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Effect of Different Types of Dampers in Design of High Rise Building for Dynamics Loads

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Abstract: *The current trends toward buildings of ever increasing heights and the use of light weight, high strength materials, and advanced construction techniques have led to increasingly flexible and lightly damped structures. Understandably, these structures are very sensitive to environmental excitations such as wind, ocean waves and earthquakes. Structural control is one area of current Research that looks promising in attaining reduce structural vibrations during loading such as earthquakes and strong winds. There are three primary classes of supplemental damping devices, categorized into three corresponding control strategies. The first class of supplemental damping devices is passive. Passive devices are non-controllable and require no power. The second class of supplemental damping devices is active. Active devices are controllable, but, require significant power to operate. The third class of supplemental damping devices is semi active. Semi active devices combine the positive aspects of passive and active control devices in that they are controllable but require little power to operate. In seismic structures upgrading, one of the lateral force reduction caused by the earthquake is use of dampers. During an earthquake, high energy is applied to the structure. This energy is applied in two types of kinetic and potential to structure and it is absorbed or amortized. If structure is free of damping, its vibration will be continuously, but due to the material damping, vibration is reduced. on the seismic performance of building structural systems having passive damping devices installed within frame. Create computer models of building with and without damper systems for investigation. Study the effect of important parameters such as damper properties, locations and configurations of the dampers. Use the research findings to propose more effective damping system for seismic mitigation. In this building frame is designed as per Indian standard i.e. IS-456:2000 and IS-1893:2016 and IS-875:2015. The study of the main objective to check performance of building when designed as per Indian Standard. The building will be analyze is G+25 R.C framed building of symmetrical rectangular plan configuration for zone IV. Complete analysis is carried out for dead load, live load & seismic load using SAP2000. Response Spectrum Method of seismic analysis will be used.*
Keyword:-- *Dampers, high rise building, dynamics loads, SAP2000.*

I. Introduction

High Rise RC Structure subjected to most dangerous earthquakes. It was found that main reason for failure of RC building is irregular geometrical configurations or irregular distributions of mass, stiffness and strength. Structural vibration control, as an advanced technology in engineering, consists of implementing energy dissipating devices into structures to reduce excessive structural vibrations(due to dynamic loads), to prevent catastrophic structural failure and enhance human comfort because of natural disturbances like strong earthquakes.
structure is free of damping, its vibration will be continuously, but due to the material damping, vibration is reduced.

Dampers are classified based on their performance of friction, metal (flowing), viscous, viscoelastic; shape memory alloys (SMA) and mass dampers. Among the advantages of using dampers we can infer to high energy absorbance, easy to install and replace them as well as coordination to other structure members.(journal,2006).

II. Literature Review

In the following, a summary of the articles and paper found in the literature, about the seismic analysis of regular and irregular structures and some of the project carried out with this type of seismic analysis, is presented.

Mr. Muralidhara G B, Mr. Naranagowda, Mrs. Swathi Rani K S [1],(2015)

Vibrations due to natural dynamic loads generated by earthquake. The reducing of structural vibrations occurs by adding a mechanical system that is installed in a structure called Dampers.

Alireza Heysami [2],(2015)

This paper investigates types of dampers and their performance during earthquake. Also, they have investigated the tall buildings in the world and satisfactory level of damper performance has been studied. And the results show that no only dampers have an acceptable seismic behavior against lateral forces such as wind and earthquake forces.

Mudabbir Imran, Dr. B. K. Raghu Prasad [3], (2017)

Tuned mass dampers are known to control the seismic response of tall buildings when subjected to earthquake ground motions. It is certainly going to regulate the natural frequencies and mode shapes. The frequency content of any ground motion is a random quantity which varies with the earthquake. , it may still be better to evaluate certain different kinds of tuned mass dampers for different ground motions and conclude its effectiveness. More particularly; multiple tuned mass dampers need to be yet explored further. Therefore, this paper examines the effectiveness of tuned mass dampers (TMDs), both single and multiple to ease translational vibration when subjected to various earthquake ground accelerations. Three models of the structure have been modelled using ETABS. They are frame with single TMD, frame with multiple TMD and shear building with single TMD. Four external loading conditions have been applied and time history analysis has been carried out for appropriate ground motion and the variations of displacements in the structure are compared.

Alireza Farzampour, Arash Kamali [4], (2017)

The behavior of structures in recent years indicates that moderate and severe earthquakes lead to substantial damages, extensively higher than what is expected. One solution in order to reduce the seismic response of the structures, especially in relative story displacements is usage of tuned mass dampers (TMD). In this study, comparisons between uncontrolled and controlled cases have been evaluated. Results for an 8-story shear building under specified records show that active tuned mass dampers (ATMD) have more appropriate efficiency in structural displacement response reduction compared to passive tuned mass dampers (PTMD) in spite of high cost of installation. In addition, implementation of PTMD would lead to more desirable results in comparison with uncontrolled case regarding acceleration and displacement time history responses, especially when the natural structures' frequency is different from the dominant frequency of the records. In addition, usage of ATMD results in significant reduction in the story shear response, whereas PTMD equipped system decreases story shear with a limited margin.

Saurabh Chalke, Prof P.V. Muley [5], (2017)

The current and modern constructions demands taller structures but these taller structures should have the adequate self weight because at the time of Earthquake the self weight of structure plays the essential role. Due to which structure should design and built with minimum possible weight but still we can't minimize the sections to reduce the self weight as it will affect the safety criteria of sections therefore the alternative to control the vibration while Earthquake and wind excitation is by installing damper in the structure, to minimize the vibration and stabilize the structure under the dynamic condition. The passive tuned mass damper is widely used to control the harmonic and wind excitation. This paper represents the vibration control of framed structure using tuned mass damper by using SAP2000. The study deals with the analysis of G+51 storey structure without damper and with tuned mass damper and the comparison of the displacement and drift values under the dynamic condition.

III. Methodology

Seismic Analysis of buildings is primarily concerned with structural safety during major ground motions, but serviceability and the potential for economic loss are also of concern. Seismic loading requires an understanding of the structural performance under large inelastic deformations.

Seismic analysis is a major tool in earthquake engineering which is used to understand the response of buildings due to seismic excitations in a simpler manner. Based on the type of external action and behaviour of Structure, the analysis can be classified as,

1) Code based Procedure for Seismic Analysis
2) Response Spectrum Analysis
3) Time History Analysis

Time History Analysis

A linear time history analysis overcomes all the disadvantages of modal response spectrum analysis, provided non-linear behavior is not involved. This method requires greater computational efforts for calculating the response at discreet time's .One interesting advantage of such procedure is that the relative signs of response quantities are preserved in the response histories. This is important when interaction effects are considered in design among stress resultants.

IV. Modelling Of RCC Frames

Modelling means the formation of structural body in the structure software and assigning the loads to the members as per loading consideration. Here the high-rise RC structures having G+ 25 storey each are selected to model in SAP2000 software. In this structural analysis study, we have adopted three different Dampers position as per IS 1893:2016, as explained below.

1. Viscoelastic Damper
2. Friction Damper
3. Tuned Mass Damper

Plan Details

The structure is 30m in x-direction & 20m in y-direction with columns spaced at 5m from center to center. The storey height is kept as 3m. Basically model consists of multiple bay 25 storey building, each bay having width of 5m. The storey height between two floors is 3.0m.

The material properties and geometry of the model are described below;

1.	Plan Dimension	:	30m x 20m
2.	Number of stories	:	G+25
3	Storey height	:	3m
4.	Parking floor height	:	3m
5.	Seismic zone	:	IV
6.	Grade of concrete	:	M35
7.	Grade of steel	:	Fe500
8.	Slab thickness	:	125mm
9.	Zone factor	:	0.25
10.	Importance factor	:	1.2
11.	Response factor R	:	5
12.	Soil Type	:	medium

Modeling

The main aim of the modeling is to study the change in building responses (mainly deflection and storey drift) due to addition of dampers. The building is analyzed in 2 stages, first is without any dampers and second is using damper, best brace configuration and best location of the dampers is concluded. And using five dampers location, differences in response is studied. Analysis is done on SAP 2000.

a) Normal RCC frame structure: It is simple structure. All the loads and details are same as mentioned conforming to IS 1893:2016. It is a simple structure analyzed for earthquake resistant conforming to the Indian design standard codes.
b) RCC Frame with viscoelastic damper – position 1 viscoelastic damper need to in software modeled as a link property with effective stiffness 57000 (kN/m) and effective damping 12000 (kN- /m)
c) RCC Frame with viscoelastic damper – position 2 viscoelastic damper need to in software modeled as a link property with effective stiffness 57000 (kN/m) and effective damping 12000 (kN- /m).
d) RCC Frame with viscoelastic damper – position 3 viscoelastic damper need to in software modeled as a link property with effective stiffness 57000 (kN/m) and effective damping 12000 (kN- /m)
e) RCC Frame with friction damper – position 1 Friction damper need to in software modeled as a link property with weight - 4.2116 kN and effective stiffness - 23772.853kN/m
f) RCC Frame with friction damper – position 2 Friction damper need to in software modeled as a link property with weight - 4.2116 kN and effective stiffness - 23772.853kN/m
g) RCC Frame with friction damper – position 3 Friction damper need to in software modeled as a link property with weight - 4.2116 kN and effective stiffness - 23772.853kN/m
h) RCC Frame with tuned mass damper – position 1 Mass damper need to in software modeled as a link property with weight - 39.269kN and effective stiffness - 9070.41kN/m
i) RCC Frame with tuned mass damper – position 2 Mass damper need to in software modeled as a link property with weight - 49.08677885kN and effective stiffness - 11338.01kN/m
j) RCC Frame with tuned mass damper – position 3 Mass damper need to in software modeled as a link property with weight - 49.08677885kN and effective stiffness - 11338.01kN/m

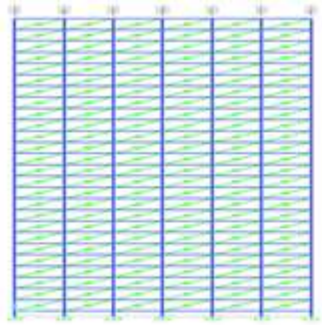

Fig a. Elevation of damper – position 1

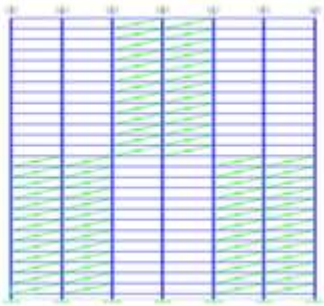

Fig. b. Elevation of damper – position 2

Fig. c Elevation of damper – position 3

V. Results And Discussions

Base shear

The response spectrum method had been adopted for seismic analysis in SAP 2000. The Table No.5a shows maximum base shear in X direction for RCC Frame and Figure 5.a shows graph of maximum base shear in X direction for RCC Frame without damper, Frame with Viscoelastic damper 1, Frame with Viscoelastic damper 2, Frame with Viscoelastic damper 3, Frame with Friction damper 1, Frame with Friction damper 2, Frame with Friction damper 3, Frame with Tuned mass damper 1, Frame with Tuned mass damper 2 and Model 10 is Frame with Tuned mass damper 3.

Type of Model	**Base shear (kN)**
Without damper	6658.92
Viscoelastic damper 1	6662.17
Viscoelastic damper 2	6657.36
Viscoelastic damper 3	6658.95
Friction damper 1	6725.41
Friction damper 2	6692.05
Friction damper 3	6691.21
Tuned mass damper 1	7269.31
Tuned mass damper 2	7038.11
Tuned mass damper 3	7042.75

Table 5.a: Base shear (kN) in X-direction

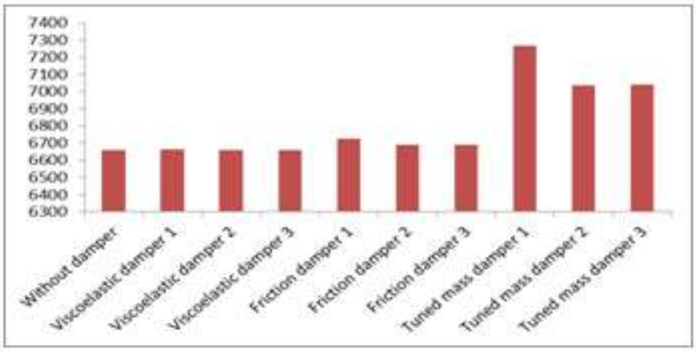

Figure 5. a: Base shear (kN) in X-direction

It shows that base shear values is maximum for frame tuned mass damper 1 and minimum for frame with viscoelastic damper 2.

The Table No. 5.b shows maximum base shear in Y direction for RCC Frame and Figure 5.2 shows graph of maximum base shear in Y direction for RCC Frame without damper, Frame with Viscoelastic damper 1, Frame with Viscoelastic damper 2, Frame with Viscoelastic damper 3, Frame with Friction damper 1, Frame with Friction damper 2, Frame with Friction damper 3, Frame with Tuned mass damper 1, Frame with Tuned mass damper 2 and Model 10 is Frame with Tuned mass damper 3.

Type of Model	Base shear (kN)
Without damper	5436.97
Viscoelastic damper 1	5434.68
Viscoelastic damper 2	5435.47
Viscoelastic damper 3	5436.64
Friction damper 1	5491.22
Friction damper 2	5464.78
Friction damper 3	5465.16
Tuned mass damper 1	5936.74
Tuned mass damper 2	5748.12
Tuned mass damper 3	5750.7

Table 5.b: Base shear (kN) in Y-direction

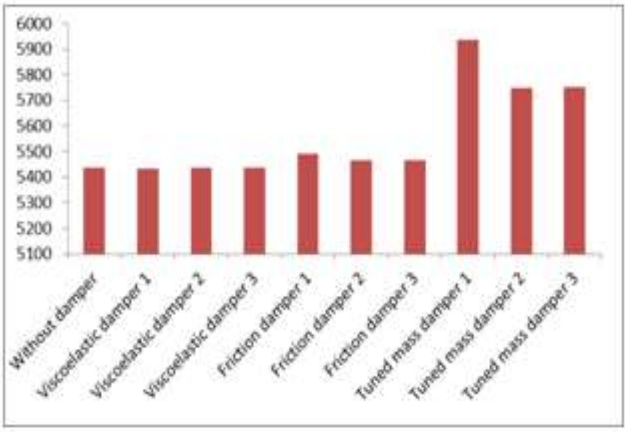

Figure 5. b: Base shear (kN) in Y-direction

It shows that base shear values is maximum for frame tuned mass damper 1 and minimum for frame with viscoelastic damper 1.

Maximum Lateral Displacement

The response spectrum method had been adopted for seismic analysis in SAP 2000. The Table No. 5.c shows maximum lateral displacement in X direction for RCC Frame and Figure 5.c shows graph of maximum lateral displacement in X direction for RCC Frame without damper, Frame with Viscoelastic damper 1, Frame with Viscoelastic damper 2, Frame with Viscoelastic damper 3, Frame with Friction damper 1, Frame with

Friction damper 2, Frame with Friction damper 3, Frame with Tuned mass damper 1, Frame with Tuned mass damper 2 and Model 10 is Frame with Tuned mass damper 3.

Type of Model	Joint Displacement(mm)
Without damper	0.373006
Viscoelastic damper 1	0.197273
Viscoelastic damper 2	0.251476
Viscoelastic damper 3	0.281089
Friction damper 1	0.248567
Friction damper 2	0.289909
Friction damper 3	0.316382
Tuned mass damper 1	0.013018
Tuned mass damper 2	0.012471
Tuned mass damper 3	0.012469

Table 5.c: Maximum Lateral Displacement (mm) in

X-direction

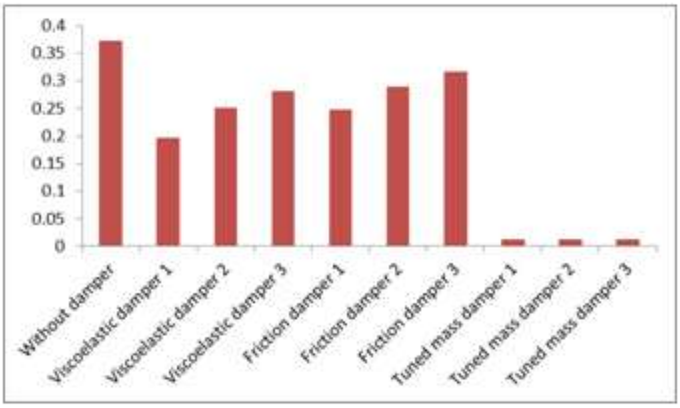

Figure 5.c: Maximum Lateral Displacement (mm) in

X-direction

It shows that lateral displacement is maximum for frame without damper and minimum for frame with mass tuned damper 3.

Table No. 5.d shows maximum lateral displacement in Y- direction for RCC Frame and Figure 5.d shows graph of maximum lateral displacement in Y direction for RCC Frame without damper, Frame with Viscoelastic damper 1, Frame with Viscoelastic damper 2, Frame with Viscoelastic damper 3, Frame with Friction damper 1, Frame with Friction damper 2, Frame with Friction damper 3, Frame with Tuned mass damper 1, Frame with Tuned mass damper 2 and Model 10 is Frame with Tuned mass damper 3.

Type of Model	Joint Displacement(mm)
Without damper	0.284706
Viscoelastic damper 1	0.169677
Viscoelastic damper 2	0.221026
Viscoelastic damper 3	0.220071
Friction damper 1	0.187614
Friction damper 2	0.236224
Friction damper 3	0.22939
Tuned mass damper 1	0.002334
Tuned mass damper 2	0.002255
Tuned mass damper 3	0.002261

Table 5.d: Maximum Lateral Displacement (mm) in

Y-direction

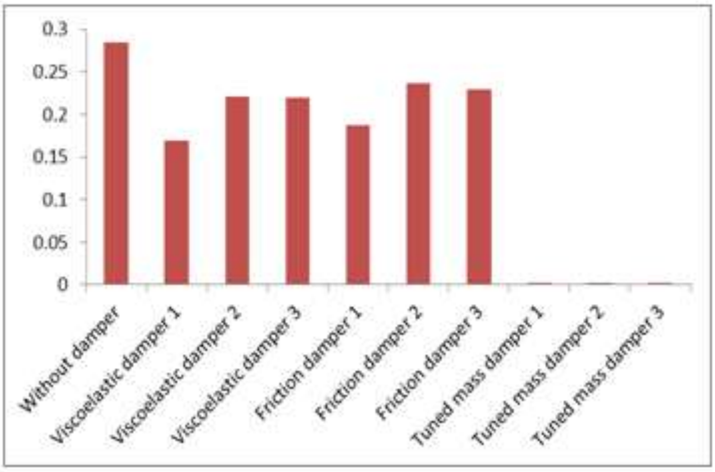

Figure 5.d: Maximum Lateral Displacement (mm) in

Y-direction

It shows that lateral displacement is maximum for frame without damper and minimum for mass tuned damper 2.

Table No. 5.e shows maximum lateral displacement in Z- direction for RCC Frame Figure 5.e shows graph of maximum lateral displacement in Z-direction for RCC Frame without damper, Frame with Viscoelastic damper 1, Frame with Viscoelastic damper 2, Frame with Viscoelastic damper 3, Frame with Friction damper 1, Frame with Friction damper 2, Frame with Friction damper 3, Frame with Tuned mass damper 1, Frame with Tuned mass damper 2 and Model 10 is Frame with Tuned mass damper 3.

Type of Model	**Joint Displacement(mm)**
Without damper	0.04207
Viscoelastic damper 1	0.07094
Viscoelastic damper 2	0.33152
Viscoelastic damper 3	0.31799
Friction damper 1	0.09487
Friction damper 2	0.69983
Friction damper 3	0.32092
Tuned mass damper 1	0.09637
Tuned mass damper 2	0.59964
Tuned mass damper 3	0.31861

Table 5.e: Maximum Lateral Displacement (mm) in

Z-direction

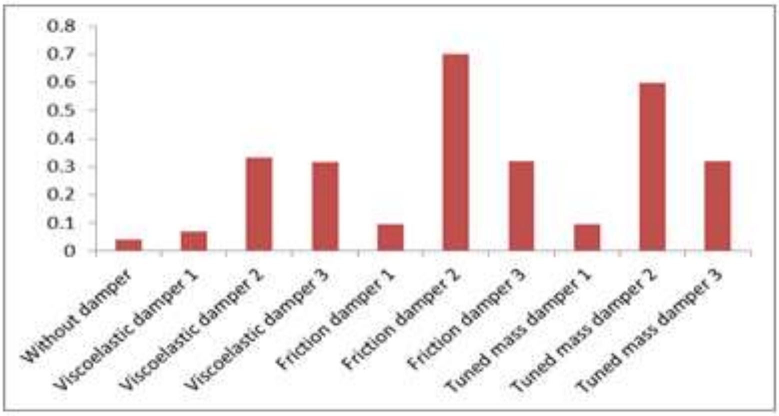

Figure 5.e: Maximum Lateral Displacement (mm) in

Z-direction

It shows that lateral displacement is maximum for frame Friction damper 2 and minimum for frame without damper.

VI. Conclusion

The results of this investigation shows that, the response of structure can be dramatically reduced by using damper without increasing the stiffness of the structure. The following conclusions were drawn:

It has been found that the viscoelastic damper, friction damper and tuned mass damper can be successfully used to control vibration of the structure.

Displacement is controlled with damper in outer position in structure. Therefore, the damper should be placed in outer position for best control of the first mode.

It is observed that, displacement is controlled by substantial amount by using tuned mass damper whereas displacement to a considerable amount by using viscoelastic and friction dampers.

Tuned mass dampers are unique in combating the wind forces, for its material, whereas other dampers are suitable mostly for earthquake forces only.

The performance of tuned mass damper devices is much better for the tall buildings with slender design.

harmful to the structures and it is important to have simpler and regular shapes of frames as well as uniform load distribution of load around the building.

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