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ANALYSIS OF MULTISTORIED BUILDING WITH AND WITHOUT TUNED MASS DAMPER

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Abstract*— During an earthquake the role of reinforced concrete buildings always critical because earthquake are most erratic and devastating of all natural calamities, which are the very difficult to save over engineering properties and life. Therefore we need to identify seismic performance of the built environment through the development of various procedures, which ensure the structures to withstand during the minor and major earthquakes events. A tuned mass damper (TMD) could be a device consisting of mass, spring, and damper that are attached to a structure in order to reduce the dynamic response of the structure. The frequency of the damper is tuned to a specific structural frequency so once that frequency is worked up; the damper can resonate out of section with the structural motion. The main objective of current work is to illustrate the effects of tuned mass damper using software ETABS 2016 and analysis of the23 story structure with and without tuned mass damper. Results of these analyses are discussed in terms of various parameters such as maximum displacement, story shear. The comparison of these various parameters is done. We concluded from the results that displacement, story drift, and story shear decreases for structure with tuned mass damper.

Keywords: Tuned Mass Damper, Earthquake, Response Spectrum Method, Time History Analysis, and Etabs.

I. INTRODUCTION

During an earthquake the role of reinforced concrete buildings always crucial because earthquake are the most unpredictable and devastating of all natural disasters, which are the very difficult to save over engineering properties and life. Therefore we need to identify seismic performance of the built environment through the development of various procedures, which ensure the structures to withstand during the minor and major earthquakes events. With the rapid development and advanced technology, civil structures like high-rise buildings, bridges are designed with an additional flexibility, which lead to an increase in their susceptibility to external excitation. Therefore, increasing flexibility of structure is one of the ways to protect the structures from significant damage. The behavior of the building during natural disasters like an earthquake depends on various factors, ductility, stiffness, regular configuration, and adequate lateral strength. In everyday life need and demand of the growing population has made the engineers inevitable towards irregular structure. Hence earthquake engineering is very important. Vibration control technology quickly moved into civil engineering structures related issues, like protection of building from earthquake and wind. We cannot count the number of buildings existing in the world that are with low damping. Seismic dampers and base isolation are the two technologies used to control building from damaging earthquake effects. Seismic dampers are the devices in the building to absorb the energy provided by ground motion. A tuned mass damper is consisting of mass, spring, and damper is attached to a structure to reduce the dynamic response of the structure. The frequency of damper and structure are tuned to same frequency so when that frequency is excited, the damper will vibrate out of phase with the structural motion. Due to the inertial force of damper acting on the structure the energy is dissipated. A tuned mass damper is generally placed where the deflections in the structure are more. TMD have been mostly used for vibration control in engineering systems[1].A multiple-degree-of-freedom system encompasses a smaller mass connected to that, and also the parameters of the smaller mass are tuned exactly, then the oscillation of the system is reduced by the smaller mass this is idea behind tuned mass damper. In the current scenario of the world the art of design is emerging rapidly for the development of high rise structures. The need of high rise buildings increases in day to day life in India due to lack of urban areas and increasing population. Because of that high rise structures are design and constructed more and height is affected by lateral forces to some extent. Hence lateral stability is important for high rise buildings.

A. Tuned Mass Damper

A TMD is an inertial mass attached to the building location with maximum motion, through a properly tuned spring and damping element. Tuned mass damper is device consisting of mass, spring, and damper that are attached to a structure in order to reduce the dynamic response of the structure shown.

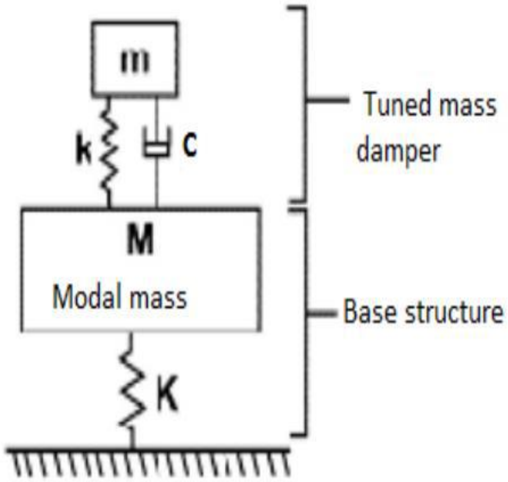

Fig. 1 Tuned mass damper [6]

B. Objectives of study

The main objectives of present study are as follows:

- To determine the effect of Tuned mass damper on the response of structure.
- To perform response spectrum and time history analysis of multistoried building frame with and without damper in ETABS software.
- To study the response of building in terms of base shear, story drift, displacement, etc.

II. LITERATURE REVIEW

Saurabh Chalke et.al, (2017) [2] discussed that vibration control of frame structure using tuned mass damper done by using ETABS 2015 software. The taller structures should have the adequate self-weight because at the time of Earthquake the self-weight of structure plays the essential role. The structure should design and built with minimum self –weight because as it possesses all design criteria. To control the harmonic and wind excitation passive tuned mass damper is widely used. In this paper G+ 51 storeys structure with and without tuned mass damper is analysed and comparison of displacement and drift values under the dynamic condition is done. They concluded that when structure is acted upon by dynamic conditions the values of displacement and drift are found to be more. The structure is going to be more stable when values of displacement and drift are reduced by installing Tuned mass damper in structure. And acceleration also reduced by using Tuned mass damper. Therefore Tuned mass damper is more useful in tall structures as it resist motion of structure under dynamic condition.

Yogesh Ravindra Suryawanshi et.al, (2012) [3] carried out case study of inner working of tuned mass damper in Taipei 101tower. The basic theory behind this TMD is that the oscillations can be reduced if multiple degree of freedom system has smaller mass and constraints of the mass are tuned correctly. Single degree of freedom system and multiple degree of freedom system are systems of tuned mass damper system. Single degree of freedom system oscillates in one direction and MDOF oscillates in two directions. Taipei 101 towers in Taiwan are with massive pendulum type tuned mass damper of steel. This massive steel sphere tuned mass damper is passive control system. Tuned mass damper equipment is an essential for keeping the structural stability. Tuned mass dampers are becoming more innovative technology in significantly reducing oscillation of structure.

M. S. Landge et.al,(2017) [4]this conference paper deals with selection of suitable type of damper which will be more resistant to earthquake for the selected building. For the analysis of G+7 storey building response spectrum method was used for analysis, earthquake loads were applied in x and y direction Results of these analyses are discussed in various parameters such as maximum absolute displacement, absolute acceleration, absolute velocity, storey shear, storey drift. The comparison of these various parameters is done. The structure is analysed with and without various types of dampers. From these comparison it is concluded that maximum absolute displacement, absolute acceleration, storey shear, storey drift values are more in case of RC building without damper as compared to RC building with dampers.

Khemraj S. Deore et.al, (2017) [5] this paper explains about the effectiveness of using Tuned mass damper for controlling vibrations of structures. Current trends in construction industry demands taller structures these are having low damping value this increases failure percentage. Nowadays various advance techniques are available to minimize the vibration of the structure out of which TMD is newer technique. Earlier practical plan model with and without TMD has prepared. And perform Response Spectrum Analysis. In which calculate different parameters like Maximum Deflection, Storey Drift, and Base shear, Natural Frequency and Fundamental period of building. From the results TMD can be effectively used for vibration control of structures and it was more effective when it is attached at the top floor of building. TMD results in gradual decrement in the displacement, storey drift and fundamental period of the structure.

III. METHODOLOGY

In this present work Tuned mass damper is placed on its top to study its effects on Storey drift, storey displacement and story shear and analysis with and without the tuned mass damper in ETAB 2016.by using response spectrum.
For investigation following assumptions are adopted.

- Columns are assumed as inextensible.
- The slab is assumed as rigid.
- Self-weight of the columns is neglected.

A. Problem statement

To study the effectiveness of tuned mass damper a reinforced concrete frame building with simple symmetric plan is selected. Height of each story is 3m. The building has plan dimensions (24m x 40m) and is symmetric in both directions as shown. The building is assumed to be located in seismic zone IV and it has 23 stories.

B. Modeling and analysis

- Size of all beams = 300mm x 600mm (Depends on structural requirements)
- Size of column = 600mmx900mm , 600mm x 600mm (Depends on structural requirements)
- Slab thickness = 150mm
- Wall thickness = 230mm
- Story Height = 3000mm
- Unit weight of concrete = 25kN/m3
- Unit weight of brick masonry = 20kN/m3
- Grade Concrete = M40
- Dead load = 1.5 kN/m
- Live load = 2 kN/m
- M10odulus of Elasticity of concrete = 31622.77 N/mm2
- Poi11sons Ratio of concrete = 0.2
- Seismic zone IV
- SBC 12of Soil – 300kN/sq.m

C. Tuned Mass Damper Description

Table I
Model description

Parameters	Numerical value
Mass ratio	3%
Mass of structure	201500 kg
Mass of the damper	6045 kg
Frequency of damper	59.66 rad/sec
Stiffness of damper	21516135
Optimum damping ratio	0.1045
Optimum damping	7.53x10^4 N/m/s

D. Elevation of building

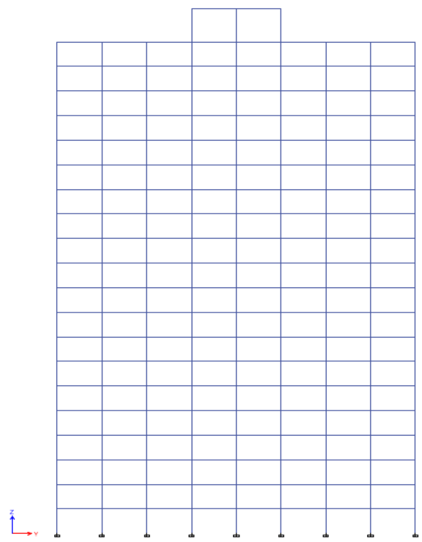

Fig 2 Elevation of building

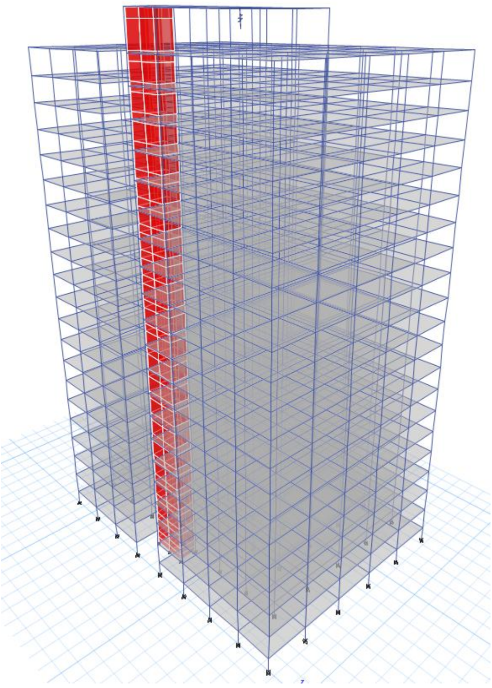

Fig.3 Model with TMD

IV. RESULT AND DISCUSSION

A. Displacement

1) Displacement in x and y direction

From the analysis of structure we get the results of the displacement in x direction. Response spectrum analysis is carried out to know the response of structure to various load combinations. By comparing the results obtained from analysis of structure with and without tuned mass damper shown in figure 3 we observed that the maximum displacement is occurred at the top floor of structure. The maximum displacement in x-direction without Tuned mass damper is 189.878 mm and that of with tuned mass damper are 136.898 mm.

From the analysis of structure we get the results of the displacement in y direction. By comparing the results obtained from analysis of structure with and without tuned mass damper shown in figure 4 we observed that the maximum displacement is occurred at the top floor of structure. The maximum displacement in y-direction without Tuned mass damper is 138.28 mm and that of with tuned mass damper are 106.232 mm. From all results it has been seen that displacement is less in building with tuned mass damper.

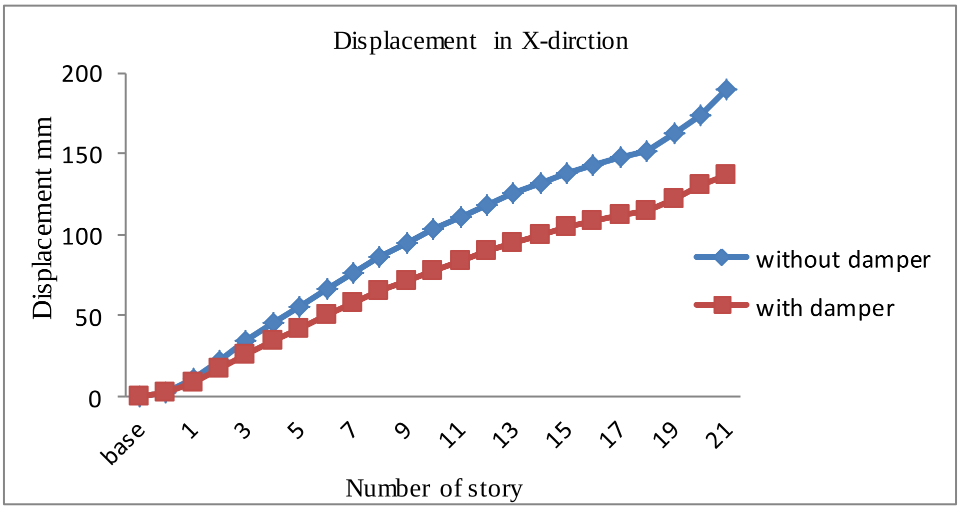

Fig.4 Displacement in x direction

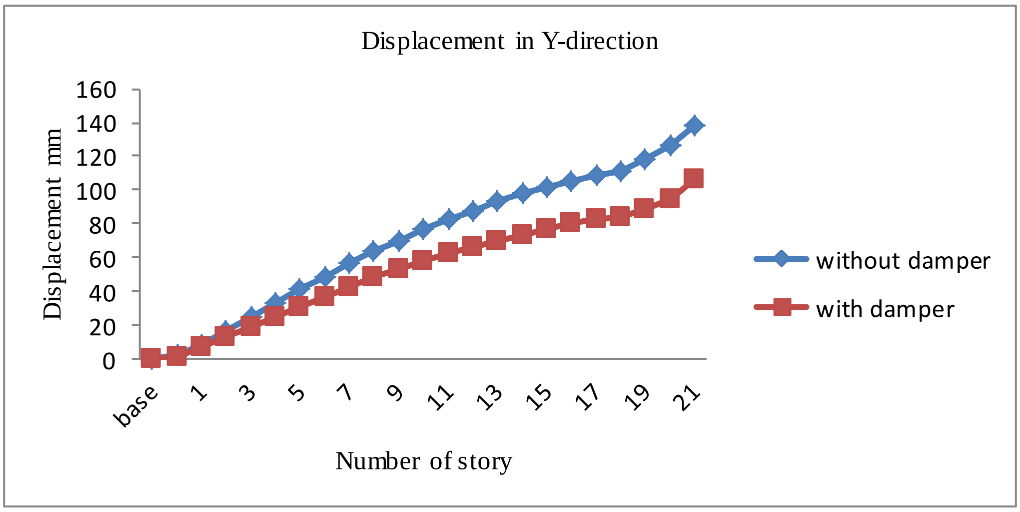

Fig. 5 Displacement in y direction

B. Story shear

The story shear is the shear value obtained from the sum of design lateral forces at the levels above the story consideration of the structure.

1) Story shear in x and y direction

For the story shear in x direction we observed that the story shear at bottom stories is maximum and minimum at the top stories. Maximum shear story at bottom story is 16739.2812 and at top story is12449.5349.

For the story shear in y direction the story shear at bottom stories is maximum and minimum at the top stories. Maximum shear story value at bottom story is 18437.8765 and at top story are 13777.7807.

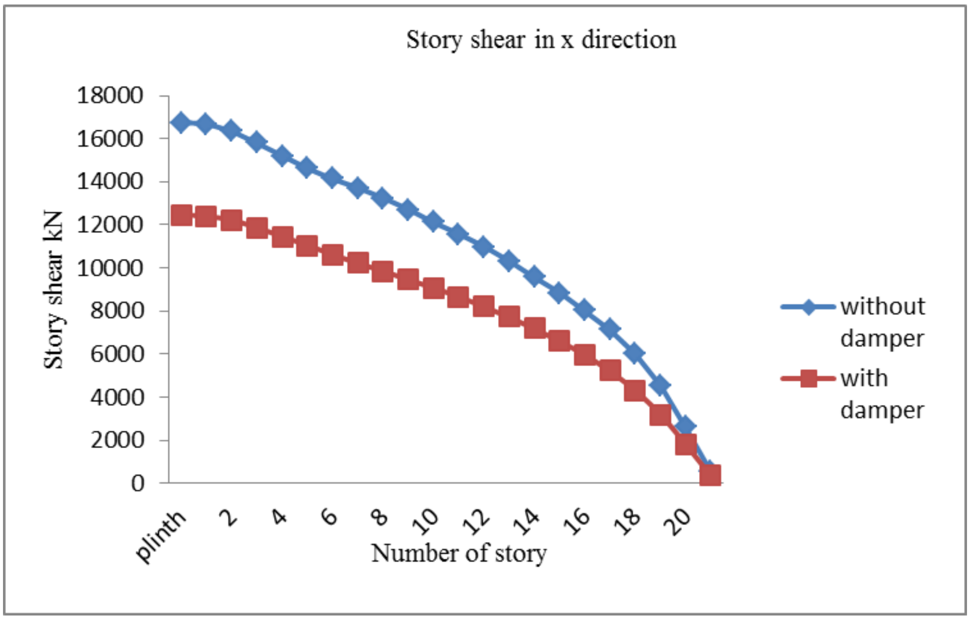

Fig.6 Story shear in x direction

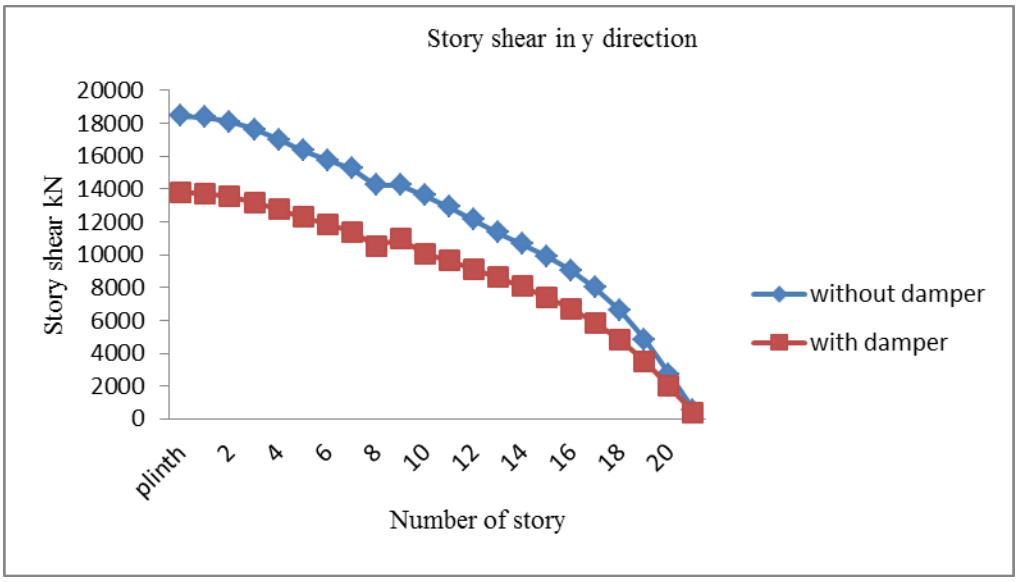

Fig. 7 Story shear in y direction

V. CONCLUSIONS

After carrying analysis of building with and without damper results are obtained. Tuned mass damper is effective in reducing displacement, story drift and story shear. This study aimed as tuned mass damper in reducing structural vibration caused due to external forces. Following are some conclusions are made.

1) It has been found that the tuned mass damper can be successfully used to control structural excitation.
2) For the regular building frame, 3% of mass of damper is found effective in reducing displacement of top story. By response spectrum analysis reduction in displacement in x and y direction is 28% and 23% respectively.
3) Story shear is maximum at the base and minimum at top by comparing results it is observed that story shear values for reinforced concrete building with tuned mass damper are minimum in both directions.

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[10] Bureau of Indian standard 875 (part 2) code of practice for design loads (other than earthquake) for buildings and structures part 2 imposed loads

[11] Bureau of Indian Standard 875 (part 3) codes of practice for design loads (other than earthquake) for buildings and structures part 3 wind loads.