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Structural Analysis of Asymmetrical Multistory Building with Water Tank as a Fluid Viscous Damper

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ABSTRACT:The way things are going in the building industry right now, structures need to be taller, lighter, more flexible, and have a low damping value. This makes it more likely that something will break and also makes it harder to use. There are a number of ways to keep a structure from shaking too much these days. The idea of using TLD is one of the more recent ways to control vibration. In this work, structural models of buildings with G+10, G+20, and G+30 stories are looked at with and without tuned liquid dampers. Structures with and without tuned liquid dampers are studied to see how vulnerable they are in different load conditions. For the analysis, different water depths in seismic region 3 are taken into account. Buildings of different heights are analysed to study how they react to earthquakes with and without tuned liquid dampers. Buildings of different heights are analysed to see what changes will happen if the height of both structural systems changes. So, the way both structural systems react to earthquakes tells us more about how to plan and build these structures in earthquake-prone areas and how to make these structural systems work better when they are under a load from an earthquake. This work is a good source of information about the parameters of lateral displacement, storey drift, and base shear. E-Tabs software is used to do the analysis.

KEYWORDS: Vibration Control, Storey Drift, Base Shear, E-Tabs software.

I.INTRODUCTION

In the past few decades, people have used certain methods to protect buildings from the effects of earthquakes. These methods have been replaced by new, better ones. These are there to get rid of the effects of earthquakes on the structures. There are also other tools, like friction dampers, fluid viscous dampers, viscous elastic dampers, metallic yield dampers, etc., that can protect a building from the effects of these disasters. These tools are used to build structures with different technologies so that earthquakes and the energy released by seismic waves cause the least amount of damage possible. Fluid viscous dampers are one of the tools for the seismic load response that is the most difficult to use.

In recent years, there have been a lot of studies and a lot of money spent to figure out how seismic waves affect buildings. Different dampers have been put in place to reduce earthquake damage. Many more changes have been made in research centres to improve the traditional damper devices that are used to get rid of the energy from these seismic waves. However, there is still a need for more theoretical and experimental research on the effects of earthquakes. Viscous damping is known as a way to get rid of energy and make a building more responsive to a strong earthquake. Earthquakes are put into two groups based on how close they were recorded to the fault: near-field earthquakes and far-field earthquakes. Its definition was changed after more research, and this grouping was also affected by other things. Recent research has focused on how the movement of the ground during an earthquake affects the way a building works. The damage caused by recent earthquakes like the Northridge, Kobe, and Taiwan quakes to the buildings in the cities closest to the fault and in the area around several Indian cities shows how important the research mentioned above is.



In the last few years, the most important changes to seismic codes have been made. Many of the changes in seismic design have come about because people have learned more about how the weakest structures work in modern earthquakes. Retrofitting the building is needed to reduce earthquake risk. This is clear from what we now know about how buildings work.

With the goal of making buildings stronger, people have come up with new and better ways to protect structures from the harmful effects of the energy that comes from seismic waves. By looking at all of these situations, researchers have come up with two very good solutions: power dissipation and seismic isolation. Both of these methods are used to protect the building and meet the requirements of modern codes. Even though there are other codes, the laws about how to protect against energy dissipation when building seismically separated structures still need to be improved.

II.LITERATURE REVIEW

2.1. Author:Liya Mathew and C.Prabha

Title: Fluid Viscous Dampers in Multi-Story Building Effect

Year: 2014

Paper description

This paper talks about how buildings are loaded in different ways. So that buildings don't get damaged by natural disasters like earthquakes, some new and effective ways to protect them are being developed. Here, what's important is the fluid viscous damper (FVD). This paper explains how to find the most dangerous things to add to concrete frames to make them stronger. Using SAP 2000 software, the analysis is done in a square building with four equal sides. Graphics are used to compare the results.

2.2. Author: Sachin Kukian, Mohamed Parvez, Avinash A R and Kiran Kamath

Studying the seismic response of reinforced structures that have been retrofitted using

Shear walls with Fluid Viscous Dampers

Year: 2015

Paper description

This paper is about the study of how earthquake waves move through buildings with more than one floor. It is done with the help of devices in the building's lateral load that resist the building's elements. The study tells us a lot about the fluid viscous damper.

2.3. By Lavanya K. R. and Dr. K. Manjunatha

Title: Comparative Study of Fluid Viscous elastic and viscous elastic Seismic Effects

RC Building Dampers in the Year: 2016

Paper description

Hurricanes, tornadoes, floods, and earthquakes are all some of the most destructive natural disasters. Since then, a series of panic signs have caused them to get hurt and lose money. As earthquakes wake up, they need to be accounted for in the design process. The best analytical methods, such as push over analysis, dynamic analysis, and time history analysis, are used to build structures that can withstand earthquakes. In the essay, the effects of viscous elastic and fluid viscous dampers in the RC Building are compared. Modeling and analysis are done with SAP 2000 software, and the results show the effects of seismic factors like Time Duration, Base Shear, Lateral Displacement, and Inter Story Drift. Then, any building with or without dampers is compared.



2.4. Author: Endow A Mazumder and M.L.V. Prasad

Title: Energy Dissipative Steel Device Using Viscous Damper

Structures Year: 2016

Paper description

This paper tells you about steel structures. By looking at these seismic viscous dampers, a 3D numerical study is done. Things that are happening to steel buildings with five to ten floors. This paper gives information based on different graphs that show how time is not linear and how force and velocity are not linear. In this paper, the facts about the evaluation of inter-story drift, maximum base shear, and maximum roof displacement were mostly talked about. It came to the conclusion that adding more dampers to the structure makes it better at getting rid of energy.

2.5. Author: A. K. Sinha Sharad Singh

Title: Structural Response Control of RCC Moment Resisting Frame Using

Fluid Viscous Dampers

Year: 2017

Paper description

This paper talks about how fluid viscous dampers are used and how well they work to reduce the damping demand on structural systems. In this paper, a 3-direction synthetic accelerometer is used to do an analysis on a 3D model of a 12-story RCC MRF building. ETABS has been used to make building patterns with and without complimentary reduction. Story responses are measured against the full maximal displacement and story shear.

LITERATURE REVIEW OUT COME:

1. The Fluid viscous damper is best considered for water tank model as it can behave similar to fluids.
2. As per Literature survey, the position of the FVD in irregular structure is always remain uncertain.
3. Position of the FVD need to be analyzed using Response spectrum as it provides base reaction which highly depends upon damper motion.
4. The Values for fluid viscous damper is derived from Taylor chart which is perfectly researched chart and provides proper insight study

III.METHODOLOGY

3.1. Gravity analysis

Loads in constructive building design are taken in to dead loads, live load. Earthquake load etc was applied.

Dead load

In the design of building the dead weight is assumed and it is given in the form of unit weight of material. The unit weight of other materials that can be stored in buildings is also considered for loading calculation. Dead loads are considered to be part of IS875 Part1.

Live load

In the design of buildings the live load is considered. It contributes to physical contribution due to individuals, furniture load and other equipment. This load consists of movable sections, distribution focused loads, impact and vibration loads, but excluding air, earthquake, snow loads and other loads. Live Loads IS875 Part2.

Load combination

When a structure is under earthquake forces the following combinations are considered as per limit state design of reinforced concrete structures.

As per IS 1893- 2002

1. $1.5(DL \pm IL)$
2. $DL + IL + EL = 1.2$
3. $1.5(DL \pm EL)$
4. $0.9DL \pm 1.5LL$

The response amount owing to dead load, imposed load, and intended seismic load are denoted by the terms DL, LL, and EL, respectively.

3.2. Earthquake analysis

- Linear static analysis (Equivalent static lateral force method)
- Linear dynamic analysis (Response spectrum method)
- Non-linear static analysis (Push over analysis)
- Non-linear dynamic analysis (Time history analysis)

3.2.1. Linear static analysis

Usually this is the result of the dynamic phenomenon of the structure that undergoes an earthquake. This dynamic analysis is not often used as it is complex and time-consuming method in daily design. Most structures undergoing seismic forces are designed with the idea that the building is strained in to the elastic range.

In this method the concept which is applied is that the static load which are on the structures with the direction and magnitude are nearly equal to the dynamic loading happened due to the earthquake. At the ceiling roof levels and floors the concentrated lateral forces will be acting due to the dynamic loading where there is a high mass concentration in the building.

3.2.2. Linear dynamic analysis

Static procedure is used only for short building; hence for tall structures having non-orthogonal or torsional irregularity the dynamic method of analysis is preferred. The concept of structure is one of several degrees of freedom.

By using either time history analysis or spectral analysis the seismic input is modeled, but in both cases by using linear elastic analysis the corresponding displacement and internal forces are determined. As compared to that of linear static procedure of analysis high modes can be used in case of linear dynamic analysis procedure.



Response spectrum analysis

This method makes use of damping level and time history to measure pseudo spectral acceleration, displacement or velocity to provide dynamic behavior of a structure. For each structural period experienced by the structure there is a smooth curve on that gives peak response in a response spectra for the dynamic response this method is related with the type of the structure selection this method is use full for the decision making for the design of a particular structure.

This method requires many building codes except for simple structure or complex structure. In a simple way a structure's response is defined as the combination of some modes in a string that vibrates to the associated harmonics. Computer software can thus be used to determine these approaches for a particular organization.

Responses are based on the modal mass and frequency as read from each mode's design spectrum. Thus, the effect on the structure should be studied in the x, y, and z directions. The combination method include followings,

- Adding together the absolute-peak values
- Square root of the squares' total sum
- Combination of complete quadratic.

This method is not suitable for a creation of airregular structure or tall formation or a great deal of community, so such cases cannot be a good method of analysis of such analysis.

3.2.3. Non-linear static analysis

This technique is sometimes called pushover analysis. It defines the capacity curve. It includes the pattern of forces. These forces are applied to the structure comprising of properties which are non linear in nature. Then the total applied forces are plotted against a reference displacement. This problem simplified to a system with a single degree of freedom since this curve can be merged with the demand curve. The process used in this method uses a single degree of freedom model. And with the response spectra it represents seismic ground motion.

3.2.4. Non-linear dynamic analysis

This method is a combination of structure and ground motion details and so that this method affects the less uncertainty. In this way of analysis, some of the majority of the analysis requires some codes for the generalization of the ground motion. To achieve structural response several different Records of ground motion are required.

The ground motion depends on the sensitivity for the earthquake reaction. Is required to consist of the evaluation of the ground motion, requires non-linear dynamic analysis to achieve a different possible situation of the earthquake. All of these factors lead the emergence of the rich dynamic analysis. **3.3.**

Building plan and layout

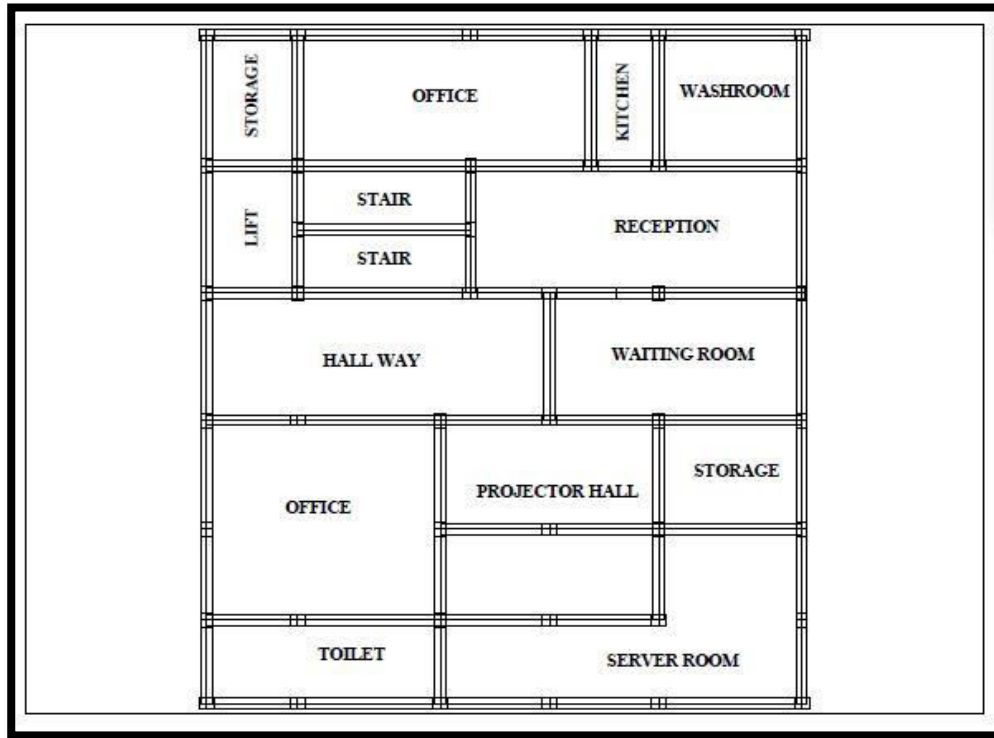


Figure 3.1: Plan of building

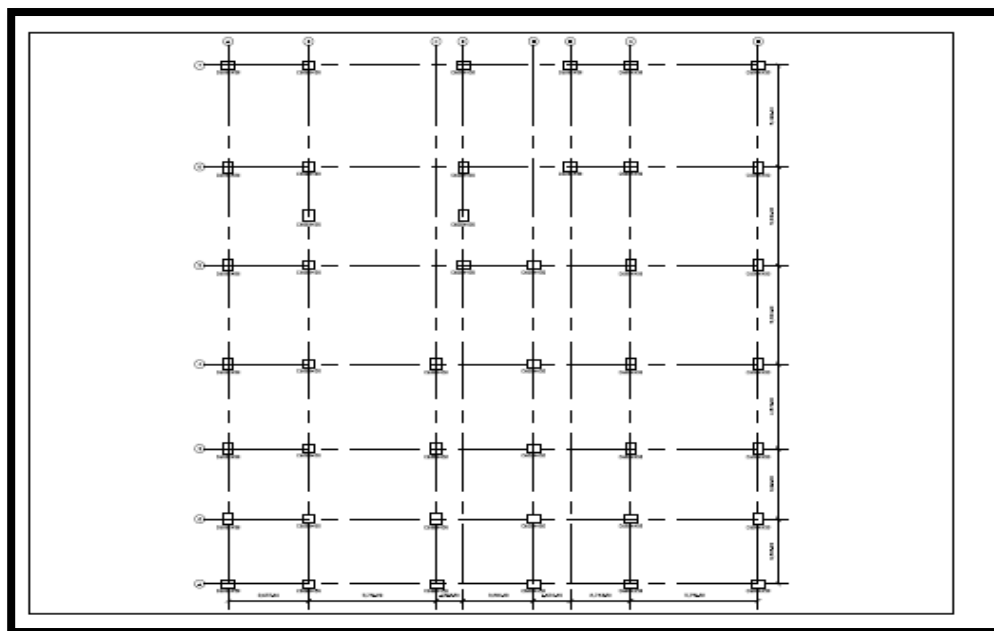


Figure 3.2: Beam Column layout



3.4. Building Description

The building used in this study is Eight storied. All building models have same floor plan.

The information used in the analysis is as follows:

Grade of concrete	: M35
Grade of steel	: Fe550
Beam	: 600×450mm
Column	: 600×450mm
One way slab	: 200mm
Story Height	: 3m

This paper looked at the best way to design fluid viscous dampers for a strong three-story concrete building based on how well they work (with regard to structural and excitation uncertainty). The cost over the whole life was chosen as the performance goal. The proposed method is based on a probabilistic framework that directly handles all sources of uncertainty related to either future excitations or the configuration of the structure by using the right probability models. In this case, the predicted life-cycle cost is defined by a multi-dimensional integral, and stochastic simulation is recommended for figuring out how much it will cost. Even though this method is reliable, it makes it hard to optimise the design because it puts a lot of computational stress on the system. This stress is lessened by using a good algorithm from the larger family of Costly Global Optimization (CGO) search strategies. An example was given that looked at the best way to design nonlinear fluid viscous dampers to keep the expected life-cycle cost of a three-story concrete building as low as possible. It was shown that adding the dampers improved the structure's performance by lowering its life-cycle cost.

3.5. Earthquake loads

Seismic design shall be done in accordance with IS: 1893:2002.

The structure is located in an earthquake zone.

The following parameters should be considered for analysis and design
(As per IS: 1893: 2002 (Part I).

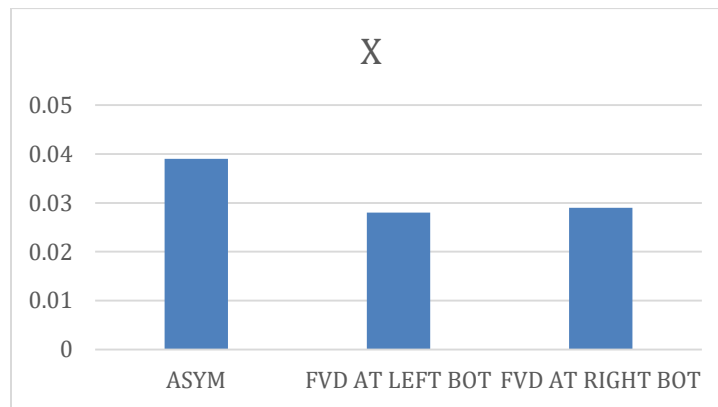
Zone factor	: 0.24 (Refer Table 2)
Importance factor	: 1.5 (Refer Table 6)
Response-reduction factor	: 3.0 (Refer Table 7)
Soil Type	: Medium
Structure type	: RC Frame Structure is the appropriate type.



IV. RESULTS AND DISCUSSION

**X DIRECTION
DISPLACEMENT**

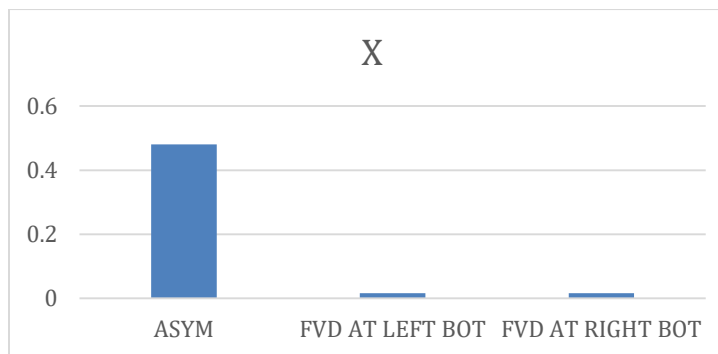
MODEL	X
ASYM	0.039
FVD AT LEFT BOT	0.028
FVD AT RIGHT BOT	0.029



In asymmetrical Model in X direction in Displacement Results the position for the water tank at Left Bottom Corner provides Better Reduction in Displacement when compared with all other positions during the Project Trials. Both the Positions are good either Left Bottom or Right Bottom with slightly differ in Values

SHEAR

MODEL	X
ASYM	0.4804
FVD AT LEFT BOT	0.0166
FVD AT RIGHT BOT	0.0166

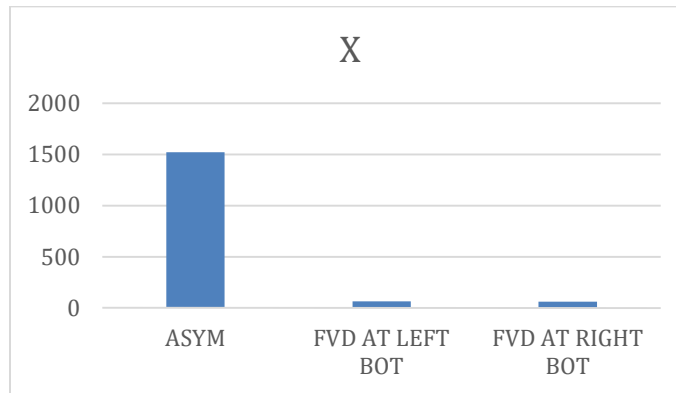




In asymmetrical Model in X direction in Shear Results the position for the water tank at Left Bottom and also at Right Corner provides Better Reduction in shear when compared with all other positions during the Project Trials. Both the Positions are good either Left Bottom or Right Bottom.

AUTO LATERAL

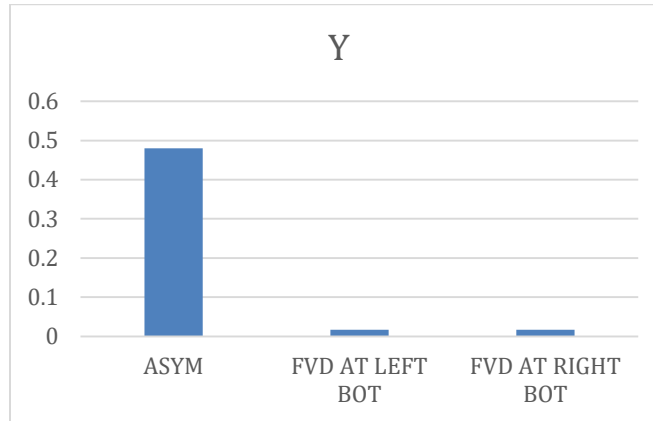
MODEL	X
ASYM	1521.9503
FVD AT LEFT BOT	62.6243
FVD AT RIGHT BOT	62.3989



In asymmetrical Model in X direction in Auto lateral Loads Results the position for the water tank at Left Bottom and also at Right Corner provides Better Reduction in Auto lateral when compared with all other positions during the Project Trials. Both the Positions are good either Left Bottom or Right Bottom.

**Y DIRECTION
DISPLACEMENT**

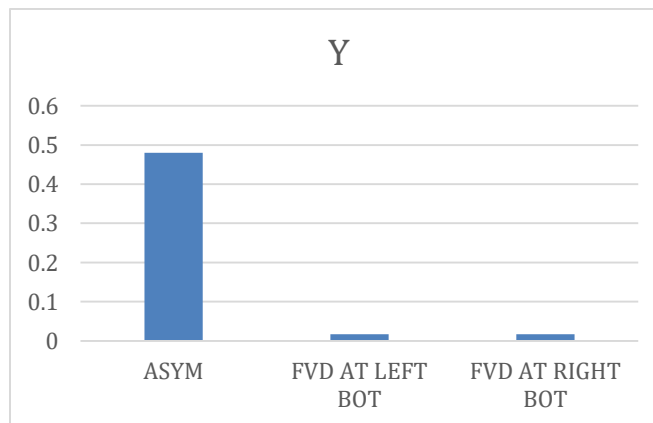
MODEL	Y
ASYM	0.035
FVD AT LEFT BOT	0.015
FVD AT RIGHT BOT	0.024



In asymmetrical Model in Y direction in Displacement Results the position for the water tank at Left Bottom Corner provides Better Reduction in Displacement when compared with all other positions during the Project Trials. Both the Positions are good either Left Bottom or Right Bottom with slightly differ in Values

SHEAR

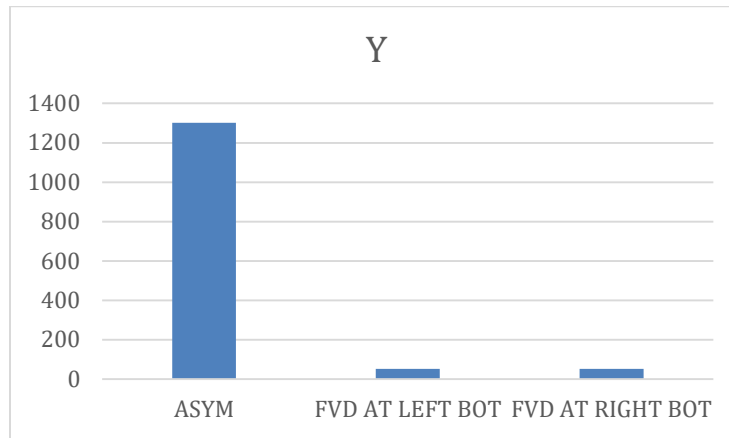
MODEL	Y
ASYM	0.4804
FVD AT LEFT BOT	0.0166
FVD AT RIGHT BOT	0.0166



In asymmetrical Model in Y direction in Shear Results the position for the water tank at Left Bottom and also at Right Corner provides Better Reduction in shear when compared with all other positions during the Project Trials. Both the Positions are good either Left Bottom or Right Bottom.

AUTOLATERAL

MODEL	Y
ASYM	1302.4335
FVD AT LEFT BOT	53.2479
FVD AT RIGHT BOT	52.8351



In asymmetrical Model in Y direction in Auto lateral Loads Results the position for the water tank at Left Bottom and also at Right Corner provides Better Reduction in Auto lateral when compared with all other positions during the Project Trials.

The Positions are good at Right Bottom.

V. CONCLUSION

1. In asymmetrical Model in X direction in Displacement Results the position for the water tank at Left Bottom Corner provides Better Reduction in Displacement.
2. In asymmetrical Model in Y direction in Displacement Results the position for the water tank at Left Bottom Corner provides Better Reduction in Displacement.
3. In asymmetrical Model in X direction in Shear Results the position for the water tank at Left Bottom and also at Right Corner provides Better Reduction in shear.
4. In asymmetrical Model in Y direction in Shear Results the position for the water tank at Left Bottom and also at Right Corner provides Better Reduction in shear.
5. In asymmetrical Model in X direction in Auto lateral Loads Results the position for the water tank at Left Bottom and also at Right Corner provides Better Reduction in Auto lateral
6. In asymmetrical Model in Y direction in Auto lateral Loads Results the position for the water tank at Left Bottom and also at Right Corner provides Better Reduction in Auto lateral.
7. Finally we can conclude that the Position at Right Bottom or Left Bottom Shows an Better Reduction of Forces when compared to other Positions considered in The project Trials.

VI. FUTUREWORK

1. This work presents an engineering technique for calculating viscous fluid damping in liquid storage tanks.
2. The free liquid surface's sloshing motion was subjected to this technique.



3. The geometry of the shell and the fluid's viscosity were used to derive the damping ratios for the convective component.
4. It is possible to distinguish between and study the damping contribution from the tank bottom and tank wall.
5. The following conclusions can be drawn regarding the convective component's dampening effects. Although the structural dampening of the tank shell dominates the impulsive component, the approach might be applied to the impulsive pressure component as well.
6. A simple method for calculating the damping ratios is proposed, and it appears to work for seismic codes. It uses normalised damping coefficients.
7. It would be fascinating to compare the projected damping ratios with experimental findings and those of more complex numerical computations, and it might even form part of future research.

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