"Dynamic Analysis of G + 20 Multi Storied Building by Using Shear Walls and Tune Mass Damper for Different Seismic Zones by Using ETABS"

Mr. Devendra Kumar Sahu[1] Mr. Bhavesh Kumar Jha[2]
[1]M.Tech. Student [2]Assistant Professor
[1,2]Department of (Structural) Civil Engineering
[1,2]GEC Jagdalpur, Chhattisgarh, India

Abstract— Structural engineers are primarily concerned with deciding how a structure behaves when exposed to horizontal forces. High-rise buildings must be rigid enough to withstand horizontal forces induced by winds and earthquakes. Shear walls are used to confront horizontal forces and to contribute more stiffness to the structure. A tuned mass damper is a device that is attached to a structure and consists of a mass, a spring, and a damper to lessen the structure's dynamic response. Response Spectrum Analysis is to investigate the use of Shear walls at various locations and tuned mass damper in a G+20 multi-story residential house. In this paper, base shear and maximum permissible displacement are investigated in a multi-story building with G+20. In India, seismic zones prescribed by IS 1893 (Part-1) 2016, the analysis and modelling for the entire structure is done using Etabs 2018, a common FEM integrated programme. In this project, a dynamic analysis is performed on type II (medium soil) for an unsymmetrical structure plan in four zones and it is result that the structure with shear walls and tuned mass damper (i.e., model 3) will display better results in terms of all seismic parameters when compared to the structures without shear wall (i.e. model 1) and with shear wall (i.e. model 2).

Keywords: High rise Building, Bare Frame, Shear Wall, Tune Mass Damper, ETABS

I. INTRODUCTION

In 21st century the demand of building constructions in increasing day by day because of rapid growth industrialization and population explosion, which is inviting the engineers to study, innovate and design new type of structure, which is extreme challenge for them especially in seismic zone. These natural disasters will have a huge effect on society, and will be incredibly difficult to cope with. So, in order to deal with this, engineers must construct seismic-resistant structures in this zone that will counteract the seismic force and mitigate its impact to the greatest extent possible. As we all know, no structure can be made fully earthquake resistant, but by building it, the strength of seismic forces can be minimised, causing less damage to humanity. High-rise buildings, also known as skyscrapers, are in high demand these days due to their many benefits, including the ability to maximise space while occupying a small footprint. They are also very attractive. These structures are extremely difficult to design, and engineers must conquer many obstacles in order to construct them. There are several criteria taken into consideration when designing it, but the focus of this project is on using a shear wall with damper to design a 21th storey building and comparing it to a regular building of the same storey with a shear wall without damper and with shear wall and damper. The following structure feature was used in the building design, which will be discussed in more detail later. The following component used in this project are

- Shear wall
- Tune mass damper

A. *Objectives of Study*

The work has been undertaken with the following objectives:

1) In ETABS, a 21-story building was modelled and evaluated for earthquake load.
2) To determine how a structure with a shear wall would behave.
3) Analysis of structure with shear wall and tune mass damper.
4) Comparative study has been done on storey displacement, fundamental natural period, frequency, storey drift and base shear for the above three cases for different seismic zone.

B. *Shear wall*

Since they give high resistance or counter the earthquake load, it is a very important structural feature used or integrated in multistory buildings in seismic prone zones. Since high-rise buildings are vulnerable to wind and earthquake loads, shear walls are used to mitigate this impact. They're also made to withstand lateral and gravity loads. Shear walls are symmetrically positioned in buildings to counteract the effects of twist. It can be mounted both inside and outside of the building, but it is more successful when placed along the building's perimeter. The following are the different forms of shear walls:

- Reinforce concrete shear wall
- Steel shear wall
- Concrete block shear wall
- Plywood shear wall
- Mid-Ply shear wall.

C. *Tune Mass Damper*

A tuned mass damper (TMD) is a passive control system that is attached to a structure and comprises of a mass, a spring, and a damper to reduce the dynamic response of the structure. The inertia force of the damper acts on the structure and dissipates steam. It's been widely employed in mechanical engineering systems to manage vibration. Several theories have recently been suggested to minimise vibration in civil engineering constructions due to the fast and simple process. The natural frequency of the secondary mass damper is frequently matched to that of the primary structure to obtain optimal response. The TMD will resonate out of phase with the structural motion when that frequency of the structure is activated. The extra energy in the structure is transformed to secondary mass and released subsequently as a result of relative motion created between them.

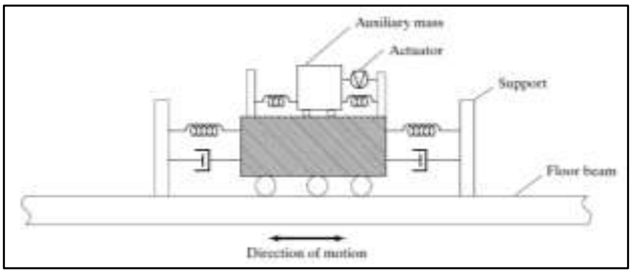
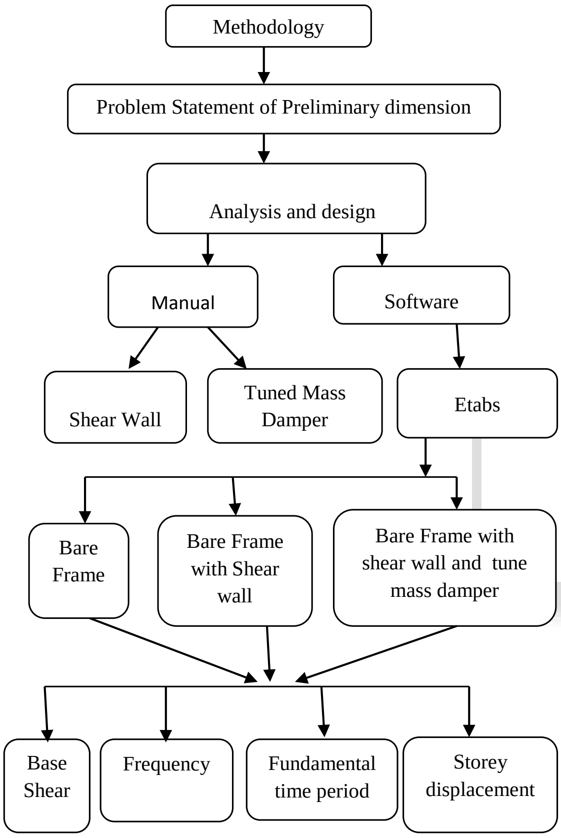


Fig. 1.0: An active tuned mass damper configuration

II. METHODOLOGY



A. *Methods of Analysis:*

1) There are a variety of research methods available, each with varying degrees of accuracy. The type of externally applied loads, the behaviour of the structure or structural materials, and the type of structural model utilised can all be used to categorise the study process. External action and structure behaviour might be used to further categorise the research.
2) Linear static analysis
   – Equivalent static method
3) Linear dynamic analysis
   – Response spectrum method
   – Elastic time history method
4) Nonlinear static analysis
   – Push over analysis
5) Nonlinear dynamic analysis
   – Inelastic time history method

Only normal structures with small height can be subjected to linear static analysis. Answer spectrum analysis and elastic time history analysis are two methods for performing linear dynamic analysis. This research would better yield higher modes of vibration and real force distributions in the elastic range. In the sense that it allows for inelastic behaviour of the system, nonlinear static analysis is superior to linear static or dynamic analysis. The only method for describing the actual behaviour of a structure during an earthquake is inelastic time history analysis.

III. BUILDING PROPERTIES &SPECIFICATION

S.NO.	Specification		Size
1	Plan size (X x Y)		12.07m x 10.11m,
2	Floor to floor height (m)		3.0m
3	Total height of the building (G+20)		63.0m
4	Soil type		Medium
5	Size of beam		0.3m x 0.5m
6	Size of column		0.5m x 0.6m
7	Wall thickness		0.2m
8	Thickness of slab		0.150m
9	Grade of concrete and steel		M25,Fe500
10	Types of soil(as per IS1893(part 1): 2002		Type II Medium rocky soil
11	Response Reduction Factor (R)		5
12	Importance Factor		1.2
13	Seismic Zone Factor		0.1,16,.24,.36 (Zone II,III,IV V)
14	Load Combination		According to IS:1893 (part 1) : 2016
115	Staircase	Rise	0.150m
		Tread	0.230m
		Width	1.5m
		Stringer	0.150m
116	Load Applied	Dead Load	Calculated as per Self Weight
		Live Load	3 KN/m^2
		Seismic Load	As per IS 1893 (part 1) : 2002
		Floor Finish	KN/m^2

Table 1: Member properties & specification

IV. PLAN

A. *Plan View of Building*

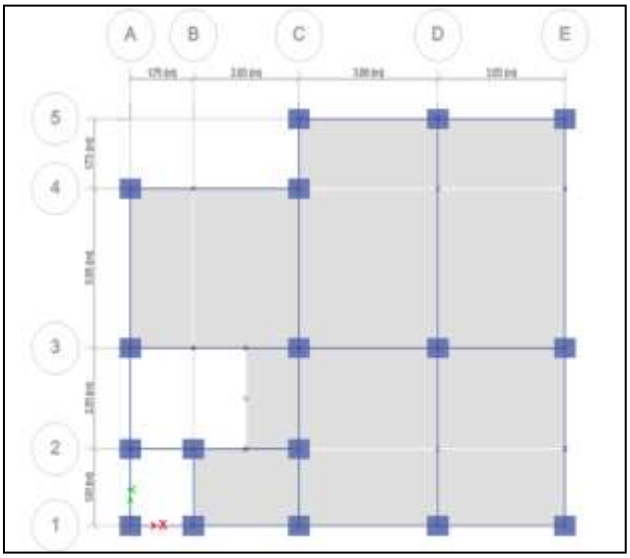


Fig. 2: model (1) Plan view of G+20 Residential building model without shear wall

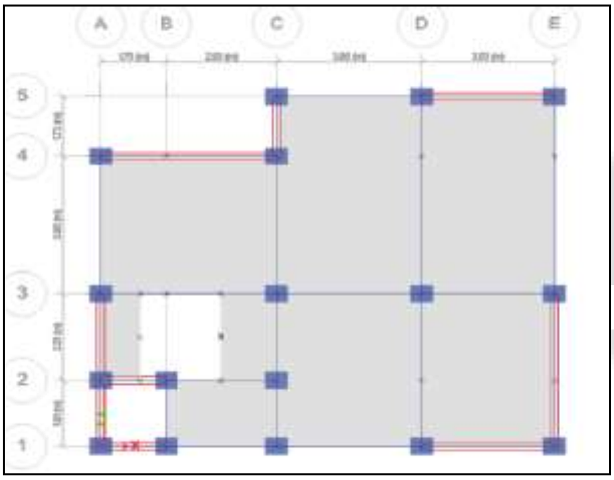


Fig. 3: model (2) Plan view of G+20 Residential building model with shear wall

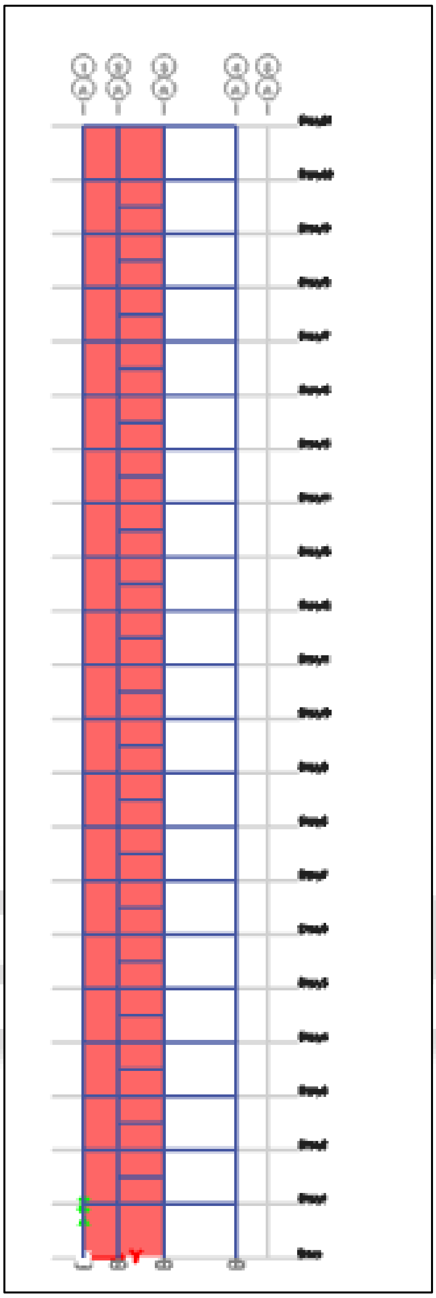


Fig. 4: G+20 Residential Building Model with Shear Wall, left elevation view

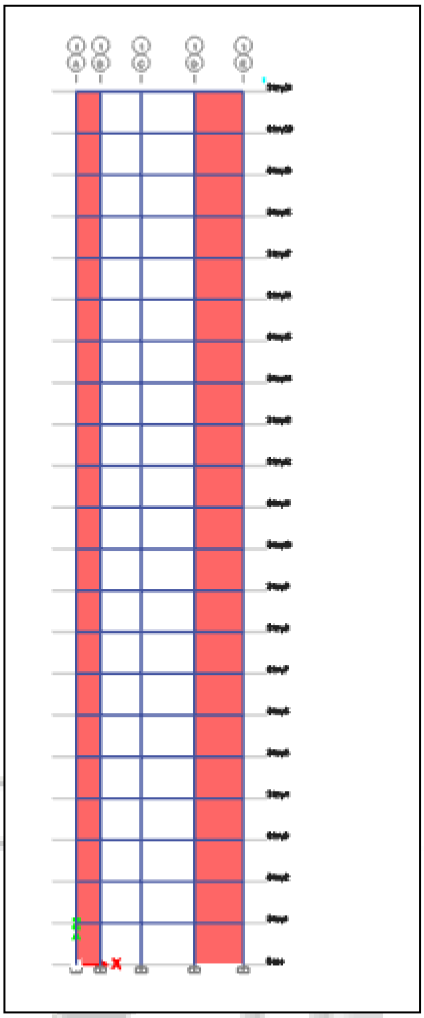


Fig. 5: G+ 20 Residential Building Model Front Elevation with Shear Wall

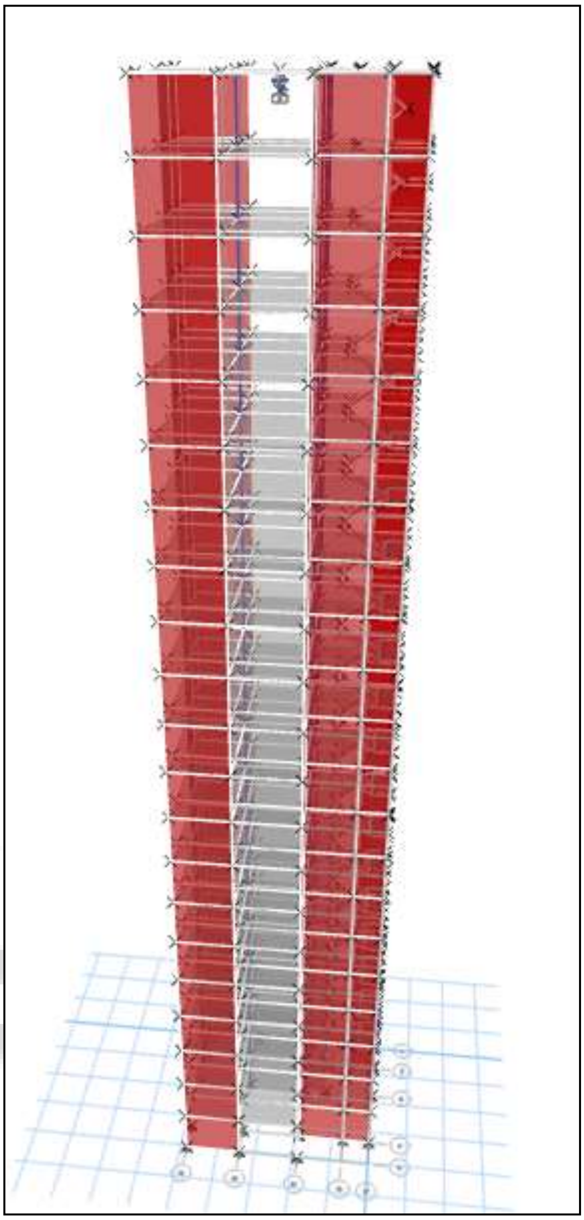


Fig. 6: model (3) Isometric view of G+ 20 Residential building model with shear wall and tune mass damper

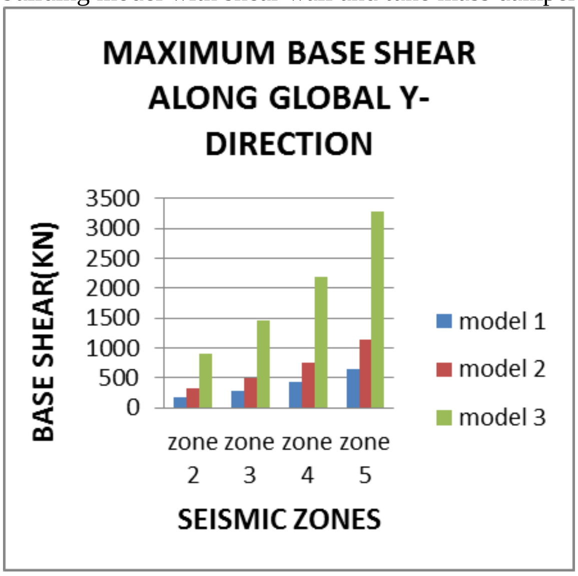


Fig. 7: Maximum Base Shear in the Global X-Axis.

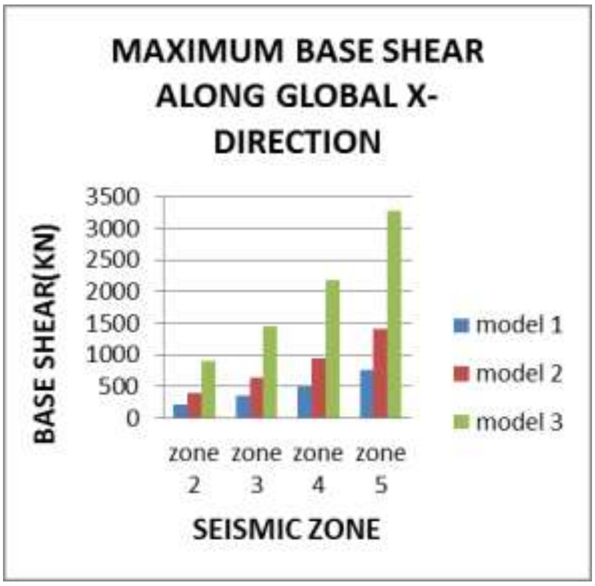


Fig. 8: Maximum Base Shear in the Global Y-Axis.

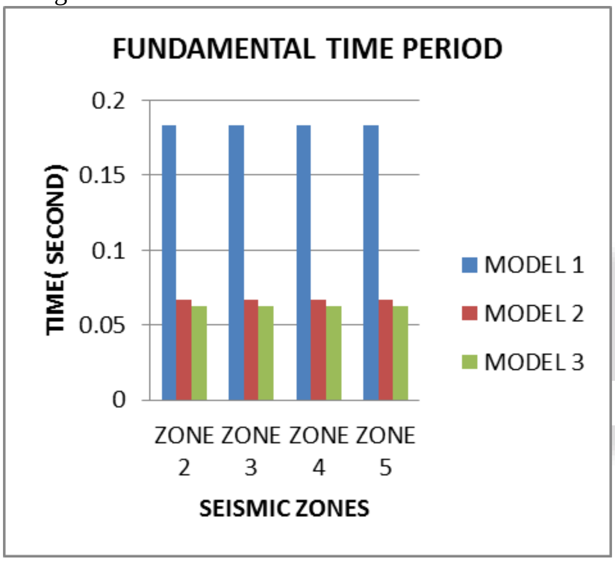


Fig. 9: Fundamental Time Period

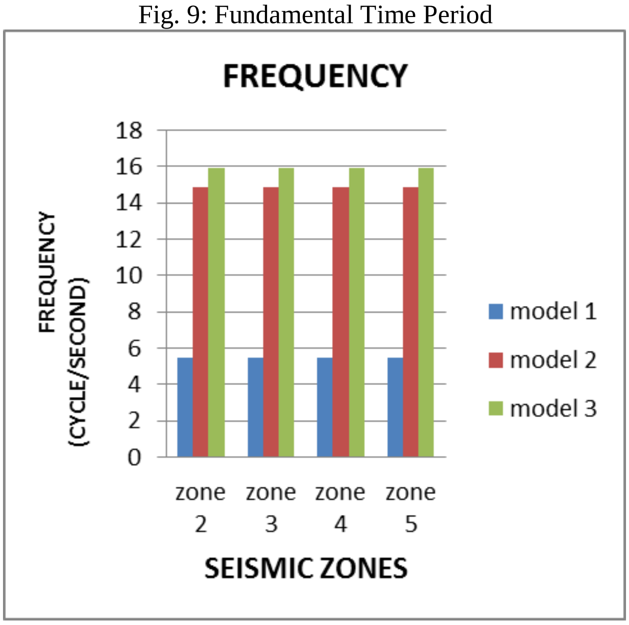


Fig. 10 Frequency

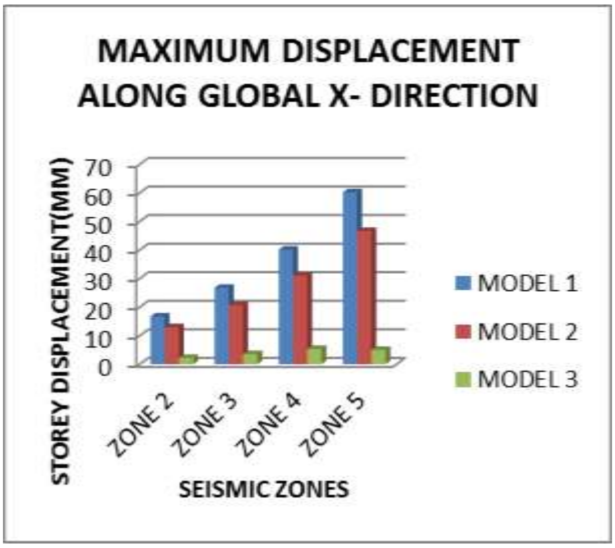


Fig. 11 Maximum Storey Displacement in the X-axis.

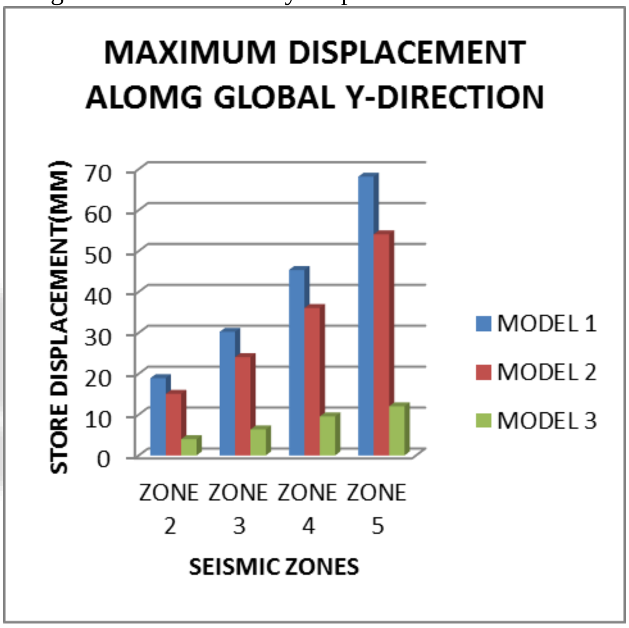


Fig. 12: Maximum Storey Displacement in the Y-axis.

V. MODEL

SPECIFICATION

1) model (1)- model without shear wall and damper
2) model (2)- model with shear wall
3) model (3)- model with shear wall and damper

VI. RESULT

1) The base shear of a shear wall with a damper is significantly higher than a shear wall without a damper because it attracts more lateral forces, whereas the base shear of a frame is lower than the other versions because the structure's weight is lower.(in fig.7&8)
2) According to IS 1893:2016 (Part-1) the time period of the building is 1.67 s without infills, which does not match any of the time periods depicted in Fig. 9, suggesting that the structure is safe from resonance effects. (as shown in fig. 9)
3) The perspective from above is depicted in Figures 11&12. It was determined that as the building's height is

reduced, the building's storey displacement reduces. The storey displacement of the frame is bigger than other types because it counters more forces, and the shear wall with damper is the smallest.

VII. CONCLUSION

1) Maximum displacement values in seismic zone V are higher than in zones II, III, IV, and V for all cases model 1, model 2, and model 3, implying that displacement can be reduced by designing a structure with uniform stiffness.
2) In terms of maximum displacement and base shear, the building with shear walls and a tuned mass damper (i.e. model 3) produced better results, leading to the conclusion that buildings with uniform stiffness provide better results.
3) According to IS 1893:2016 (Part-1) the time period of the building is 1.67 s, which does not match either of the time periods depicted in Fig. 9, suggesting that the structure is safe from resonance effects.

REFERENCES

[1] S. Akhil Ahamad and K. V. Pratap, "Dynamic analysis of G + 20 multi storied building by using shear walls in various locations for different seismic zones by using Etabs," Mater. Today Proc., no. xxxx, 2020, doi: 10.1016/j.matpr.2020.08.014.
[2] Z. Zhang, J. Ou, D. Li, and S. Zhang, "Optimization design of coupling beam metal damper in shear wall structures," Appl. Sci., vol. 7, no. 2, 2017, doi: 10.3390/app7020137.
[3] D. R. Pant, M. Montgomery, and C. Christopoulos, "Analytical Study on the Dynamic Properties of Viscoelastically Coupled Shear Walls in High-Rise Buildings," J. Eng. Mech., vol. 143, no. 8, p. 04017047, 2017, doi: 10.1061/(asce)em.1943-7889.0001247.
[4] V. More, V. Patil, and S. Takkalaki, "Dynamic Analysis of RCC Frame Structures with and Without Viscous Damper Having Different Aspect Ratio," vol. 6, no. 10, pp. 64–70, 2019.
[5] R. Chen and G. Xing, "SEISMIC analysis of high-rise buildings with composite metal damper," MATEC Web Conf., vol. 31, pp. 1–5, 2015, doi: 10.1051/matecconf/20153111002.
[6] B. Islam, "Optimization of Tuned Mass Damper Parameters Using Evolutionary Operation Algorithm," 15th World Conf. Earthq. Eng., no. 1998, 2012.
[7] C. C. Lin, L. Y. Lu, G. L. Lin, and T. W. Yang, "Vibration control of seismic structures using semi-active friction multiple tuned mass dampers," Eng. Struct., vol. 32, no. 10, pp. 3404–3417, 2010, doi: 10.1016/j.engstruct.2010.07.014.
[8] N. A. Alexander and F. Schilder, "Exploring the performance of a nonlinear tuned mass damper," J. Sound Vib., vol. 319, no. 1–2, pp. 445–462, 2009, doi: 10.1016/j.jsv.2008.05.018.
[9] K. K. F. Wong, "Seismic energy dissipation of structures with tuned mass dampers," Wind Earthq. Eng. - Proc. 10th East Asia-Pacific Conf. Struct. Eng. Constr. EASEC 2010, vol. 3, no. 2, pp. 231–236, 2006.
[10] [10] I. Saidi, a D. Mohammed, E. F. Gad, J. L. Wilson, and N. Haritos, "Optimum Design for Passive Tuned Mass Dampers Using Viscoelastic Materials," Aust. Earthq. Eng. Soc. 2007 Conf., pp. 1–8, 2007.
[11] [11] K. C. S. Kwok and B. Samali, "Performance of tuned mass dampers under wind loads," Eng. Struct., vol. 17, no. 9, pp. 655–667, 1995, doi: 10.1016/0141-0296(95)00035-6.
[12] [12] N. Chouw, "Behaviour of soil-structure system with tuned-mass dampers during near-source earthquakes," 13th World Conf. Earthq. Eng., no. 1686, 2004.
[13] A. Ghosh and B. Basu, "Effect of soil interaction on the performance of tuned mass dampers for seismic applications," J. Sound Vib., vol. 274, no. 3–5, pp. 1079–1090, 2004, doi: 10.1016/j.jsv.2003.09.060.
[14] C. Li and Y. Liu, "Active multiple tuned mass dampers for structures under the ground acceleration," Earthq. Eng. Struct. Dyn., vol. 31, no. 5, pp. 1041–1052, 2002, doi: 10.1002/eqe.136.
[15] D J Carson, "Seismic Evaluation of the Historic East-Memorial Building Retrofitted with Friction Dampers, Ottawa, Canada," 15th World Conf. Earthq. Eng., 2012.
[16] IS 456, "Concrete, Plain and Reinforced," Bur. Indian Stand. Dehli, pp. 1–114, 2000.
[17] Microsoft Excel 2010.

