Performance study of coupled building connected by horizontalMR damper under damper parameters

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ABSTRACT- Because of their asymmetric nature, most actual structures are prone to significant reactivity and destruction during a seismic event. This imbalance in structures is caused mostly by unequal mass distribution and/or stiffness of structural components for elastic range. Buildings are particularly sensitive to earthquake-induced damage due to their asymmetric nature, which causes torsional deformations. The structural engineer's primary goalis to limit torsional response, mostly by minimizing eccentricity caused by unequal mass and stiffness distribution. However, due to stringent architectural and functional requirements, there are many limitations for avoiding eccentricity between mass and stiffness, and thus in such cases, implementation of supplemental energy dissipation devices proves to be an effective solution to minimize the lateral-torsional response of the buildings. The depicts EQX direction deformation for neighboring linked, alternative damper, double alternate dampers, and individual building. As we can see, the frequency of the Double Alternate Dampers is greater than that of the other. Alternate damper has percent more deformation than individual building.

KEYWORDS- *Stiffness, Torsional, Deformations, MR Damper, Reactivity*

1. INTRODUCTION

Many times, most of the real structures are prone to the severe response and damage during a seismic event due to their asymmetric nature. This asymmetry in the buildings arises primarily due to uneven distribution of mass and/or stiffness of the structural components for elastic range. Due to the asymmetric nature of buildings causing the torsional deformations, they are more vulnerable to the earthquake induced damage. The prime focus of the structural engineer is to reduce the torsional response mainly by avoiding the eccentricity which is produced due to uneven mass and stiffness distribution. However, there are many limitations for avoiding the eccentricity between mass and stiffness due to stringent architectural and functional requirements and hence in such cases, implementation of supplemental energy dissipation devices proves to be an effective solution to minimize the lateral-torsional response of the buildings.

1.2 Types of Dampers on Structural BuildingsFriction Dampers

Friction dampers (FDs) generate the desired energy discharges via the friction produced by two solid bodies sliding relative to each other. This is a common process used in the engineering field. It can also be applied to seismic building structures. This friction can also beused, on a smaller scale, to absorb kinetic motion energy. As such, developed passive FDs to improve a structure's seismic responses. This was based on the resistance developed between two interfaces to remove a number of different input energies. During seismic stimulation, thedevice was found to provide the desired amount of energy dissipation under a predetermined load. It was also found to be immune to thermal effects and have reliable performance and stable hysterical behavior.

Magnetorheological Dampers for Structural Buildings Magnetorheological Fluids

When subjected to a magnetic field, magnetorheological fluids change their rheological behavior in response to growing yield stresses. As such, MR fluids have great potential in the development of electromechanical devices as they provide a simple, responsive, quiet, and quick interface between mechanical and electronic control systems.

MR fluids were first discovered by Jacob Rainbow and have only grown in popularity since then. MR fluid is considered to be a multifunctional intelligent fluid as it can be rapidly modified and reversed in a short period of time (milliseconds) when a magnetic field is applied. In the absence of a magnetic field, MR fluids behave like Newtonian fluids. The magnetic field applied to MR fluids changes the arrangement of particles to form a chain-like shape. This chain-like shape modifies the fluid's rheological properties by drastically changing the value of the viscosity. This change in viscosity results in yield stress changes depending on the magnitude and direction of the applied magnetic field. The characterization of the rheological behavior of these fluids occurs at two stages: pre-yield and post-yield

Modeling of MR Dampers

The structure of a building is exceptionally vulnerable to seismic loads, especially seismic loads at higher frequencies. Additionally, the control systems used are widely discussed. This section discusses models and controls that have been used in MR dampers in previous studies. Small-scale MR dampers are mostly described using the Bingham model due to its simplicity. This model consists of dashpot and friction elements connected in parallel, while the damper force is formulated as shown in.

When the acceleration had a negative value, the measured force had a positive value. Conversely, when the acceleration had a positive value, the measured force had a negative value. This occurred when the velocity was zero. The self-tuning fuzzy model, a general modelcommonly used to improve MR dampers, was then utilized.

2. RELATED WORK

2.1 Magnetorheological Damping Systems on a Seismic Building.

Building structures are vulnerable to the shocks caused by earthquakes. Buildings that have been destroyed by an earthquake are very detrimental in terms of material loss and mental trauma. However, technological developments now enable us to anticipate shocks from earthquakes and minimize losses. One of the technologies that has been used, and is currently being further developed, is a damping device that is fitted to the building structure. There are various types of damping devices, each with different characteristics and systems. Multiple studies on damping devices have resulted in the development of various types, such as frictiondampers (FDs), tuned mass dampers (TMDs), and viscous dampers (VDs).

S. D. Bharti et.al (2014) examined Earthquake response of asymmetric building with MR damper. Plan asymmetric buildings are very susceptible to earthquake induced damage due to lateral torsional coupling, and the corners of these systems suffer heavy damage during earthquakes. Therefore, it is important to investigate the seismic behavior of an asymmetric plan building with MR dampers. In this study, the effectiveness of MR damper-based control systems has been investigated for seismic hazard mitigation of a plan asymmetric building. Furthermore, the influence of the building parameters and damper command voltage on the control performance is examined through parametric study. The building parameters chosen are eccentricity ratio and frequency ratio. The results show that the MR damper-based control systems are effective for plan asymmetric systems.

Yunbyeong Chae et.al (12 March 2014) examined Large-scale real-time hybrid simulation of a three-story steel frame building with magneto-rheological dampers. A series of large-scale real-time hybrid simulations (RTHSs) are conducted on a 0.6-scale 3-story steel frame building with magneto-rheological (MR) dampers. The lateral force resisting system of the prototype building for the study consists of moment resisting frames and damped brace frames (DBFs). The experimental substructure for the RTHS is the DBF with the MR dampers, whereas the remaining structural components of the building including the moment resisting frame and gravity frames are modeled via a nonlinear analytical substructure. Performing RTHS with an experimental substructure that consists of the complete DBF enables the effects of member and connection component deformations on system and damper performance to be accurately accounted for. Data from these tests enable numerical simulation models to be calibrated, provide an understanding and validation of the in-situ performance of MR dampers, and a means of experimentally validating performance-based seismic design procedures for real structures. The details of the RTHS procedure are given, including the test setup, the integrationalgorithm, and actuator control.

Osamu Yoshida et.al (2015) Conducted research on Experimental verification of torsional response control of asymmetric buildings using MR dampers. This paper proposes a semi active control system to reduce the coupled lateral and torsional motions in asymmetric buildings subjected to horizontal seismic excitations. Magnetorheological (MR) dampers are applied as semi active control devices and the control input determination is based on a clipped- optimal control algorithm which uses absolute acceleration feedback. The performance of thismethod is studied experimentally using a 2-story building model with an asymmetric stiffnessdistribution.

Mehmet E et.al (2014) Examined Optimal design of semi active control for adjacent buildings connected by MR damper based on integrated fuzzy logic and multi-objective genetic algorithm. An optimal design strategy based on genetic algorithms (GA) is proposed for nonlinear hysteretic control devices that prevent pounding damage and achieve the best resultsin seismic response mitigation of two adjacent structures. An integrated fuzzy controller is used in order to provide the interactive relationships between damper forces and input voltages for MR dampers based on the modified Bouc-Wen model. Furthermore, Linear Quadratic Regulator (LQR) and H2/LQG (Linear Quadratic Gaussian) controllers based on clipped voltage law (CVL) are also used to compare the results obtained by fuzzy controller. This study employs the main objectives of the optimal design that are not only to reduce the seismic responses but also to minimize the total cost of the damper system. A set of Pareto optimal solutions is also conducted with the corresponding results obtained from the optimal surface of Pareto solutions in this study. As a result, decreasing the number of dampers does necessarily increase the efficiency of the system. In fact, reducing the number of dampers for the dynamic response of the system can contribute more than increasing the number of dampers.

Xiufang Lin et.al (2020) Conducted research on Modified crow search algorithm–based fuzzy control of adjacent buildings connected by magnetorheological dampers considering soil–structure interaction. Finding effective means of protecting structures from dynamic hazards is a challenging task and has gained increasing significance. As for the seismically excited adjacent structures, an intelligent control strategy using magnetorheological dampers as connection devices considering soil–structure interaction is presented. First, the calculation model for the coupled structure–soil–structure interaction–magnetorheological damper system is developed, and the motion equation for calculating the seismic responses is then derived. Second, a semiactive control strategy integrating a modified crow search algorithm into a fuzzy logic control is proposed. Omar A.S. Al-Fahdawi et.al examined Utilizing the Adaptive Control in Mitigating the Seismic Response of Adjacent Buildings Connected with MR Dampers. The use of the adaptive controller is advantageous as it can cope with the structural characteristics change during the severe events such as earthquakes. The simple Bouc-Wen model is considered in the analysis to model the highly nonlinear behavior of the MR damper. The Linear Quadratic Regulator (LQR) is used to design the reference model with desired trajectories. The change in the structural characteristics is reflected as a reduction in the plant’s mass and stiffness as a result of the damage in the structural system. The efficacy of the simple adaptive controller is investigated in the presence of damage and in case where the system still undamaged. The results show that connecting adjacent buildings with MR dampers driven by the Simple Adaptive Control method is quite effective in mitigating the seismic responses.

Chih-Chen Chang et.al (June 2002) Examined Intelligent technology-based control of motion and vibration using MR dampers. Due to their intrinsically nonlinear characteristics, development of control strategies that are implementable and can fully utilize the capabilities of semiactive control devices is an important and challenging task. In this study, two control strategies are proposed for protecting buildings against dynamic hazards, such as severe earthquakes and strong winds, using one of the most promising semiactive control devices, the magnetorheological (MR) damper. The first control strategy is implemented by introducing an inverse neural network (NN) model of the MR damper. These NN models provide direct estimation of the voltage that is required to produce a target control force calculated from some optimal control algorithms. The major objective of this research is to provide an effective means for implementation of the MR damper with existing control algorithms. The second control strategy involves the design of a fuzzy controller and an adaptation law. The control objective is to minimize the difference between some desirable responses and the response of the combined system by adaptively adjusting the MR damper. The use of the adaptation law eliminates the need to acquire characteristics of the combined system in advance. Because the control strategy based on the combination of the fuzzy controller and the adaptation law doesn'trequire a prior knowledge of the combined building-damper system, this approach provides a robust control strategy that can be used to protect nonlinear or uncertain structures subjected to random loads.

3. METHODOLOGY

3.1 PROBLEM STATEMENT

Modeling and analysis of multistorey framed structure consisting of ordinary moment resisting frames, subjected to various different load conditions involve large degrees of freedom to be formulated. Hence huge stiffness matrix evaluation and subsequent computation of forces becomes a tedious job for hand calculations. The problem at hand can be solved with the help of software like STAAD/ETABS/ANSYS etc. for analyzing and designing multistoried buildings models. The model is analyzed using structural design software STAAD Pro 2007 structural engineering software. For being validated by many structural design firms and manyscrutinizing authorities as well the post processing graphical capabilities for viewing bending moment diagrams, shear force diagrams, deflection diagrams are used to the fullest extent to verify logical behavior pattern by engineering common sense.

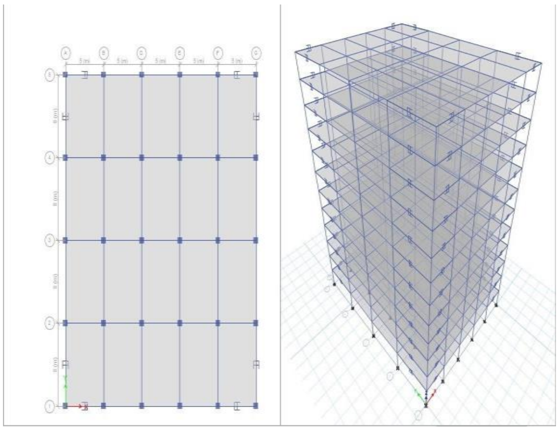


Fig No - 12 Storey With Damper

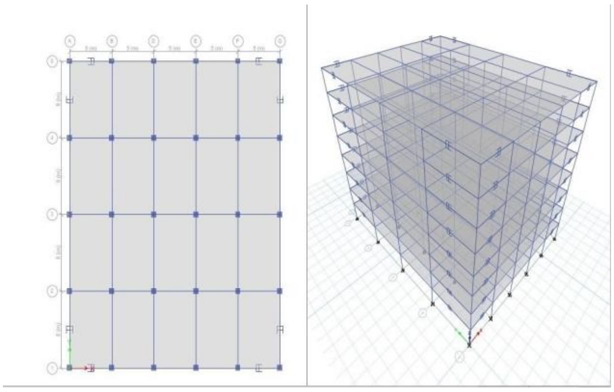


Fig No -8 Storey Building With Damper

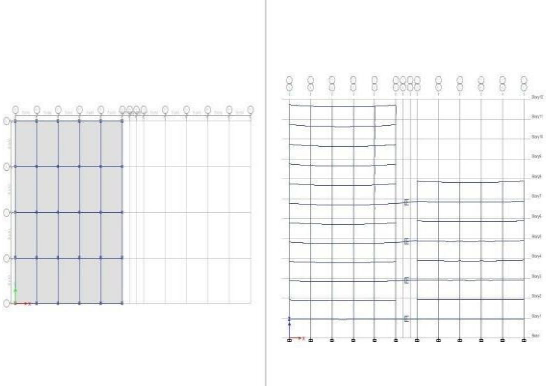


Fig No-Alternate Damper Model

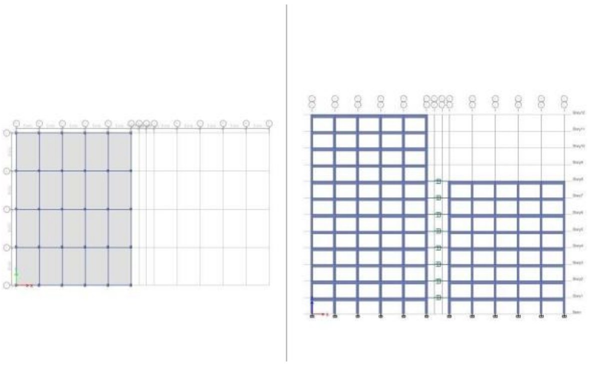


Fig No -All Floor Level Mr Damper

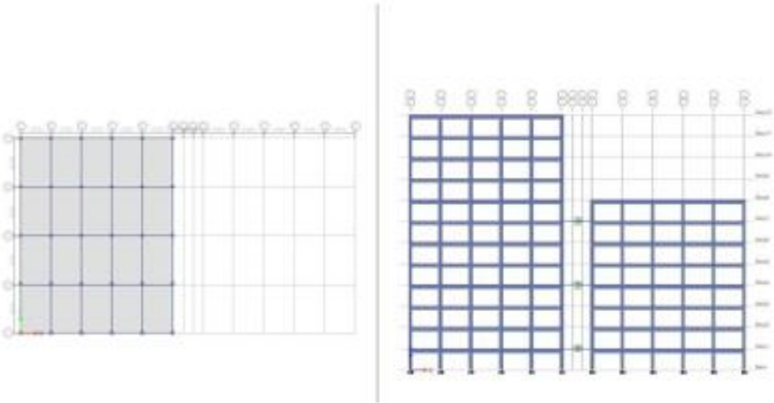
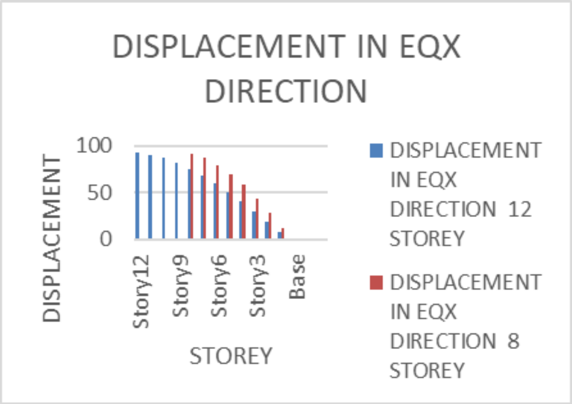


Fig No-Coupled Building with Double Alternate Damper

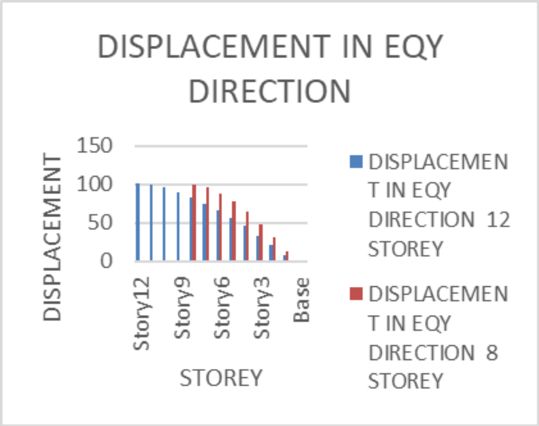
4. RESULT AND DISCUSSION

Table no 4.1- Displacement in EQX Direction

DISPLACEMENT IN EQX DIRECTION			
	12 STOREY	8 STOREY	
Story12	93.474		
Story11	90.812		
Story10	86.822		
Story9	81.561		
Story8	75.176	91.07	Story8
Story7	67.794	86.925	Story7
Story6	59.523	79.883	Story6
Story5	50.445	70.136	Story5
Story4	40.64	58.056	Story4
Story3	30.201	44.028	Story3
Story2	19.267	28.507	Story2
Story1	8.206	12.265	Story1
Base	0	0	Base



Graph no 4.1- Displacement in EQX Direction



Graph no 4.2- Displacement in EQX Direction

The above table shows Displacement in X direction for G+6 and G+10 storey building. G+10 building has lower Displacement than the G+10 storey building by 2.57 %

The above table shows Displacement in Y direction for G+6 and G+10 storey building. G+10 building has lower Displacement than the G+10 storey building by 2.57 %

Table no 4.3- Frequency

FREQUENCY		
MODE SHAPE	12 STOREY	8 STOREY
1	0.688	1.042
2	0.761	1.159
3	0.844	1.271
4	2.091	3.187
5	2.312	3.523
6	2.555	3.863

Graph no 4.3- frequency

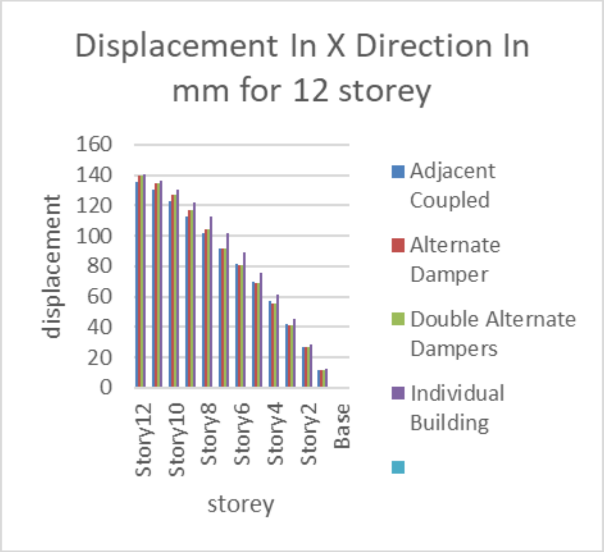
The above table shows Frequency in direction for G+6 and G+10 storey building. G+10 building has lower frequency than the G+10 storey building By 33.97 %

4.4 Comparison for 8 and 10 storey

COMPARISON OF DAMPERS FOR INDIVIDUAL 12 STOREY BUILDING

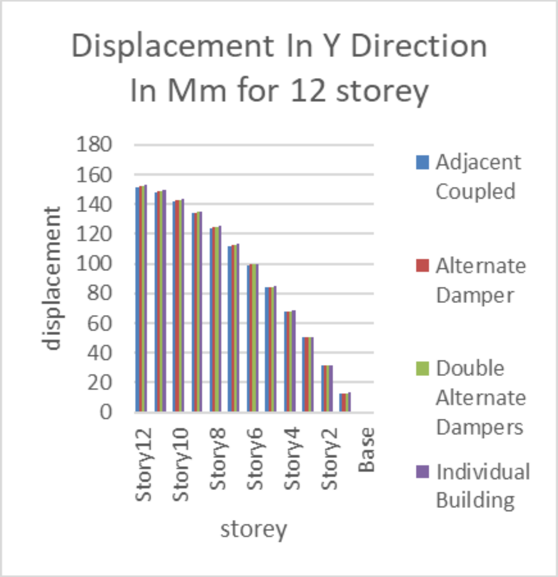
Table no 4.4- Displacement In X Direction In mm for 12 storey

Displacement In X Direction In mm for 12 storey					
	Adjacent Coupled	Alternate Damper	Double Alternate Dampers	Individual Building	
Story12	135.404	139.796	139.8	140.171	Story12
Story11	130.504	134.746	134.751	136.193	Story11
Story10	122.905	126.944	126.949	130.205	Story10
Story9	112.928	116.651	116.657	122.316	Story9
Story8	101.745	104.405	104.412	112.74	Story8
Story7	92.054	91.411	91.429	101.671	Story7
Story6	81.682	80.309	80.382	89.265	Story6
Story5	69.883	68.514	68.621	75.651	Story5
Story4	56.713	55.573	55.606	60.947	Story4
Story3	42.365	41.533	41.516	45.293	Story3
Story2	27.114	26.586	26.572	28.896	Story2
Story1	11.566	11.347	11.344	12.326	Story1
Base	0	0	0	0	Base



Graph no 4.4- Displacement In X Direction In mm for 12 storey

Above graph shows deformation in EQX direction for adjacent coupled, alternate damper, Double alternate dampers, individual building. as we can see that individual building has the higher deformation than the other. individual building has higher deformation than adjacent coupled by 3.40 %

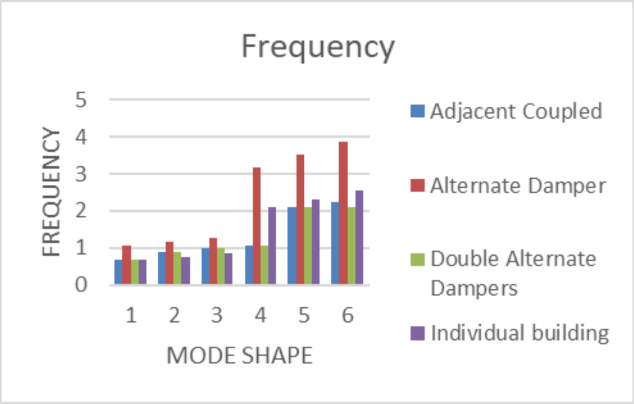


Graph no 4.5- Displacement In Y Direction In mm for 12 storey

Above graph shows deformation in EQY direction for adjacent coupled, alternate damper, Double alternate dampers, individual building. as we can see that individual building has the higher deformation than the other. individual building has higher deformation than adjacent coupled by 0.99 %

Table no 4.6- frequency

FREQUENCY for 12 storey				
MODE SHAPE	Adjacent Coupled	Alternate Damper	Double Alternate Dampers	Individual building
1	0.689	1.042	0.689	0.688
2	0.893	1.159	0.883	0.761
3	0.989	1.271	0.978	0.844
4	1.042	3.187	1.042	2.091
5	2.092	3.523	2.092	2.312
6	2.236	3.863	2.092	2.555



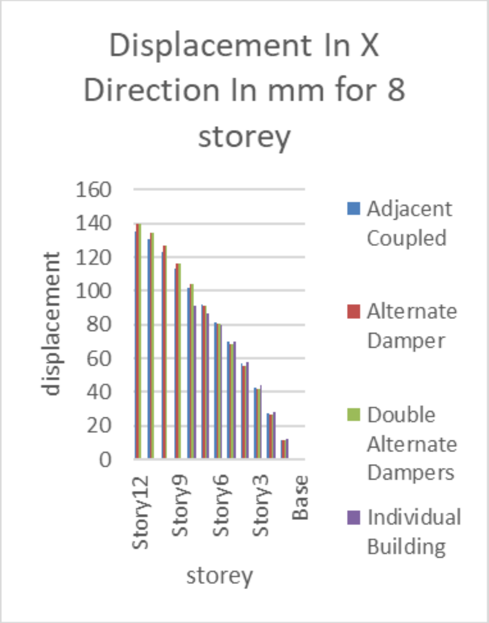
Graph no 4.6- Frequency

Above graph shows frequency direction for adjacent coupled, alternate damper, Double alternate dampers, individual building. as we can see that alternate damper has the higher frequency than the other. Alternate damper has higher deformation than individual building by 0.14 %.

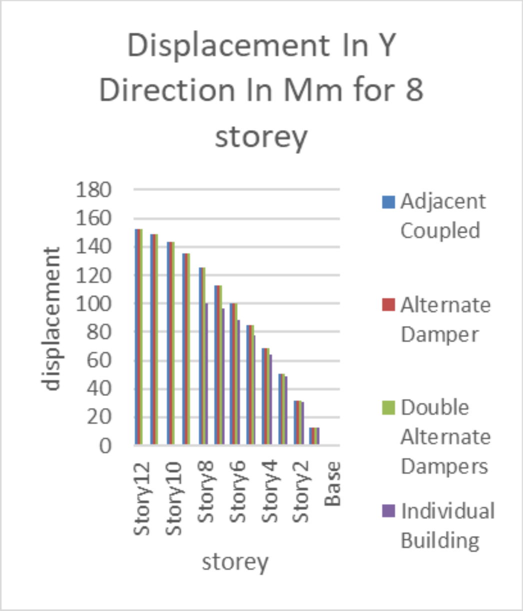
4.7 COMPARISON OF DAMPERS FOR INDIVIDUAL 8 STOREY BUILDING

Table no 4.7- Displacement In X Direction In mm for 8 storey

Displacement In X Direction In mm for 8 storey					
Storey	Adjacent Coupled	Alternate Damper	Double Alternate Dampers	Individual Building	Storey
Story12	135.404	139.796	139.8		
Story11	130.504	134.746	134.751		
Story10	122.905	126.944	126.949		
Story9	112.928	116.651	116.657		
Story8	101.745	104.405	104.412	91.07	Story8
Story7	92.054	91.411	91.429	86.925	Story7
Story6	81.682	80.309	80.382	79.883	Story6
Story5	69.883	68.514	68.621	70.136	Story5
Story4	56.713	55.573	55.606	58.056	Story4
Story3	42.365	41.533	41.516	44.028	Story3
Story2	27.114	26.586	26.572	28.507	Story2
Story1	11.566	11.347	11.344	12.265	Story1
Base	0	0	0	0	Base



Graph no 4.7- Displacement In X Direction In mm for 8 storey



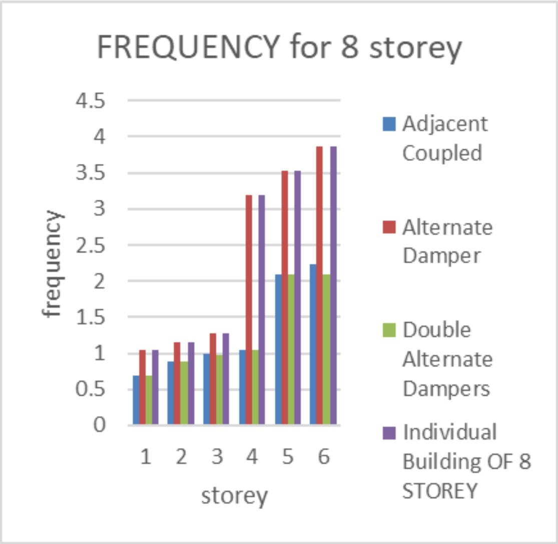
Graph no 4.8- Displacement In Y Direction In mm for 8 storey

Above graph shows deformation in EQX direction for adjacent coupled, alternate damper, Double alternate dampers, individual building. as we can see that Double Alternate Dampers has the higher frequency than the other. Alternate damper has higher deformation than individual building by 32.74 %.

Above graph shows frequency direction for adjacent coupled, alternate damper, Double alternate dampers, individual building. as we can see that adjacent coupled, alternate damper, Double alternate dampers has the higher frequency than the individual building. Alternate damper has higher deformation than individual building by 34.20 %.

Table no 4.9- frequency

FREQUENCY for 8 storey				
MODE SHAPE	Adjacent Coupled	Alternate Damper	Double Alternate Dampers	Individual Building OF 8 STOREY
1	0.689	1.042	0.689	1.042
2	0.893	1.159	0.883	1.159
3	0.989	1.271	0.978	1.271
4	1.042	3.187	1.042	3.187
5	2.092	3.523	2.092	3.523
6	2.236	3.863	2.092	3.863



Graph no 4.9- Frequency

Above graph shows frequency direction for adjacent coupled, alternate damper, Double alternate dampers, individual building. as we can see that alternate damper has the higher frequency than the other. Adjacent Coupled has higher deformation than individual building by 33.87 %.

CONCLUSION

Comparison between 8 and storey and 12 storey

The Displacement in X direction for G+8 and G+10 storey building. G+10building has lower Displacement than the G+10 storey building by 2.57 %

The Displacement in Y direction for G+8 and G+10 storey building. G+10building has lower Displacement than the G+10 storey building by 2.57 %

The Frequency in direction for G+8 and G+10 storey building. G+10 building has lower frequency than the G+10 storey building by 33.97 %

Comparison of Dampers for Individual 8 Storey Building

Above graph shows deformation in EQX direction for adjacent coupled, alternate damper, Double alternate dampers, individual building. as we can see that Double Alternate Dampers has the higher frequency than the other. Alternate damper has higher deformation than individual building by 32.74 %.

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Above graph shows frequency direction for adjacent coupled, alternate damper, Double alternate dampers, individual building. as we can see that alternate damper has the higher frequency than the other. Adjacent Coupled has higher deformation than individual building by 33.87 %.

Comparison of Dampers for Individual 12 Storey Building

Above graph shows deformation in EQX direction for adjacent coupled, alternate damper, double alternate dampers, individual building. as we can see that individual building has the higher deformation than the other. individual building has higher deformation than adjacent coupled by 3.40 %

Above graph shows deformation in EQY direction for adjacent coupled, alternate damper, Double alternate dampers, individual building. as we can see that individual building has the higher deformation than the other. individual building has higher deformation than adjacent coupled by 0.99 %

Above graph shows frequency direction for adjacent coupled, alternate damper, Double alternate dampers, individual building. as we can see that alternate damper has the higher frequency than the other. Alternate damper has higher deformation than individual building by 0.14 %.

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