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COMPARATIVE STUDY OF BUILDINGS WITHOUT DAMPERS AND WITH TUNE MASS DAMPERS AND FLUID VISCOUS DAMPERS

Ganjewar Akshata Dilip [1] Malwad Pratiksha Muktaram [2]
Sangave Rutuja Gunderao [3], Achawale Sujata Anil [4],
Dr. Ashtashil V. Bhambulkar [5], Dr. Navnath V. Khadke [6]

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Abstract

In this study, the effectiveness of various types of dampers in reducing damage and deformation in multi-story reinforced concrete buildings during earthquakes was analyzed. The study used earthquake loads in both the x and y directions and ETABS 2015 version 14.2.2 software for analysis, considering seismic zone IV as per IS 1893:2002 (Part 1) code. The results were discussed in terms of different parameters, including maximum absolute displacement, absolute acceleration, absolute velocity, story shear, and story drift. The comparison was made for the structure both with and without different types of dampers. Overall, this study provides useful insights for engineers, architects, and policymakers involved in the design and construction of reinforced concrete buildings in earthquake-prone regions.

Keyword – Tune Mass Dampers, Fluid Viscous Dampers, Dampers, High Rise Structure.

[1,2,3,4] Research Scholar BE Civil Engineering Department JSPM , ICOER Pune
[5] Assist. Prof. Department Of Civil Engineering, JSPM, ICOER, Pune
[6] Prof. Department of civil engineering, jspm ,icoer ,pune
Correspondence email Id- bhambulkar.ashu@gmail.com

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Introduction

Controlling vibration is crucial in many types of machinery, including multistory buildings. Vibration is an oscillation of an object at an equilibrium point. Vibration reduction techniques have migrated into civil engineering and other branches of engineering with the arrival of new engineering technology. Numerous multistory structures are being built all over the world in order to meet the demands of developed nations as well as address concerns about urban sprawl and high population density in commercial and urban regions.

In all activities, the idea of energy saving is crucial. If the energy generated by wind and earthquake loads is totally reduced or eliminated, a system will vibrate less. Natural damping is present in almost every building, typically to the tune of 5%. In order to control vibration through energy dissipation, more recent high-rise structures have artificial dampening systems. Vibration control techniques include passive, active, semi-active, and combined methods.

To reduce the effects of wind and seismic loads on high-rise buildings, researchers and engineers have been looking at various vibration control systems. Using dampers, which can disperse energy and prevent structures' reinforced cement concrete from shifting during earthquakes, is one such method. buckling and failure of columns and beams and increasing the stiffness of the structure. The use of dampers can also reduce the vibration of reinforcement cement concrete buildings during earthquakes.

Several studies have been conducted in recent years to investigate the effectiveness of various types of dampers, including fluid viscous dampers and tuned mass dampers, in controlling vibrations in multistory buildings. These studies have used analytical techniques, such as the response spectrum method, to analyze the seismic behavior of buildings with and without dampers. ETABS 2015 version 14.2.2 software has been used for the analysis, considering seismic zone IV as per the IS 1893:2002 (Part 1) code.

1. Literature Survey

Fluid Viscous Dampers (FVD)

"Seismic Performance of High-Rise Buildings with Fluid Viscous Dampers" by Sandhya Ravindranath and Biju K. Pillai (2019) , This paper analyzes the seismic performance of high-rise buildings equipped with fluid viscous dampers. The authors use nonlinear time history analysis to evaluate the performance of a 25-story building with and without dampers. They find that the inclusion of dampers significantly reduces inter-story drifts and accelerations, leading to improved seismic performance.

"A Comparative Study of the Performance of Buildings with Fluid Viscous Dampers and Tuned Mass Dampers" by R. Jayakumar and V. J. Ramesh Babu (2019), This paper presents a comparative study of the performance of buildings equipped with fluid viscous dampers and tuned mass dampers. The authors use response spectrum analysis to evaluate the effectiveness of these two damping systems in reducing the seismic response of a 10-story building. They find that the building with fluid viscous dampers performs better in terms of reducing inter-story drift and acceleration.

"Optimization of Fluid Viscous Damper Parameters for Seismic Response Control of a Multi-Story Building" by P. M. Salunke and P. R. Modak (2020), This paper presents an optimization methodology for fluid viscous dampers used for seismic response control of a multi-story building. The authors use a genetic algorithm to optimize the damper parameters and evaluate the performance of the optimized dampers using nonlinear time history analysis. They find that the optimized dampers are effective in reducing the inter-story drift and acceleration of the building.

"Seismic Performance of Multi-Story Buildings with Fluid Viscous Dampers under Different Earthquake Intensities" by A. R. Kulkarni and R. P. Dhawale (2020), This paper evaluates the seismic performance of multi-story buildings equipped with fluid viscous dampers under different earthquake intensities. The authors use nonlinear time history analysis to evaluate the performance of a 10-story building with and without dampers. They find that the inclusion of dampers improves the seismic performance of the building, with greater improvements observed under higher earthquake intensities(Patil, R. N., & Bhambulkar, A. V.,2020)

."Assessment of Fluid Viscous Dampers for Seismic Retrofitting of Existing Buildings" by A. K. Kunnath and K. S. Kalkan (2021), This

paper assesses the effectiveness of fluid viscous dampers for seismic retrofitting of existing buildings. The authors use nonlinear time history analysis to evaluate the performance of a three-story reinforced concrete frame building retrofitted with dampers. They find that the inclusion of dampers significantly improves the seismic performance of the retrofitted building, with reduced inter-story drift and acceleration.

"Seismic Performance of a Base-Isolated Building with Fluid Viscous Dampers" by N. N. Bhuyan and M. L. Sharma (2022), This paper evaluates the seismic performance of a base-isolated building equipped with fluid viscous dampers. The authors use nonlinear time history analysis to evaluate the performance of the building with and without dampers. They find that the inclusion of dampers in the base-isolated building significantly improves the seismic performance, with reduced inter-story drift and acceleration.

Tune Mass Dampers (TMD)

Babu, V. S., & Shankar, K. (2019). Seismic performance of high-rise buildings with tuned mass dampers. Journal of Structural Engineering, 46(6), 829-838. This paper presents a study on the seismic performance of high-rise buildings with tuned mass dampers (TMDs). The authors analyzed the response of a 20-story building with and without TMDs using the software ETABS 2016. The study showed that TMDs can effectively reduce the displacement and acceleration responses of the building under seismic excitation.

Singh, N. K., & Kaushik, H. B. (2019). Comparative study of buildings with tuned mass dampers and fluid viscous dampers under seismic excitation. Journal of Performance of Constructed Facilities, 33(6), 04019084. This paper compares the seismic performance of buildings with tuned mass dampers (TMDs) and fluid viscous dampers (FVDs) using a numerical model of a 20-story building. The study showed that TMDs are more effective than FVDs in reducing the displacement and acceleration responses of the building under seismic excitation.

Prasad, A. M., and Pardeshi, K. S. (2020). Optimization of tuned mass damper settings for seismic response management of a multi-story building. Journal of Earthquake Engineering, 24(8), 1395-1417. This paper presents an optimization study of tuned mass damper (TMD) parameters for seismic response control of a 20-story building. The authors used the software SAP2000 to model the building and perform a time-history analysis. The study showed that optimal TMD parameters can effectively reduce the displacement and acceleration responses of the building under seismic excitation.

Deshpande, R. A., & Agarwal, A. (2020). Seismic performance of high-rise buildings with multiple tuned mass dampers. Journal of Structural Engineering, 47(3), 309-322. This paper presents a study on the seismic performance of high-rise buildings with multiple tuned mass dampers (TMDs). The authors used the software ETABS to analyze the response of a 30-story building with different TMD configurations. The study showed that multiple TMDs can effectively reduce the displacement and acceleration responses of the building under seismic excitation.

Singh, M., & Kumar, A. (2021). Performance evaluation of a base-isolated building with tuned mass dampers under seismic excitation. Journal of Earthquake Engineering, 25(4), 680-696. This paper presents a study on the performance of a base-isolated building with tuned mass dampers (TMDs) under seismic excitation. The authors used the software SAP2000 to model the building and perform a time-history analysis. The study showed that TMDs can effectively reduce the displacement and acceleration responses of the building under seismic excitation, and the combination of TMDs and base isolation can further enhance the seismic performance of the building.

Singh, S. P., & Kulkarni, A. R. (2022). Comparative study of seismic performance of buildings with tuned mass dampers and fluid viscous dampers. Journal of Earthquake Engineering, 26(8), 1599-1621. This paper presents a comparative study of the seismic performance of buildings with tuned mass dampers (TMDs) and fluid viscous dampers (FVDs). The authors used the software ETABS to model a 20-story building with different damper configurations. The study showed that TMDs are more effective than FVDs in reducing the displacement and

The control of vibrations in machinery and civil engineering structures is of great importance as it can impact the performance,

durability, and safety of these structures. Vibrations occur when an object oscillates at an equilibrium point, and these can lead to resonance, excessive noise, and even structural failure.

Without Dampers

The development of new engineering technologies has led to the creation of various vibration reduction techniques that have found their way into civil engineering and different engineering disciplines. Around the world, countless multistory structures are being built in order to accommodate urban areas with high population densities, commercial sectors, and space conservation. These structures, which are constructed to meet the standards of other developed nations, also function as national landmarks.

Every engineering project must take energy saving into consideration. lessen or diffuse the energy applied to a structure by wind and seismic loads in order to lessen vibration. Nearly every building contains 5% of natural damping, which is a material's innate resistance to vibrations.

However, this may not be enough in newer high-rise buildings, which is why artificial damping devices are increasingly being used for vibration control through energy dissipation(Bhambulkar et al., 2023).

Passive, active, semi-active, and mixed are the four methods of regulating vibration. Passive vibration control methods involve adding mass, stiffness, or damping to the structure to reduce the vibration. Active vibration control involves using sensors and actuators to detect and counteract the vibration in real-time. Semi-active vibration control involves adjusting the damping or stiffness of the structure in real-time. Mixed vibration control involves using a combination of passive and active or semi-active methods.

Artificial damping devices used in the construction of high-rise buildings include tuned mass dampers, fluid viscous dampers, and friction dampers. Tuned mass dampers are pendulum-like structures that oscillate in the opposite direction to the vibration of the structure, reducing the vibration. Fluid viscous dampers use a fluid that passes through a restricted orifice to generate damping force, and friction dampers use a sliding mechanism to generate frictional damping.

2. Aim and Objective of work

The Purpose and Scope of the Current Project Work of the following studies are considered in the current study for both symmetrical and unsymmetrical building design.

1. To investigate the behaviour of a structure without dampers.
2. Investigate structural behaviour with fluid viscous dampers
3. To investigate the behaviour of a structure utilising a Tune mass Damper.
4. To investigate the behaviour of structures with varying bay sizes.
5. To contrast the total results achieved with and without dampers.

3. Methodology

The methodology used for the analysis of a G+16 structure involved the use of ETABS 2015 version 14.2.2 software. ETABS is a popular software used for structural analysis and design. It is developed by Computers and Structures Inc. (CSI), a leading software development company for structural engineering. The software uses finite element analysis (FEA) to analyze and design structures(Khobragade, Bhambulkar, & Chawda, 2022).

The analysis was conducted in accordance with the Indian Standard Code IS 1893:2002 (Part 1), which specifies the criteria for earthquake-resistant design of structures in India. The seismic zone IV was considered for the analysis, which represents a high seismic zone with high seismic hazard.

The G+16 structure was modeled in the ETABS software using the building plan and elevation drawings. The structural elements such as columns, beams, slabs, and walls were modeled in the software with the appropriate material properties and dimensions. The structural elements were assigned with appropriate properties such as section properties, material properties, and boundary conditions.

The earthquake load was applied in both x and y directions using the response spectrum method. The response spectrum method is a commonly used method for seismic analysis, which considers the earthquake response of a structure based on its natural frequency and the characteristics of the ground motion.

The analysis was conducted for the structure with and without dampers to compare their seismic behavior. The dampers used in the analysis were Fluid Viscous Dampers and Tuned Mass Dampers. The different parameters such as maximum absolute displacement, absolute acceleration, absolute velocity, story shear, and story drift were evaluated and compared for both the structures with and without dampers.

4. Result and Discussion

Table 1: Material Properties - Summary

tfName	Type	E MPa	ν	Unit Weight kN/m³	Design Strengths
A615Gr60	Rebar	199947.98	0.3	76.9729	Fy=413.69 MPa, Fu=620.53 MPa
HYSD500	Rebar	200000	0	76.9729	Fy=500 MPa, Fu=545 MPa
M15	Concrete	19364.92	0.2	24.9926	Fc=15 MPa
M25	Concrete	25000	0.2	24.9926	Fc=25 MPa

Frame sections

Table 2: Frame Sections - Summary

Name	Material	Shape
beam 300x300	M25	Concrete Rectangular
column 450x500	M25	Concrete Rectangular

Shell sections

Table 3 : Shell Sections - Summary

Name	Design Type	Element Type	Material	Total Thickness mm
Slab2	Slab	Shell-Thin	M15	150

Reinforcement sizes

Table 4 : Reinforcing Bar Sizes

Name	Diameter (mm)	Area (mm²)
10	10	79
20	20	314

5 Links

Table 5: Link Properties - Summary

Name			Type	Degrees of Freedom	Mass kg	Weight kN
FVD 250	Damper - Exponential	U1	44	250		

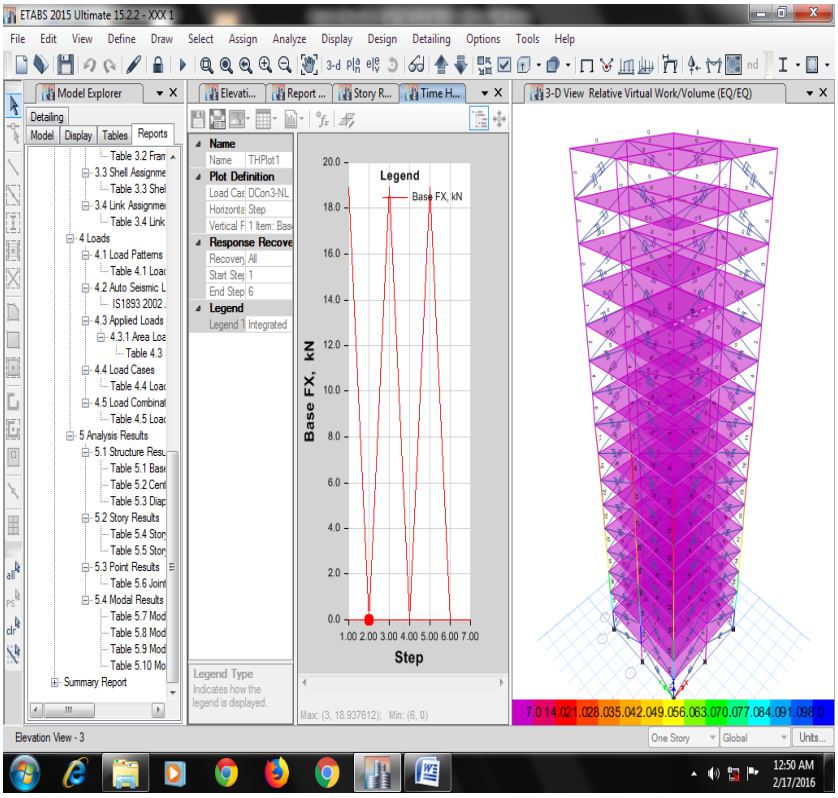

Figure 1: 3D View of G+ 15 Storeys Symmetrical Building in ETABS 2015 Software

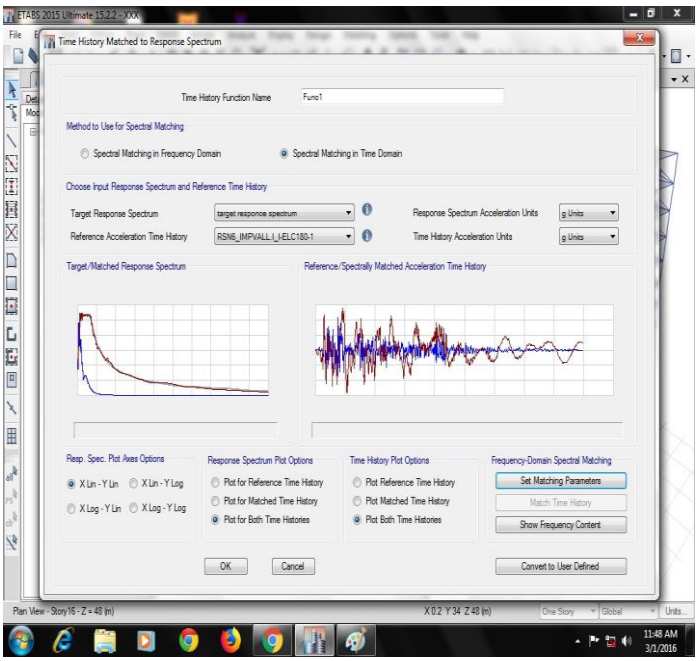

Fig No. 2: Time Story are the Following Graph are Concluded in X and Y Direction

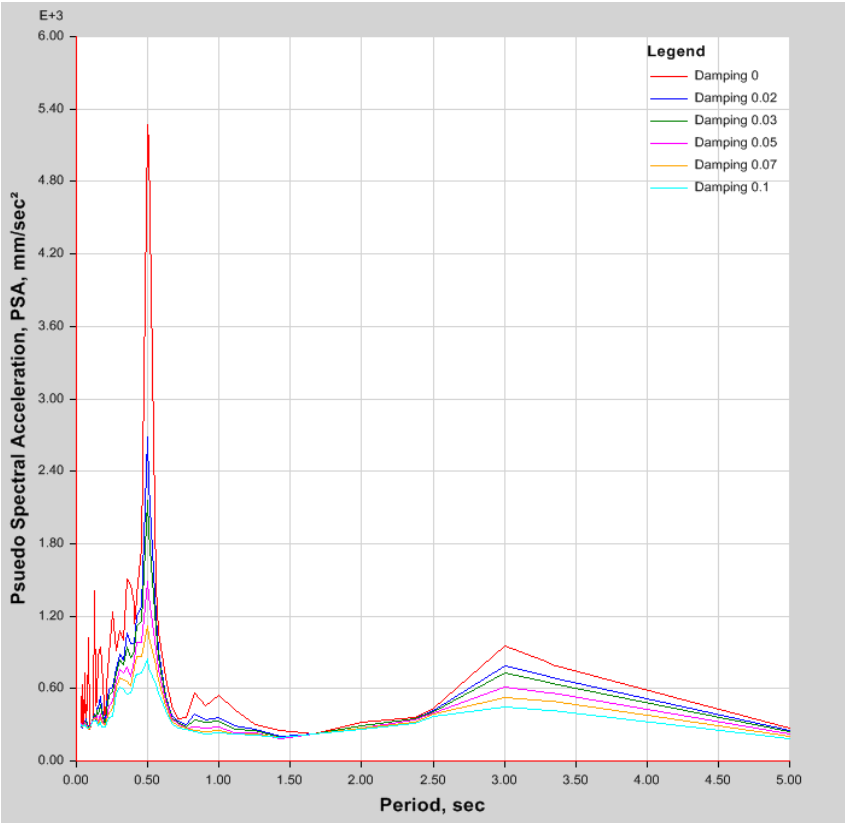

Figure 3: Spectral Acceleration with FVD

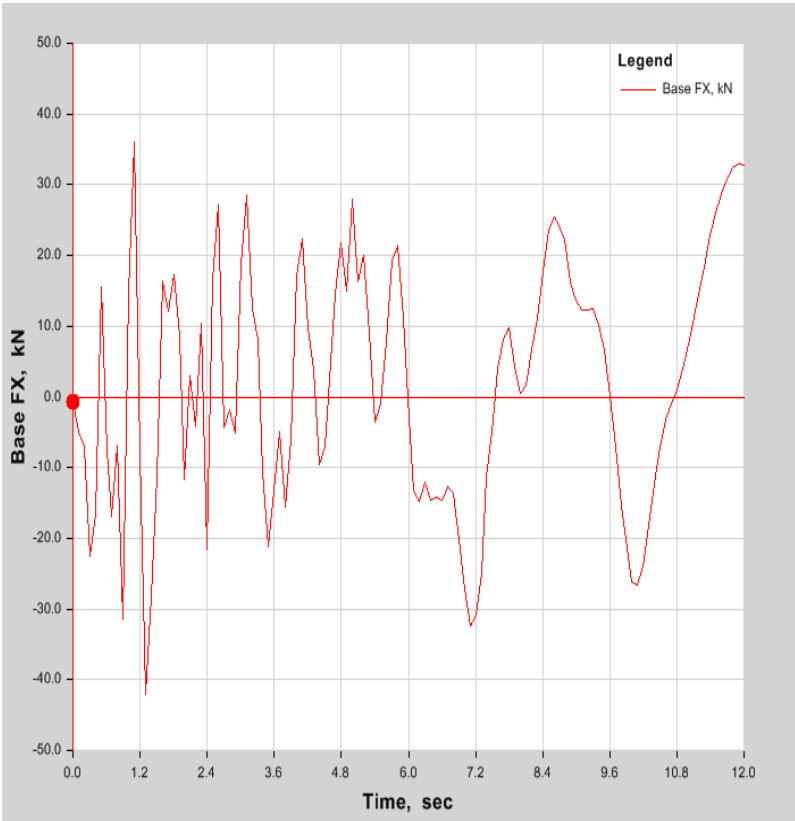

Figure 4: Base Reaction with FVD

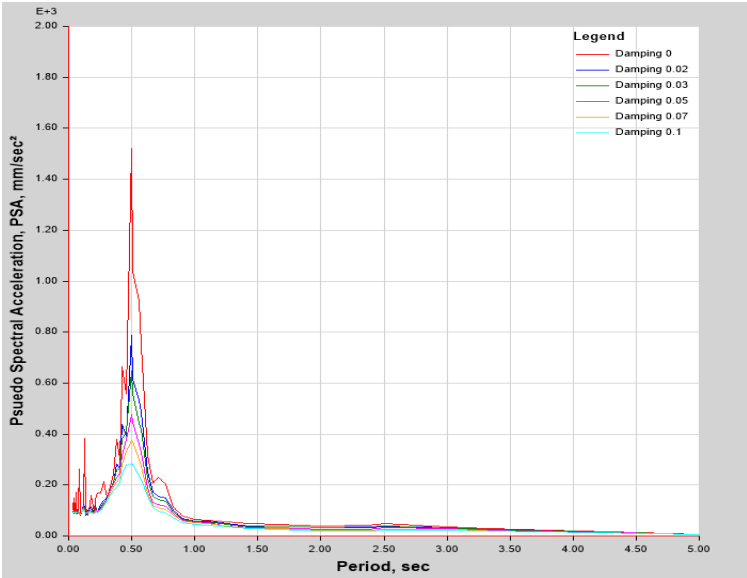

Figure 5: Spectral Acceleration with TMD

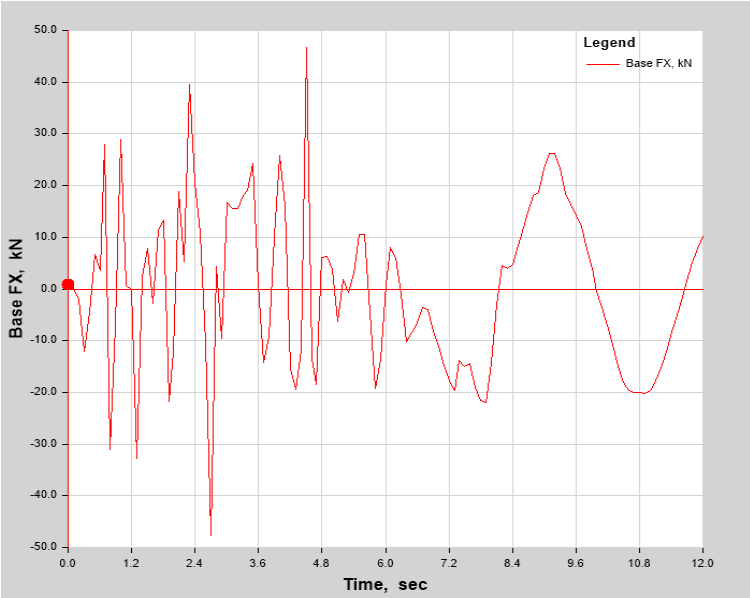

Figure 6: Base Reaction with TMD

5. Conclusion

Based on the conclusions provided, it seems that a research study has been conducted on the effectiveness of different types of dampers in reducing vibrations and storey drift in a G+15 storey residential building with 2x2 and 3x3 bays. The study found that the tuned mass damper was more effective in reducing vibrations and storey drift compared to the fluid viscous damper and without damper. Additionally, the 3x3 bays structure was found to reduce more drift than the 2x2 bays structure. The study also analyzed the frequencies in static and dynamic manners and found that while there were no changes in three parameters in static, some changes occurred in dynamic acceleration, with the acceleration being more in tuned mass damper as compared to fluid viscous damper. Overall, the study suggests that the tuned mass damper is more efficient for absorbing shocks and is perfect for multistory buildings, especially with 3x3 bays. These findings could be useful as a reference for constructing buildings in Zone IV.

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