Case Study on Seismic Analysis of Symmetrical and Unsymmetrical RC Frame Structure with Tuned Mass Damper

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Abstract –*A Vibrations are one of many environmental factors that act on building and potentially reduce their lifetime. Current trends in construction demand taller and lighter structures, which are also flexible and having quite low damping value. Tuned Mass Damper (TMD) is a control device, which absorbs energy & reduces response of vibration. Tuned mass damper have been widely used in building to mitigate dynamic responses of buildings. The aim of this study is to analysis the structural behaviour of symmetrical structure and Unsymmetrical structure subjected to seismic forces and a general understanding of the structural behaviour using ETABS software. The percentage of Tuned mass damper is taking 2%, 3% and 4% total weight of structure. The study includes the comparison of the base shear, net displacement, storey drift and time period obtained for buildings with and without tuned mass damper.*

Key Words*: Etabs, TMD, *Vibrations, base shear, net displacement, storey drift

1. INTRODUCTION

High-rise buildings are more suitable in urban areas due to high cost of land, shortage of open spaces and scarcity of lands. The tall buildings are in general highly vulnerable to lateral forces arising out of earthquakes. Vibration control of environmentally induced motions in civil engineering structures has been a topic of intensive research over the last many years. Designing the structures to withstand these earthquake lateral forces is very expensive hence it is not always desirable. A need for new and better means of designing new structures and retrofitting existing ones from the damaging effects of severe dynamic loadings has motivated civil engineer to embark on rather unfamiliar but innovative concepts of structural control. The use of lightweight, high strength materials, and advanced construction techniques have led to increasingly flexible and lightly damped structures, which is prone to cause human discomfort, structural damage and even failure in extreme dynamic loadings. The means to suppress undesirable levels of vibration have then become essential and integral aspect of structural system in tall buildings.

1.1 How Tuned Mass Dampers Work?

A tuned mass damper (TMD) consists of a mass (m), a spring (k), and a damping device (c), which dissipates the energy created by the motion of the mass (usually in a form of heat). In this figure, M is the structure to which the damper would be attached.

From the laws of physics, we know that F = ma and a = F/m. This means that when an external force is applied to a system, such as lateral force acting on a skyscraper, there must be acceleration. Consequently, the people in the skyscraper would feel this acceleration. In order to make the occupants of the building feel more comfortable, tuned mass dampers are placed in structures where the horizontal deflections from the lateral force are felt the greatest, effectively making the building stand relatively still.

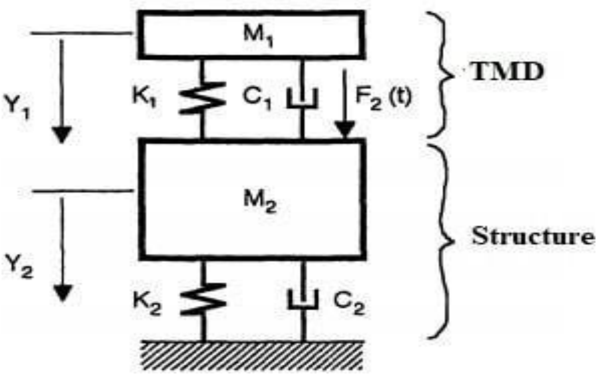

Fig:1 Tuned mass damper operating principles

2. OBJECTIVES

(i) To find to get most effective mass ratio for damper condition for maximum reduction in structural response. To check position of mass damper at various story height this is most effective in seismic response reduction.

(ii) To check suitability of mass damper conditions in symmetrical and unsymmetrical buildings.

3. LITREATURE VIEW

K. M. Mini, Lekshmi Suresh[1] (2019) [1] investigated the effectiveness of a multiple TMD system as a passive vibration control strategy. A three-degrees-of-freedom frame with single, double, and triple TMDs was studied experimentally and analytically to investigate the effect of TMD on structures. A structure with assumed mass, stiffness, and damping, and dampers with assumed mass ratio and stiffness were considered for the analytical study.

Yoyong Arfiadi (2016) [2] investigated the optimization of composite tuned mass dampers in reducing the response of structures subject to earthquake are discussed. Composite tuned mass dampers are mass dampers that consist of two mass dampers connected in series. The mass of the auxiliary dampers is in general relatively smaller than the one of the first damper. . However, in this paper the mass ratio of the auxiliary damper to total mass of dampers is varied from 0.1 up to 0.9; and the optimum stiffness and damping of the first and auxiliary dampers are obtained.

Mehdi Setareh (2007) [3] analysed a study of the application of the semiactive pendulum tuned mass dampers to control excessive building floor vibrations. Using a test floor and a SAPTMD, a series of analytical and experimental studies was conducted. Performance of the SAPTMD in reducing the floor vibrations was compared to that of its equivalent passive counterpart. y. To correlate the results of the analytical and experimental studies, the human occupants were considered as dynamic systems. Analytical and experimental studies of a SAPTMD with a laboratory test floor were conducted and the SAPTMD performance was compared to the equivalent PTMD.

Chia-Ming Chang (2018)[4] investigated The objective of this study is to develop a new tuned mass damper design procedure based on the active control algorithm. Given a mass ratio between the damper and structure, the stiffness and damping coefficient of the tuned mass damper are derived by minimizing the response objective function of the primary structure, where the structural properties are known. This study examines various objective functions as well as derives the associated equations to compute the stiffness and damping coefficient. The relationship between the primary structure and optimal tuned mass damper is parametrically studied. This design procedure yielded an effective tuned mass damper through the active control algorithm that tended to generate a high performance feedback controller in a structure-control system. Thus, the stiffness and damping coefficient of TMDs were taken.

Deepak P. Kadam (2019) [5] investigated tuned mass damper is located on the top of the structure comprises of a mass, spring and a damper. By placing the TMD centrally and top of structures, the torsional reaction of the structure may likewise be controlled. The Time history analysis is performed to decide seismic responses of structure. In the present work Tuned mass damper (TMD) is set on top of the structure and through it, to determine its effectiveness on Storey drift, storey displacement and base shear in ETABS.

In this project one regular and two different irregular models are taken. Two irregular models are with two different irregularities viz. Stiffness irregularity and torsional irregularity. Following are material properties, sizes of elements (beams, columns, slabs), seismic and wind parameters considered this project. The building location where seismic Zone is IV with factor 0.24. Since it is a residential building, which is having importance factor 1.2. A Lateral force resisting system in which RC SMRF with response reduction factor (R) 5 is taken. Project building is located on soft soil site.

4. METHEDOLOGY

4.1 MODELLING OF BUILDING

In the present study G+50 high-rise buildings are modelled using ETABS package. The response spectrum method is considered as per IS 1893-Part 1-2016. Seismic zones V considered. Type of soil medium considered.

4.2 BUILDING PLAN AND DIMENSION DETAILS

The analysis was carried out by considering different parameters to understand the behaviour of TMD. A standard G+50 story buildings with TMD were modelled. The analysis is carried out on the 30 models using response spectrum method in ETABs 2015. IS 1893:2016 codal provisions is considered for the analysis. The plan dimensions considered for analysis are as shown in fig. C shape building has 50m x 65 m. L shape building has 50m x 65m and square shape building has 65m x 65m plan dimensions. Each bay having 5 m span in both directions.

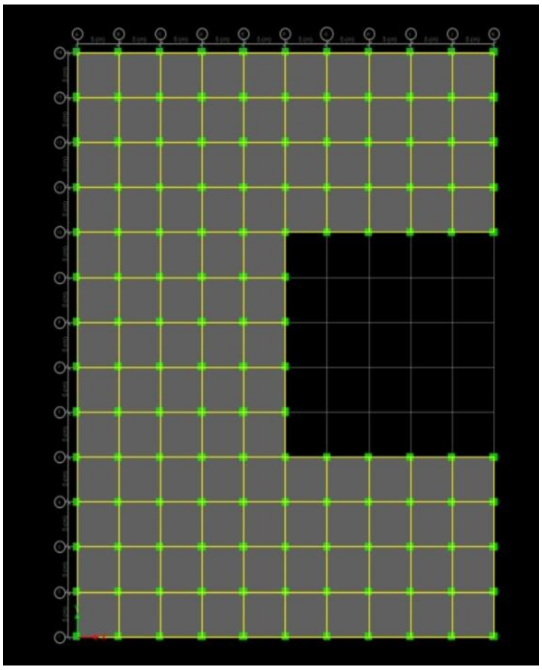

Fig 2: Plan of C shape building (50 m x 65 m)

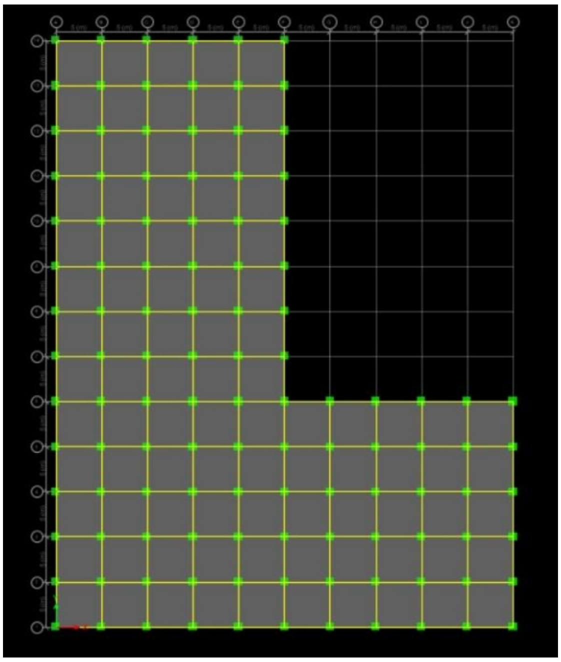

Fig 3: Plan of L shape building (50 m x 65 m)

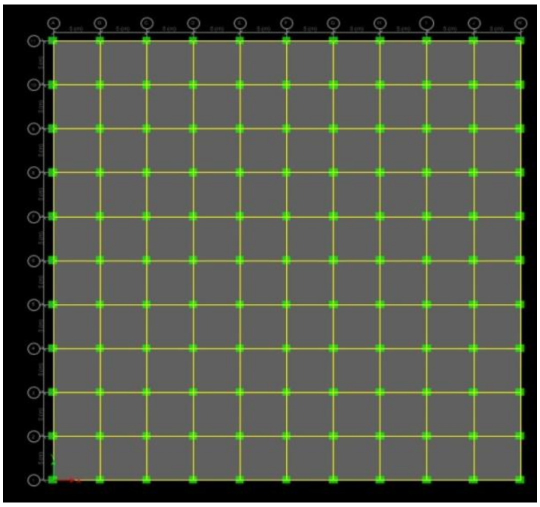

Fig 4: Plan of Square shape building (50 m x 50 m)

4.3 Dimensions of the structural elements

No. of story: 50 story
Story height: 3m
Bottom story height: 3.3m
Spacing in X-Direction & Y-direction: 5m
Size of column: 900mm x 900 mm
Size of beam: 300 mm x 600mm
Slab thickness: 150 mm
Thickness of exterior walls: 230 mm
Thickness of inner walls: 115 mm

4.4 Material properties

Grade of concrete: columns M30,
Beams and Slab M25
Grade of steel: Fe500

4.5 Other considerations

Soil type: II
Seismic zones: V
Importance factor: 1
SMRF building type considered. Response reduction factor: 5

4.6 Dimensions of Tuned mass damper

Size of the TMD plan: 5 m x 5 m
Size of column: 600mm x 600 mm
Size of beam: 300 mm x 600mm

The weight of the TMD considered as the various percentages of total mass of the building. The various percentages considered as the 2%, 3% and 4% of total mass of the building. The TMD located at the top of the building, half height of the building and one-third height of the building. The TMD is located at the centre of the buildings.

6. RESULTS

After analyzing the models, the following results were obtained for different seismic zones V. The charts were generated for easy comparison of the results for different parameters i.e. Displacement, base Shear and Drift as below.

Fig 5: Comparison of displacement for C shape

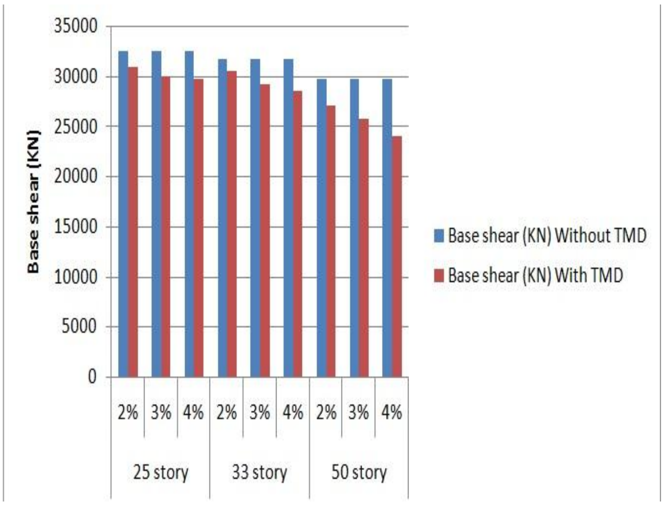

Fig 6: Comparison of base shear for C shape

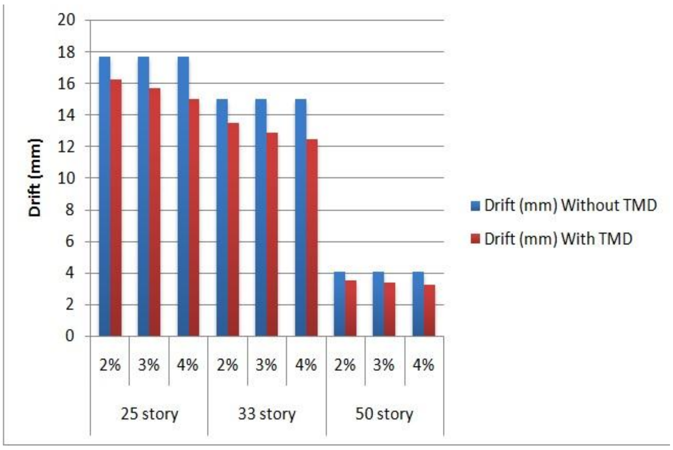

Fig 7: Comparison of drift for C shape

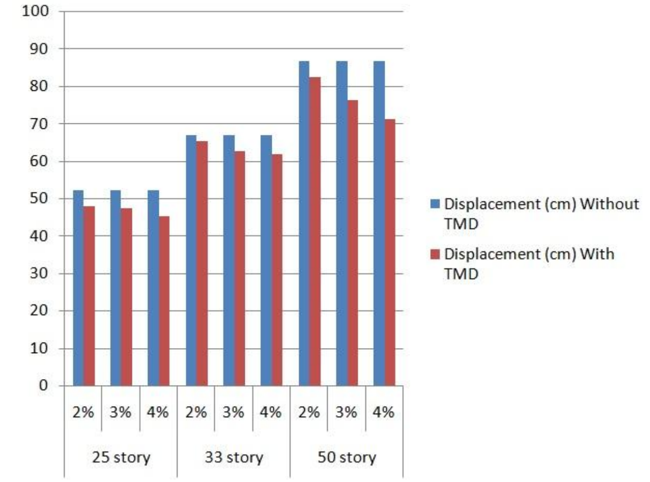

Fig 8: Comparison of displacement for L shape

Fig 9: Comparison of Base shear for L shape

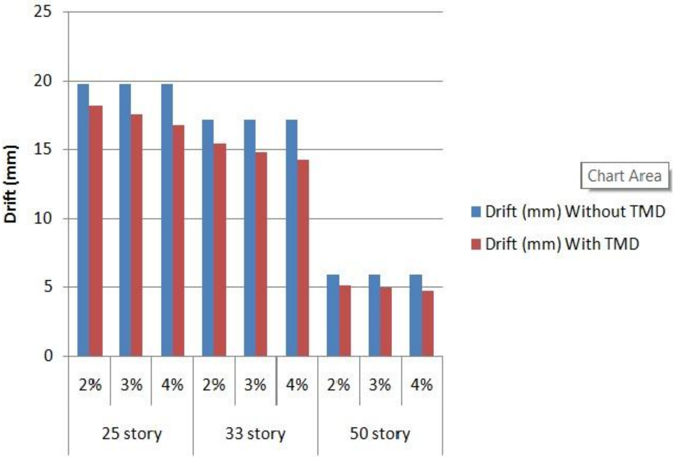

Fig 10: Comparison of drift for L shape

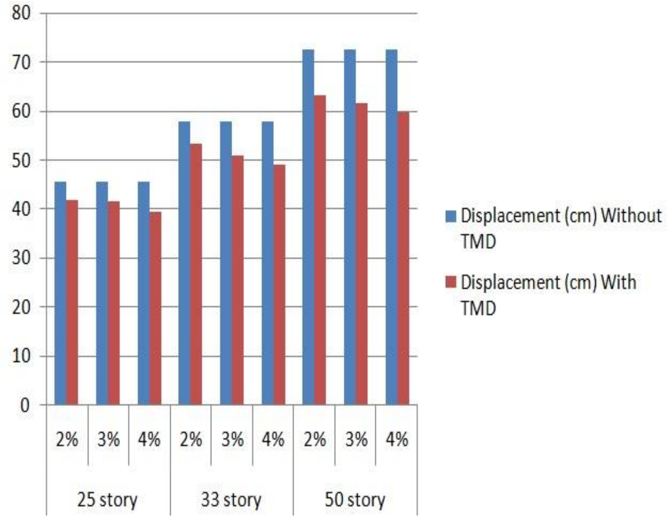

Fig 11: Comparison of displacement for Square shape

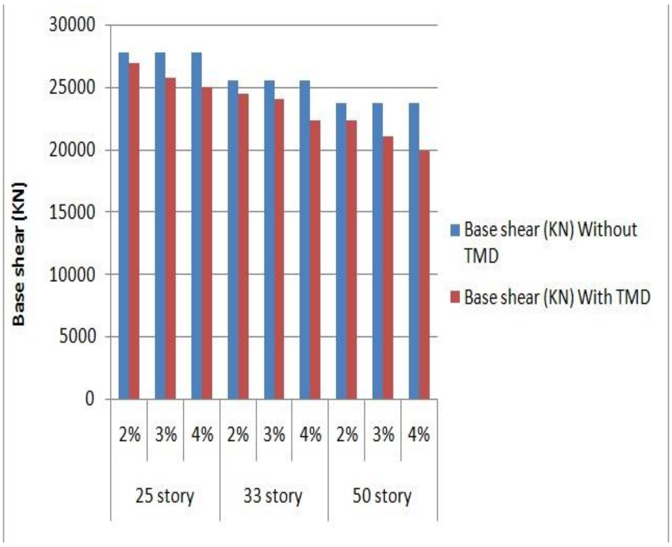

Fig 12: Comparison of Base shear for Square shape

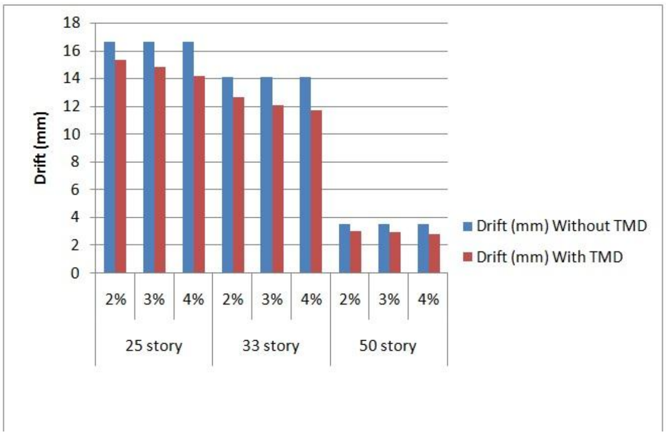

Fig 13: Comparison of drift for Square shape

7. CONCLUSIONS

The important conclusions which can be derived from this research work are as follows:

- ➢ The Tuned mass damper provided at the various height of buildings and shows considerable changes in seismic parameters like Displacement, Base Shear and Drift.
- ➢ The response of building under earthquakes depends on the amount of percentage TMD provided.
- ➢ Among 2% ,3% and 4% TMDs, 4% TMD is found better than 2% and 3% TMDs in reducing axial force, bending moment and displacement.
- ➢ The Tuned mass damper provided at the top of the buildings instead of provided at various height of buildings having more effectiveness against seismic excitations.
- ➢ By applying Tuned mass damper in building the seismic parameters like Displacement, Base Shear and Drift are reduced.
- ➢ From analysis it can be seen that it is necessary to properly implement and construct a damper in any high rise building situated in earthquake prone areas to reduce the damage of building.
- ➢ In seismic parameters like displacement, drift and base shear reduction is found to be 10 to 20%.

REFERENCES

1. Suryawanshi, Y. R., and Rahane, A. S. “Study of Tuned Mass Dampers System as Vibration Controller in Multistoried buildings” © 2012 IJAIR. ALL RIGHTS RESERVED ISSN: 2278-7844, 2012.

2. V.M. Thakur, and P.D. Pachpor, Seismic Analysis of Multistoreyed Building with TMD (Tuned Mass Damper), International Journal of Engineering Research and Applications, Vol. 2, Issue 1, 2012, 319-326, 2012.

3. Mohite, A. A., and Patil, G.R. “Earthquake Analysis of Tall Building with Tuned Mass Damper” IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 22781684, p-ISSN: 2320–334X PP 113-122, 2015.

4. Julie S, Sajeeb R “Performance of Base Isolators and Tuned Mass Dampers in Vibration Control of a Multistoried Building” IOSR Journal of Mechanical and Civil Engineering Volume 2, Issue 6, PP 01-07, 2012.

5. Muhammed murad.k, lavanya.g “Dynamic resistance of tall buildings by using tuned mass damper” International Conference on Current Research in Engineering Science and Technology, pp 01-07, 2016

6. Thakur, V.M. and Pachpor (2012), “Seismic Analysis of Multi-storeyed Building with TMD (Tuned Mass Damper)”, International Journal of Engineering Research and Applications, Vol. 2, Issue 1, 319-326

7. P. Kundu, Vibration Control of Frame Structure Using Multiple Tuned Mass Dampers. Master Thesis, Department of Civil Engineering, National Institute Of Technology, Rourkela, India, 2012.

8. Giaralis Agathoklis, Petrini Francesco,” Optimum design of the tuned mass-damper-inverter for serviceability limit state performance in wind-

excited tall buildings", Procedia Engineering 199 (2017), PP. 1773–1778.

9. Khan, W., Akhtar, S., and Hussain, A. "Non-linear Time history analysis of tall structure for seismic load using damper", International Journal of Scientific and Research Publications, Volume 4, Issue 4, 2013.

IS CODES

1. Indian Standard Code, Criteria for Earthquake Resistant Design of Structures (IS 1893-Part 1-2016).

2. Indian Standard Code, Design Loads (Other Than Earthquake) For Building and Structures (IS 875-Part 3-2015).

3. Indian Standard Code, Design Loads (Other Than Earthquake) For Building and Structures (IS 875-Part 1 & 2-1987).