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SEISMIC ANALYSIS OF WATER TANK AT DIFFERENT STOREY HEIGHT OF THE BUILDING AND TO CHECK FLUID SLOSHING EFFECT.

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Abstract—**Sloshing is one of the most dominant effects in elevated water tanks, water storage tanks, and structures. An earthquake is a disruptive disturbance that causes shaking of the earth's surface due to movement along a fault plane or volcanic activity. The nature of the produced forces is reckless and only lasts a brief time. Sloshing thus involves a wide range of engineering difficulties, one of which is the dynamic response of lifeline liquid storage tanks in the event of an earthquake. Aerospace, civil, and nuclear engineers are all concerned about liquid sloshing in moving or stationary containers. DOSIWAM Sewage Treatment Plants serve to reduce negative environmental effect by enhancing effluent quality. The current study is the extension of the "environmental floor" concept, where installing the DOSIWAM system at intermittent levels of a multistoried building is carried out. The water coming out of this tank has very low BOD, so the water becomes suitable for reuse in gardening, irrigation, and firefighting operations. A novel approach was used, combining the CFD software and structural analysis software to check the sloshing effect. This is part of a research effort dedicated to developing a CAE (Computer-Aided Engineering) methodology. The project's objective was to check the effect of the storage tank on the environmental floor. Thus, a storage tank and a water tank with an aspect ratio close to 1 can be safely provided. The difference in time period of the water tank and the structure was found to reduce the effect of sloshing. Hence, the Storage tank of the DOSIWAM system can be safely installed on the structure.**

Keywords—**Ansys, CFD, DOSIWAM, Etabs, Response Spectrum Analysis, Sloshing, Time History Analysis, Water TANK.**

I. INTRODUCTION

Natural disasters such as earthquakes have claimed millions of lives throughout known and unwritten human history. An earthquake is a disruptive event that generates surface shaking due to subsurface movement along a fault line or volcanic activity. Humans, on the other hand, are perplexed by the uncertainty surrounding its presence and nature. However, with the advances in various sciences through the centuries, some degree of predictability in terms of probabilistic measures has been achieved.

Furthermore, with these advancements, forecasting the occurrence and strength of earthquakes for a certain location has become quite accurate; yet this only solves one aspect of the problem of protecting a structure - knowing what is coming! The seismic design of structures is the second phase, which ensures that they can withstand anything is thrown at them. Over the last century, this part of the problem has taken various forms, and improvements in its design philosophy and methods have continuously been researched, proposed, and implemented. Multi-story structures, bridges, and tanks supported by isolators are modeled and analyzed to demonstrate the effectiveness of seismic isolation. However, when earthquakes occur, there are more consequences to them.

One of the most Dominating Effects occurs in Elevated water tanks, the water storage tank structure in sloshing. Sloshing, therefore, involves a broad range of engineering difficulties, one of which is the dynamic response of lifeline liquid storage tanks in the event of an earthquake [7]. These parameters directly affect the dynamic stability and performance of Structures. At times, a sloshing-induced hydrodynamic load may adversely affect the dynamic behavior and structural safety of the liquid storage tank [13]. The primary goal of this discussion is to investigate the impact of the dynamic response of rigid rectangular liquid storage tanks on the structure when subjected to lateral seismic ground motion.

II. PROBLEM STATEMENT

The current study is the extension of the 'environmental floor' concept, where installing the DOSIWAM system at intermittent levels of a multistoried building is carried out. The term 'environmental floor' is designated for the refuge floor, where the treatment units are located, keeping the common refuge area vacant and working on a gravity basis to fulfil the requirement for treated water used for various nonconsumptive purposes like flushing, gardening, firefighting, floor washing, etc.

- The treatment units consist of the Malaprabha digester, the Intercepting tank, the Stabilization tank, and the Storage tank.
- For the Successful implementation of the System and the concept, studies such as Environment and Environmental Impact Assessment have been carried out.

In this study, the effect of the Storage tank from the Treatment unit on the building will be carried out along with the Static loading; the time history loading analysis will be carried out to comprehend the effect of the sloshing of water from the tank. The research presented here is part of an effort to establish a CAE (Computer-Aided Engineering)-based methodology for studying the sloshing phenomena and the influence of sloshing on structures utilizing a novel approach.
This project involves a CFD analysis of the tank's working fluid (water) flow dynamics. The CFD study uses acceleration data from structural analysis software to determine dynamic pressure on tank walls. The study's result, dynamic pressure, will be used as structural loading in the building to anticipate the structure's behavior.

1. The first section of this paper describes structural analysis software, which in this case is Etabs v19. The Software Response Spectrum analysis was performed, and Acceleration data were extracted from the results.

The Analysis is obtained for three cases,

a. For storage tank at the Maximum filled level.
b. For storage tank at Minimum Level.
c. For storage tank at partially filled at 50% Level.

2. The second part includes CFD based numerical procedure used for Analysis. For CFD analysis, Ansys Fluent software was used. The process includes the formulation of models and Initialization of initial conditions and acceleration parameters. In the Analysis, the Dynamic pressure due to Sloshing was Plotted with respect to time.
3. The third part is related to the time history loading analysis of the Dynamic forces obtained from the CFD software. Then the Analysis was compared with and without the Sloshing effect for the structure.

III. RESEARCH METHODOLOGY

A. Research Work

- The main aim of this study is to understand the behavior of water tank at different story to give better performance during earthquake.
- The basic problem of liquid sloshing involves the estimation of hydrodynamics pressure distribution.
- When seismic excitation causes fluid sloshing in storage tanks, it might result in significant problems including tank roof failure and oil storage tank fire.
- Study different storey height of water tank and study of seismic resistant design of water tank near refuge area of the building as per IS:1893-1984, IS:1893-2016, IS :11682-1985 and IITK- GSDMA guidelines.

B. Methodology

From the literature review aim and objectives were decided and according to it following methodology has been adopted.
The **Error! Reference source not found.** shown above shows the Process of the project. Each Part will be explained in Detailed manner in the subsequent sections

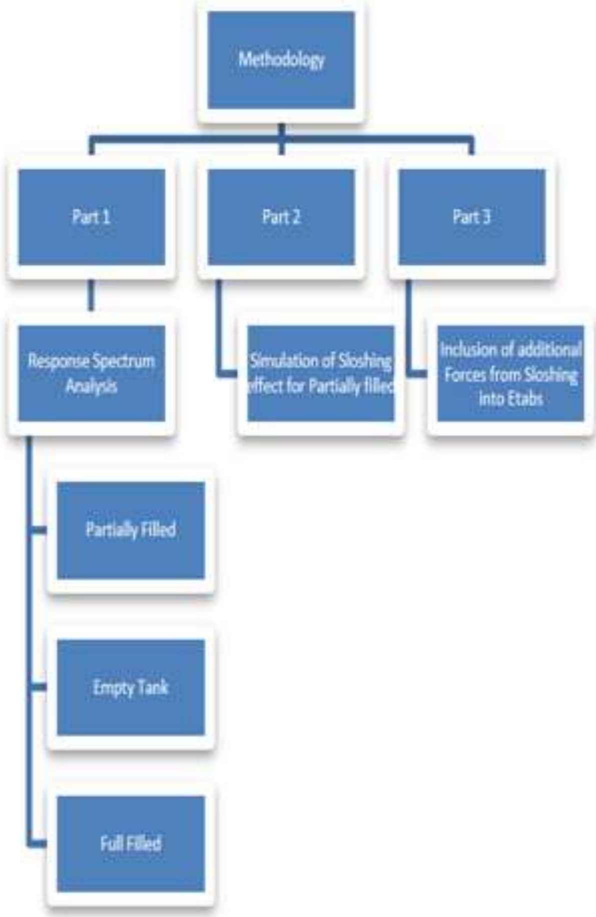

Fig. 1. Methodology

The Flow of the project is divided into Three Parts

1) Part 1

As shown in **Error! Reference source not found.**, the methodology for the Part 1 of the project. Which includes Response analysis for the structure for three cases

- Empty Case
- Partially filled at 50% Level Case
- Full Filled Case

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2) Part 2

The sloshing analysis was performed for a partially filled case at 50% water level. The analysis was performed using Ansys 2022 R1.

3) Part 3

The forces from the part 2, were applied on the structure and Time history analysis was performed. And then the results were compared.

IV. RESULTS AND DISCUSSION

The results of the current investigation are discussed in depth in this section. The computational simulation for a 3-D liquid storage tank when subjected to earthquake ground motion and triggered by seismic frequencies is carried out for the current sloshing problem. Forces on the walls were generated from CFD Software Ansys. The Etabs Software calculated the time history using the forces on the walls.

A. Empty Tank

Error! Reference source not found. is the graph plotted for the case where, the tank is empty. Thus, there won't be any sloshing and Dynamic Forces due to

sloshing. It can be observed from the response of max Displacement in the Structure that the max Displacement occurred at the topmost storey i.e., 21st Floor which is 23.26 mm. And then it was observed that the displacement at 15th and 8th Floor where the tank is located to be 18.7 mm and 10.72 mm respectively.

Table 1: Story Displacements for Empty Tank case

Partially Filled Tank	**RS case**
15th Floor	**18.7 mm**
8th Floor	**10.72 mm**
Max	**23.26 mm**

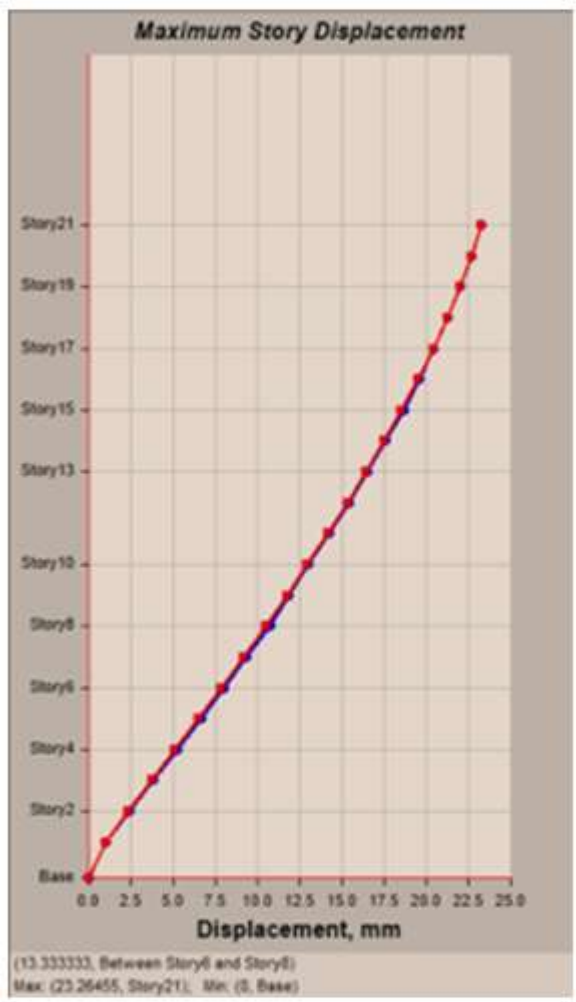

Fig. 2. Maximum Story Displacement for Empty Tank

B. Full Tank

Error! Reference source not found. is the graph plotted for the case where, the tank is Full. Thus, there won't be any sloshing and Dynamic Forces due to sloshing. It can be observed from the response of max Displacement in the Structure that the max Displacement occurred at the topmost storey i.e., 21st Floor which is 36.37 mm. And then it was observed that the displacement at 15th and 8th Floor where the tank is located to be 29.09 mm and 16.56 mm respectively

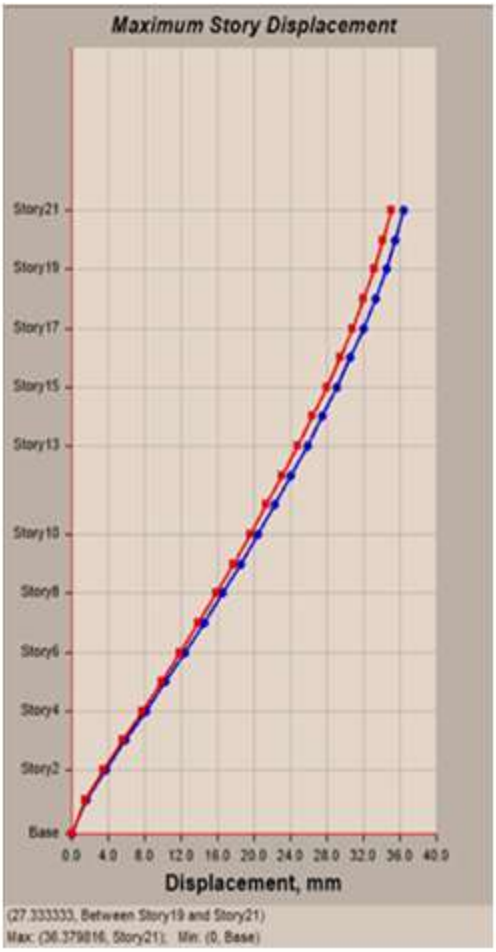

Fig. 3. Maximum Storey Displacement for Partially filled at 50% Level tank

Table 2: Story Displacements for Full tank case

Full Tank	RS case
15th Floor	29.09 mm
8th Floor	16.56 mm
Max	36.37 mm

C. Partially filled at 50% Level Tank

Table 3: Story Displacements for Partially filled at 50% Level tank Case without sloshing shows the values obtained from the Response spectrum analysis from case 3, which pertains to Partially filled tank.

Error! Reference source not found. is the graph plotted for the case where, the tank is Partially filled at 50% Level. Thus, there is a possibility of sloshing, and the sloshing amplitude depends upon the Characteristic of the Vibrations and Due to Vibration induced there will be Dynamic Forces on the walls due to sloshing. It can be observed from the response of max Displacement in the Structure that the max Displacement occurred at the topmost storey i.e., 21st Floor which is 24.25 mm. And then it was observed that the displacement at 15th and 8th Floor where the tank is located to be 19.4 mm and 11.83 mm respectively.

Table 3: Story Displacements for Partially filled at 50% Level tank Case without sloshing

Partially Filled Tank	**RS case**
15th Floor	**19.4 mm**
8th Floor	**11.83 mm**
Max	**24.25 mm**

We can clearly see that due to sloshing the Displacement at 8th and 15th Storey has been Increased. The Effect of sloshing tough have dispersed in whole structure but , the Major impact can be seen on 8th , 9th 15th and 16th Floor.

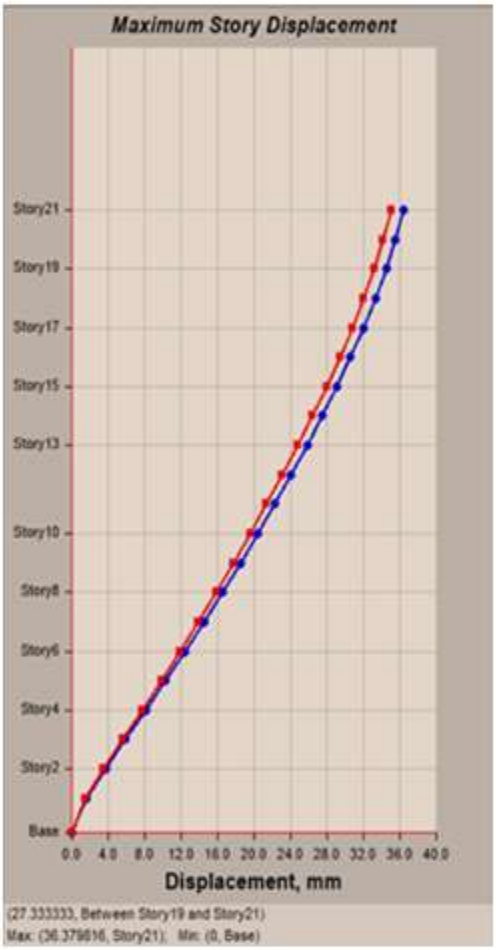

Fig. 4. Maximum Storey Displacement for Full tank

D. Combined Response

Error! Reference source not found. is the graph plotted for the case where, the tank is Partially filled at 50% Level, and the effect of sloshing is considered.

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It can be observed from the response of max Displacement in the Structure that the max Displacement occurred at the topmost storey i.e., 21st Floor which is 29.83 mm. And then it was observed that the displacement at 15th and 8th Floor where the tank is located to be 22.83 mm and 13.10 mm respectively.

Table 4: Story Displacements for Partially filled at 50% Level tank Case with sloshing

Partially filled at 50% Level Tank	RS case
15th Floor	22.83 mm
8th Floor	13.10 mm
Max	29.17 mm

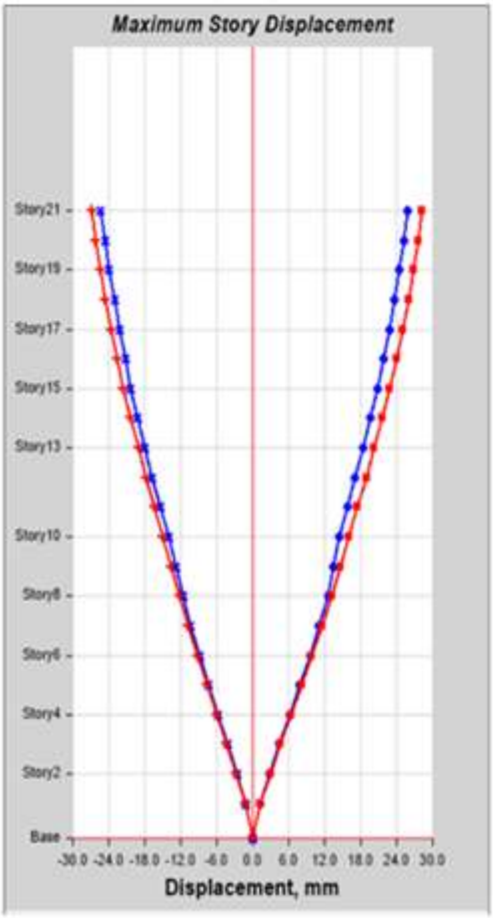

Fig. 5. Combine Displacement

Fig. 6. Maximum Displacement for Structure.

V. OBSERVATIONS AND CONCLUSIONS

A. Observations

1. The Objective of the Project was to check the effect of Storage tank if provided on environmental floor.
2. As per Results, in all three cases the Maximum Displacement was less than 40 mm, which can be considered Negligible.
3. As compared to empty tank, the Max displacement for Partially filled at 50% Level tank without sloshing is 2.38 mm, which is 4.25%
4. As compared to Empty tank case, the Max Displacement for Full filled tank was 5.84 mm, which is 55%.
5. Due to aspect ratio of water tank close to 1, the Time period of Building and time period of Water tank was found to be different. Which Reduced the maximum Resultant Dynamic Forces on the walls, hence the Max Displacement when sloshing considered were Found to be Less.
6. A novel approach was used combining the CFD Software and Structural Analysis Software to Check the Sloshing effect, the Method was found to be effective and the can be used for analysis of sloshing effect on structure.

B. Conclusion

1. For Sloshing case, the Maximum Displacement increased by 4.92 mm to 29.17 mm, which is around 20% , but the Maximum displacement of the Sloshing case is less than Full tank case by 19.7%., hence the Structure can be considered safe with the loading applied on the structure during analysis.
2. The Objective of the Project was to check the effect of Storage tank if provided on environmental floor. aspect ratio close to 1 can be safely Provided in the Structure.
3. Thus, a storage tank and also water tank having an
4. The Difference of time period of water tank and Structure was found to be reducing the effect of sloshing.
5. Hence, the DOSIWAM system can be safely installed on the structure.

VI. FUTURE SCOPE

1. The DOSIWAM System consist of three components as mentioned the theory (The treatment units consist of the Malaprabha digester, the Intercepting tank, the Stabilization tank, and the Storage tank.)
2. Future scope will be to analyse the structure with other components together, and check for Structural Safety of the structure.
3. Further study can be done with irregular building models and varying storey numbers, as well as increasing the capacity of the treatment plant that will be positioned in the buildings. Where the additional load due to water treatment plants is not significant, it will also be beneficial to investigate and reduce the sizes of structural elements.
4. Further, instead of allocating treatment units to environmental floors, the building could have an environmental shaft, which can be made up of stories and can treat wastewater from individual floors. A structural analysis of this shaft could then be performed.

VII. ACKNOWLEDGMENT

We acknowledge that the completion of this Project entitled “Seismic Analysis of Water Tank at Different Storey Height of the building and to check fluid Sloshing Effect”. Was under the continuous guidance Dr. S.S. Angalekar of our department. We would like to thank to Dr. S. S Shastri, Head of Department for providing all the facilities for carrying out the work required for the project. Also, we cannot overlook the fact that, without the support of our Principal Dr. S. D. Lokhande our work would not be accomplished in its perfections.

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