage tanks are used. In general water tanks are mainly classified as elevated water tank and ground supported water tank, i.e. E.S.R (Elevated Storage Reservoir) and G.S.R (Ground Storage Reservoir). For an efficient water distribution system, overhead water tanks or elevated storage reservoirs are one of the most important components. The basic purpose of elevated water tanks is to secure constant water supply with sufficient flow to wide area by gravity. The height of the elevated tank depends on the area to be covered for the water supply. Wider the area to be served higher will be the required elevation of the tank.

Elevated tanks are classified on the basis of
  - Shape of container
  - Supporting system

The shape of container may be square, rectangle, circular, conical or intze. The supporting system may be shaft supported or trestle supported.

The loads that act upon water tanks are dead load, wind load, seismic load and vibration forces.
For the purpose of analysis, IS 1893:1984 suggests elevated tanks shall be regarded as systems with a single degree of freedom with their mass concentrated at their centers of gravity. However this is reasonable only for closed tanks completely full of water. The design force for the tank highly depends upon the natural time period and hence the natural time period should be calculated with greater accuracy. Under lateral accelerations, the fluids in the upper regions of the tank do not move with the tank wall thus generate seismic waves or sloshing motion of fluids (convective behavior). As the IS: 1893-1984 suggests a single degree of freedom idealization, accuracy of estimated natural time period is questionable,

particularly when the tank is partially full due to the reason that sloshing mode of vibrations also contribute to the seismic response of the system. For some containers (large width to depth ratios), single mass model is certainly not an appropriate representation as most of the mass in the tank acts as a convective one and this will take to misleading behavior of the tank. The code recommends that design shall be worked out both when the tank is full and when empty.
  - When empty, the weight W used in the design shall consist of the dead load of tank and one third the weight of staging.
  - When full, the weight of contents is to be added to the weight under empty condition.

IS 1893:2002 (Part 2) contains provisions on liquid retaining tanks. This standard incorporates the following important provisions and changes for elevated water tanks:
  - For elevated tanks, the single degree of freedom idealization of tank is replaced by a two-degree of freedom idealization is used for analysis.
  - The effect of convective hydrodynamic pressure is included in the analysis.

II. HYDRODYNAMIC PRESSURE IN TANKS

When a tank containing fluid with a free surface is subjected to ground motion, it experiences dynamic fluid pressure of two types. Firstly when the walls of tank accelerate the adjacent fluid also accelerates and exerts on wall an impulsive pressure which is directly proportional to the acceleration of the wall. Secondly the effect of the impulsive pressure exerted by the wall on the fluid is to excite the fluid into oscillation and the oscillatory acceleration of the fluid produces convective pressures on the walls whose magnitude is proportional to the magnitude of the oscillation.

When a tank containing liquid with a free surface is subjected to horizontal earthquake ground motion, tank wall and liquid are subjected to horizontal acceleration. The liquid in the lower region of tank behaves like a mass that is rigidly connected to tank wall. This mass is termed as impulsive liquid mass which accelerates along with the wall and induces impulsive hydrodynamic pressure on tank wall and similarly on base. Liquid mass in the upper region of tank undergoes sloshing motion. This mass is termed as convective liquid mass and it exerts convective hydrodynamic pressure on tank wall and base. Thus, total liquid mass gets divided into two parts, i.e., impulsive mass and convective mass. The portion of the tank fluids that act in impulsive mode largely depends on the aspect ratio (height/diameter) of the tank. For tanks of very low aspect ratio, a very little of tank fluids acts in the impulsive mode. Various experimental works suggest that convective mode period is considerably higher than the impulsive mode period.

If hydrodynamic pressure exceeds 33% of hydrostatic pressure, then analysis and design for hydrodynamic pressure is to be taken into account for cylindrical wall of intze tank container.

III. PARAMETRIC STUDY FOR SEVERITY OF HYDRODYNAMIC PRESSURE

To analyze the severity of hydrodynamic pressure, parametric study is carried out for various parameters like

- tank capacities = 700, 800, 900, 1000, 1200, 1500 and 1800m3
- height/diameter (h/d) ratios = 0.4, 0.5, 0.6
- Seismic zones = 3, 4 and 5
- Soil conditions = soft, medium and hard

Graphs of % variation of hydrodynamic pressure w.r.t. hydrostatic pressure have been plotted as shown in fig.1 to fig.9
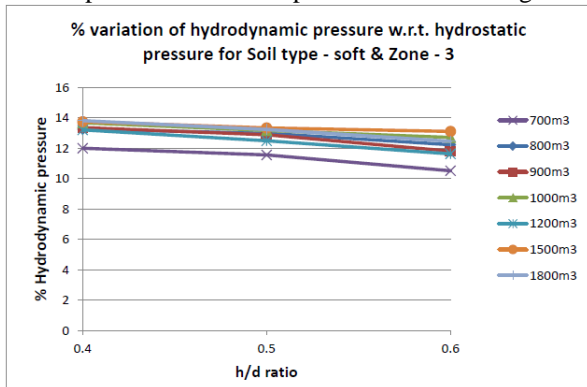
Fig.1 % variation of hydrodynamic pressure w.r.t. hydrostatic pressure for Soil type - soft and Zone – 3
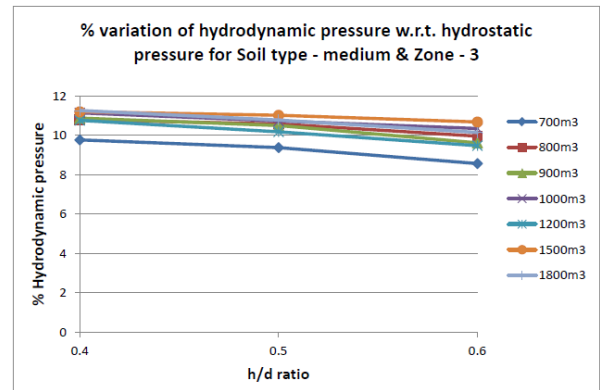

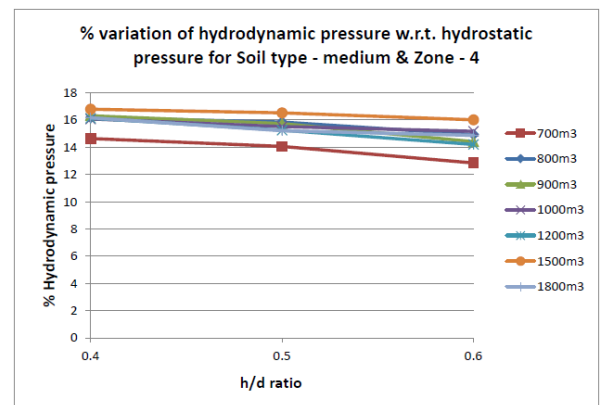**Fig.2 % variation of hydrodynamic pressure w.r.t. hydrostatic pressure for Soil type - soft and Zone – 4**

Fig.3 % variation of hydrodynamic pressure w.r.t. hydrostatic pressure for Soil type - soft and Zone – 5

Fig.4 % variation of hydrodynamic pressure w.r.t. hydrostatic pressure for Soil type - medium and Zone – 3

Fig.5 % variation of hydrodynamic pressure w.r.t. hydrostatic pressure for Soil type - medium and Zone – 4
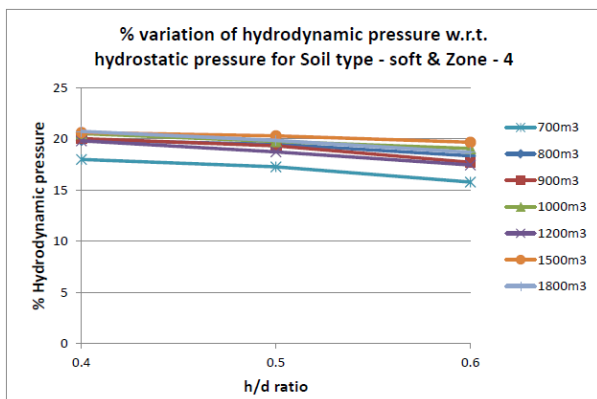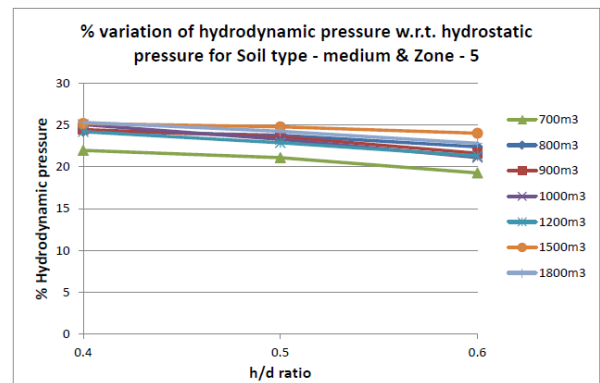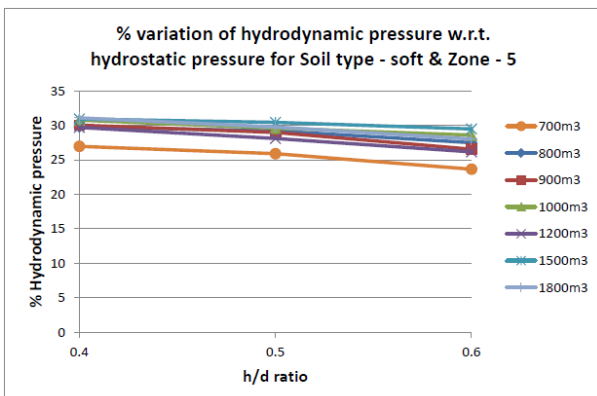

Fig.6 % variation of hydrodynamic pressure w.r.t. hydrostatic pressure for Soil type - medium and Zone – 5
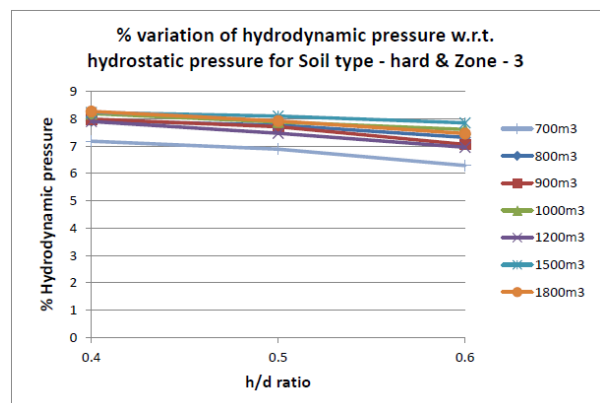

Fig.7 % variation of hydrodynamic pressure w.r.t. hydrostatic pressure for Soil type - hard and Zone – 3
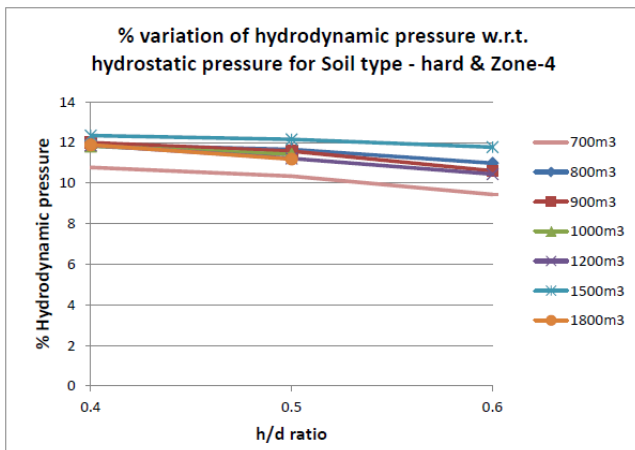
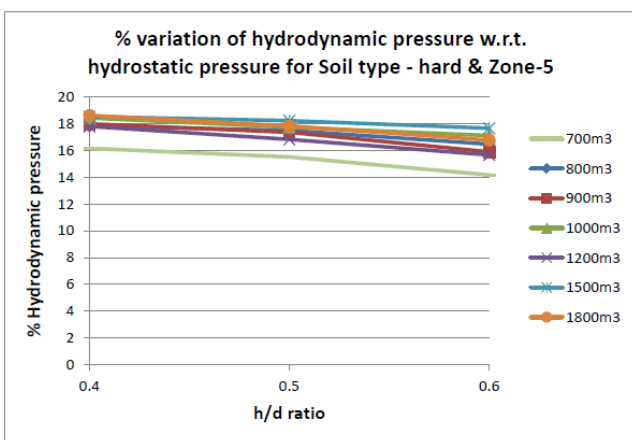**Fig.8 % variation of hydrodynamic pressure w.r.t. hydrostatic pressure for Soil type - hard and Zone – 4**

Fig.9 % variation of hydrodynamic pressure w.r.t. hydrostatic pressure for Soil type - hard and Zone – 5

IV. CONCLUSION

➢ As seen in fig. 6, of the parametric study, maximum hydrodynamic pressure is 31.08% of hydrostatic pressure.

➢ Maximum hydrodynamic pressure is 31.08% of hydrostatic pressure, which is less than 33%. Hence it is not critical in case of intze tank.

➢ From fig. 6, it can be seen that soft soil type and seismic zone V is the most critical combination in the parametric study.

➢ It is also observed from fig. 1 to fig. 9 that % hydrodynamic pressure w.r.t. hydrostatic pressure decreases, as h/d ratio for cylindrical wall of intze tank increases.

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