Study of Effect of Friction Damper on Mitigation of Pounding Effect Responses of Adjacent Building

Shweta Sharad Kulkarni[1], S.A.Bhalchandra[2]
[1, 2]GOVT COLLEGE OF ENGINEERING AURANGABAD

Abstract- *Seismic pounding between closely spaced structure is the main cause of building damages.Due to earthquake induced viberation, the building which are adjacent will move out of phase resulting in the collision .seismic pounding can be prevented by use of dampers at various locations in the building..the current study aims to mitigate seismic pounding observed in the same height adjacent multistoried building G+9. Frictions dampers are provided at various location to study seismic response .G+9 multistoried building with and without friction damper are modelled and analyzed by Response spectrum method using ETABS 2020. Seismic gap is considered from IS Code method.Gap element has used to connect multistoried buildings.seismic responses in terms of storey displacement, storey shear, overturning moment, storey stiffness and drift are considered and results are compared.*

Keywords- seismic pounding, seismic gap, Response spectrum method, adjacent building.

I. INTRODUCTION

Earthquake is most destructive and unpredictable natural hazards that occur in most contents. In the past few decades, the world has experienced a large number of devastating earthquakes which lead to the collapse of buildings, severe structural damages, resulting in loss of human life and property. The occurrence of such damages proves that lifeline structures present within the seismic-prone regions should be designed thoroughly to prevent them from earthquakes.

An earthquake with a magnitude of six is capable of causing vulnerability to severe damage and collapse during moderate to strong ground motion. Among the possible structural damages, Pounding is one of the causes of damage in the building. The seismic pounding effect has been commonly observed in several earthquakes. Investigation of past and recent records has illustrated several instances of building pounding damage. Building pounding was observed during the El Centro earthquake (1940), the Mexico earthquake (1985), the sequenay earthquake (1988) in Canada, the Cairo earthquake (1992), Northridge (1994), Kobe (1995), Kocaeli earthquake (1999) and the Nepal earthquake (2015)

Adjacent buildings with insufficient separation, having different dynamic characteristics may vibrate out of the phase during earthquakes is termed as Pounding. Residential buildings, educational buildings, Institutional buildings, etc. are a gaggle of buildings next to every other with an equivalent utility. Constantly, these adjoining buildings are designed with similar structural property for an economy in the design, construction, and maintenance costs. The similar architectural and structural design will make these buildings dynamically similar, having the same natural frequency and other dynamic properties [1].

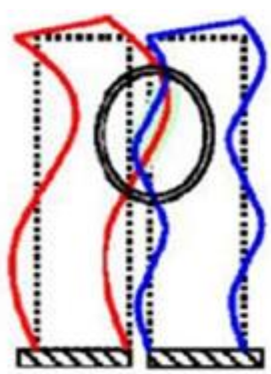

Fig 1.: Out of phase vibration of two adjacent structures

an enormous amount of energy is released during earthquake vibration and transferred to the building. Hence the structure undergoes large displacement, drifts because of the release of unwanted energy leading to the collision of adjacent buildings ultimately failing the structure. The simplest and the effective way to prevent seismic pounding damage is to provide safe separation distance between the two adjacent buildings, sometimes getting of required safe separation gap is highly impossible. Due to limited availability of land space, high cost of land the buildings are constructed close to each other [1]. Hence, for the protection of the structure, there's a requirement for energy dissipation systems to accommodate the relative motions of the adjacent buildings. one among the advantageous alternatives to supply seismic gap between the adjacent structures is by introducing the structural control devices in the form of retrofit and thereby minimizing the building pounding effect.

In seismic structures progression, the lateral force due to earthquake can be reduced by the use of Seismic control devices called “Dampers”. During seismic events, an enormous amount of energy is transferred to the structure. The Friction dampers (FD) are the more applied devices for controlling the responses of the structures. These devices are applied based on different construction techniques to reduce the structural responses to the seismic excitation

II. LITERATURE REVIEW

Ramakrishna Uppari proposed that adjacent similar building connected by viscoelastic dampers are considered for analysis. For the study, two ten story Reinforced Concrete buildings which are dynamically similar in natur e, were considered. The optimization and entire simulation have been performed using MATLAB R2015a Software. The dampers had been connected by various configuration, diagonal damper, cross damper, alternate diagonal. The Similar buildings were subjected to El-Centro ground motion, and Newmark’s beta method was used to calculate seismic response at each. The matched ground motion data were obtained using Seismo-Match-2018.Six earthquake ground motion records were used.

The comparative study with various damper configurations has shown that alternative diagonal dampers are effectual and economical in seismic response reduction compared to cross and diagonal damper configurations. At optimized location by providing only 4 damper, the seismic performance of the coupled building has been economically improved compared to alternate diagonal dampers connected on all floors [1].

Majd Armali proposed on comparision of shear wall system and friction damper in high rise building and propose some design optimization of the position and number of dampers installed in the building. The seismic performance of the building with friction damper was compared with performance of conventional system (shear wall system). 40 story high rise RC building with 123 m height was considered for analysis. Non-linear modal Time History Analysis was carried out using EL Centro Ground motion data using ETABS Software.

The time history analysis of Acceleration, and displacement shows reduction over time period with the use of dampers. There was 43.77% reduction in base shear, 21.50 % reduction in structural period, 50 % reduction in Storey displacement with use of friction damper system compared with conventional (shear wall) system. There was a considerable reduction in story shear, maximum story displacement and story drifts when the damper were used in buildings [2].

Farzad Hejazi presented to locate the optimum viscous damper location inside the shear wall and to find the effect of shear wall under three-dimensional earthquake excitations.3 story shear wall frame structure reinforced concrete building with height of 10.5 m has been modeled using ETABS. Model type one, the shear wall was located at the middle span of three spans frame. Model type two, the shear wall was located at the corner spans of the same frame. 10 models have been modelled, damper at bottom, middle, top, all stories, bare frame. The nonlinear time history El Centro 1940 record data was considered for the analysis using ETABS software.

The shear wall frame with viscous damper at the top of the structure accomplished best performance compared to shear wall frame with average peak displacement reduction of 25.15 % and 25.93% for model 1 and 2 equipped with viscous damper at top. Model 2 shear wall with damper at top gave reduced values based on structural member forces. The optimum location of the viscous damper equipped in the shear wall frame was at the top of the model type two shear wall frame structure [3].

Min Zhang studied the seismic response of frame structure with friction dampers. A 10 story Reinforced Concrete building has been modelled using SAP 2000. 5 models have been modelled, (a) No damper; (b) damper only in the 1st floor; (c) damper in the 1st to 3rd floor; (d) no damper only in the 6th floor; (e) dampers in each floor. The structure was subjected to following earthquake wave (a) Oroville earthquake wave, (b)EL Centro earthquake wave, (c)Hollywood Storage earthquake wave and d) Tian Jing earthquake wave. 1.1 m/s2 was the peak acceleration of the above earthquake wave considered.

It was observed that when the friction damper was evenly installed on each floor, the maximum displacement of each floor can be reduced more greatly than that of the corresponding seismic structure. Friction damper was effective only to the floor on which the damper are installed, and had little effect on the damping of the other floors [4].

III AIM AND OBJECTIVE

- To study the seismic performance of adjacent Multistoried Building with and without friction Dampers Using Response Spectrum Method.
- To study Effect of Friction Dampers on Mitigation of structural Pounding and Responses like Displacement

Drift , overturning Moment, Base shear Using Etabs Software.

IV. METHODOLOGY

The current study aims to mitigate the seismic pounding observed in the adjacent buildings connected with Friction Dampers (FD). For the purpose of study Building models of similar heights are considered for analysis i.e. Model 1 of G+9 multi-storied similar height adjacent buildings with and without Dampers are analysed with Response Spectrum Method . The structures are modeled and analyzed using ETABS 2020. The Earthquake loads and analyses methods performed in the study are as per IS 1893:2016 (part 1). Code IS 456:2000 for concrete. By keeping the mass of the damper and zone of the building constant, Total 8 Models with various location of Dampers are prepared for Response spectrum Analysis.

Initially the analysis is carried out considering individual buildings and calculated for seismic gap.

Then the buildings are placed adjacently with proper seismic gap considered to observe seismic pounding effect between the adjacent structures.Friction dampers are installed in between the structures if they are subjected to seismic pounding. Two adjacent building are connected with spring element .for various position of Friction damper in adjacent building of same height and different height are analysed using ETABS software by using Response spectrum method.

V. MODEL DESCRIPTION

For present Research work 4 Different models are considered for analysis.

Model 1 Two adjacent same height multistoried buildings without Damper as shown in fig 2
Model 2 Two adjacent same height multistoried buildings with Damper at floor as shown in Fig 3
Model 3 Two adjacent same height multistoried buildings with one Damper at two floor as shown in Fig 4
Model 4 Two adjacent same height multistoried buildings with Damper at alternate floor as shown
In fig 5

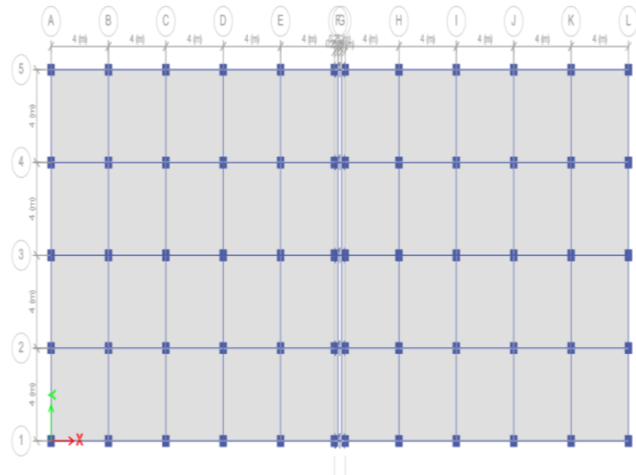

Fig 2 plan of Building without Damper Model 1

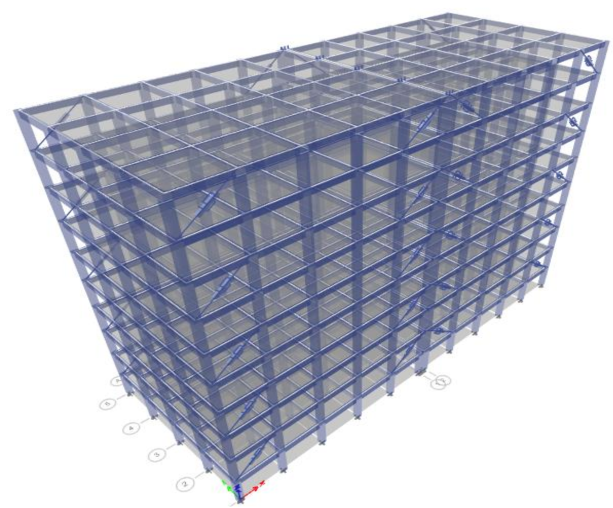

Fig 3 3-D view of Building with Damper at each floor Model 2

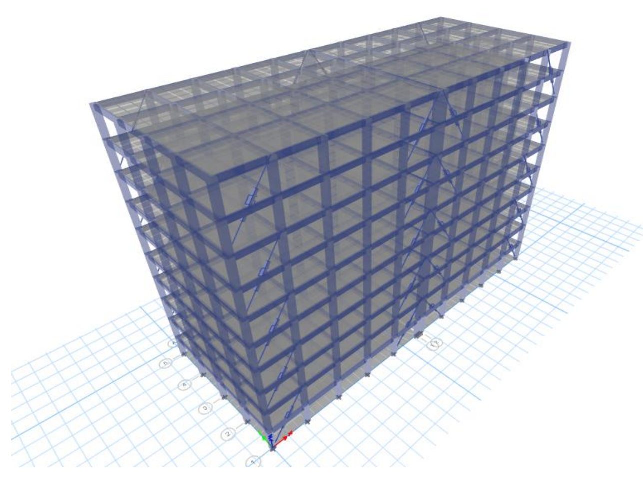

Fig 43-Dview Building with one Dampers at each floor Model 3

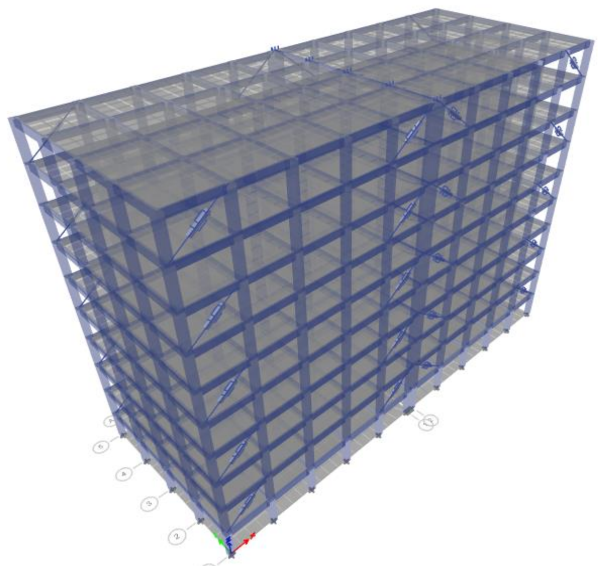

Fig 5 3-D Model Building with Dampers at Alternate floor Model 4

Table 1 shows Geometric details, Section properties, material properties and loads.

Table1: Building Properties ofModel1 &Model2 considered for the analysis

GEOMETRICDETAILS	
Structure type	RCC building
Type of the Structure	Symmetric
Number of Storys	Building1:G+9 Building2: G+14
Story Height (m)	3.2 m
SECTION PROPERTIES	
Slab Thickness (mm)	150MM
Beam size(mm)	300X500 mm
Column size (mm)	500x500 mm
Thickness of the brick wall (mm)	230mm
Thickness of parapet wall (mm)	115mm
MATERIAL PROPERTIES	
Grade of Concrete	M30
Grade of Steel	HYSD500
LOADS	
Live load (kN/m^2)	3
Floor Finish Load (kN/m^2)	1
Dead load of wall (kN/m)	12.42
Dead load of parapet wall (kN/m)	2.07
SEISMIC PROPERTIES	
Seismic zone factor (Z)	0.36(Zone V)
Importance factor(I)	1
Response reduction factor (R)	5
Site type	II(medium)
LINK TYPE- PLASTIC WEN	

Seismic Gap : Minimum Seismic gap Requirement to avoid pounding as shown in table **2 as per IS 4326**

Table **2** Minimum Seismic gap Requirement

SL.NO	Type of Construction	Gap width/story in mm for Design Seismic Coefficient αh = 0.12
1.	Box system or frames with shear walls	15
2.	Moment resistant reinforced concrete frame	20
3.	Moment resistant steel frame	30

According to IS 1893 part 1:2016 clause 7.11.3:

1. Two adjacent buildings shall be separated by a distance equal to R times the sum of storey displacements Δ_1 and Δ_2 so as to avoid building pounding effect between the adjacent structures as they tend to oscillate towards each other due to earthquake induced vibrations.
2. For the adjacent buildings with same floor levels, the seismic separation gap is given by:

$$\text{Seismicgap}=\frac{(R1\Delta1+R2\Delta)}{2}$$

Where,

R_1R_2=Response reduction factor
$\Delta_1\Delta_2$=MaximumStorey Displacement ofbuilding1 and 2

Result and Disscussion

For present work 4 Different Models with and without Friction Dampers are Analysed using Response spectrum method by ETABS software.The Results are obtained and compared as discussed below

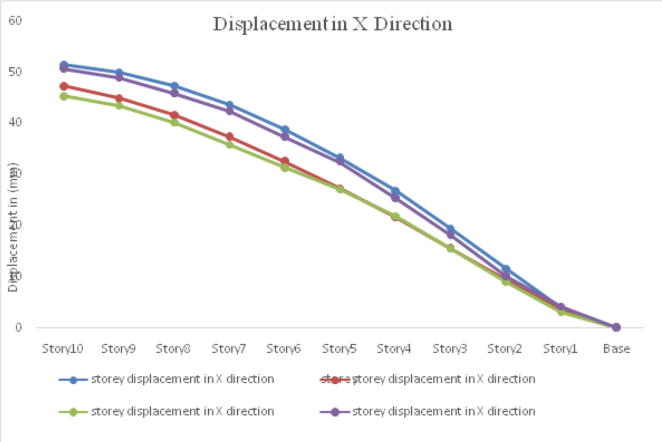

Fig 6 Storey Displacement in X –Direction for adjacent Building with same height

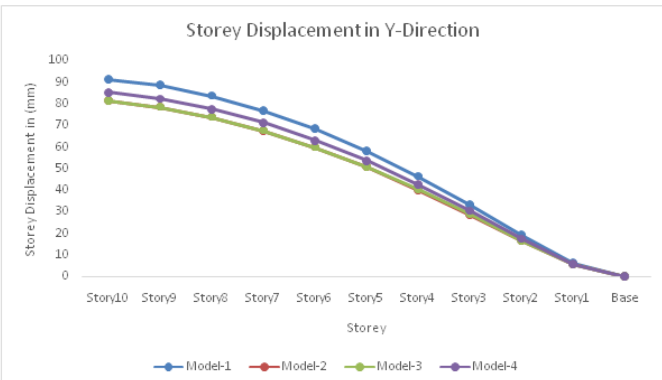

Fig 7 Storey Displacement in Y –Direction for adjacent with same height

Figure 6 and 7 shows Maximum Displacement in X & Y Direction for adjacent building with same height , maximum storey Displacement is 51.553 mm and 91.271mm.maximum displacement is observed for adjacent building without damper.

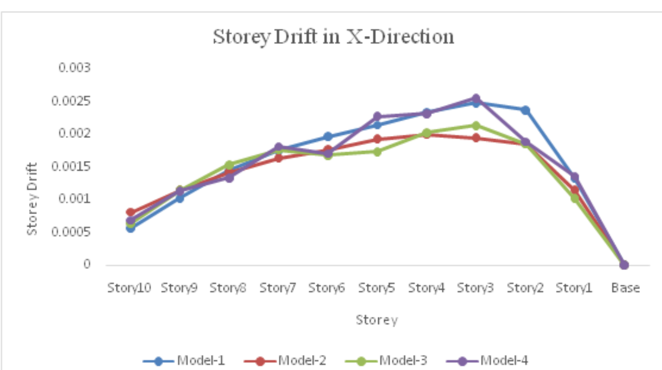

Fig 8 Storey Drift in X –Direction for adjacent Building with same height

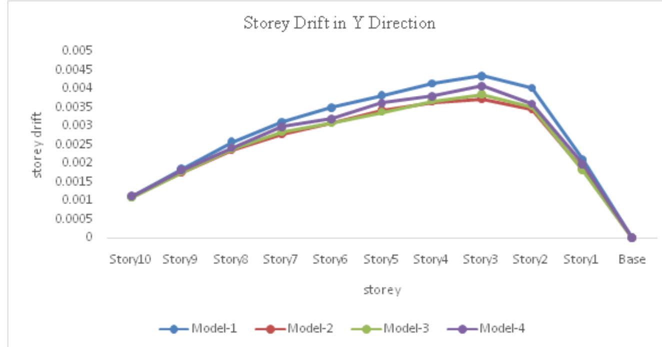

Fig 9 Storey Drift in Y –Direction for adjacent with same height

Figure 8 and 9 shows Storey Drift in X & Y Direction for adjacent building with same height , the maximum allowable storey drift according to Indian standard codes given as 0.004 times the floor height i.e.0.004x3.2=0.0128. Maximum storey Drift in X and Y direction is 0.00068 and 0.00112.

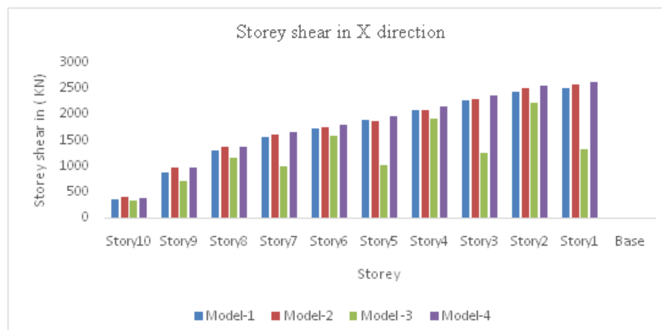

Fig 10 Base shear in X –Direction for adjacent Building with same height

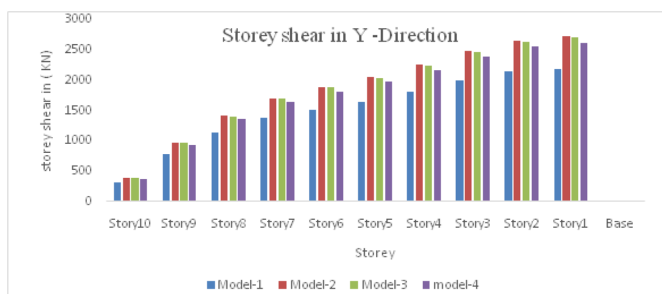

Fig 11 Base shear in Y –Direction for adjacent Building with same height

Fig 10 and 11 shows Storey shear in X& Y direction Respectively Maximum value of storey shear For x and y direction is 2624.297 KN & 2712.498 KN.

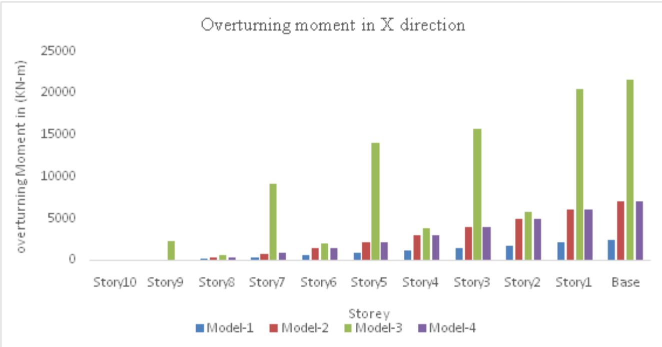

Fig 12Overturning Moment in X Direction for adjacent Building with same height

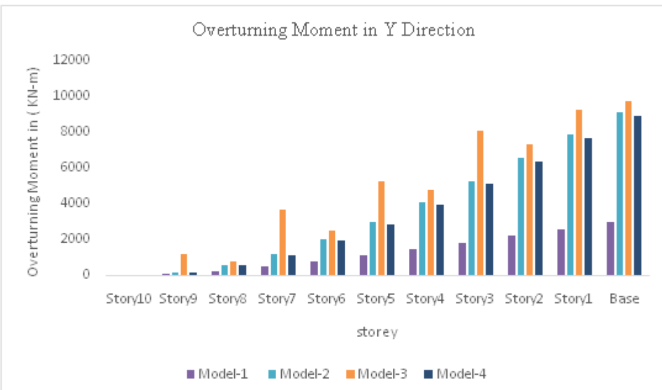

Fig 13Overturning Moment in y Direction for adjacent Building with same height

Fig 12& 13 shows Overturning moment in X & Y Direction Respectively. Maximum value of Overturning moment is 21565.96 kn-m and 9745.544 Kn-m in x and y direction.

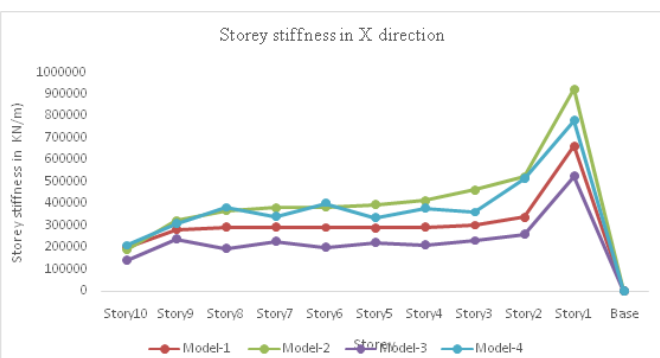

Fig 14 storey stiffness in X-Direction for adjacent Building with same height

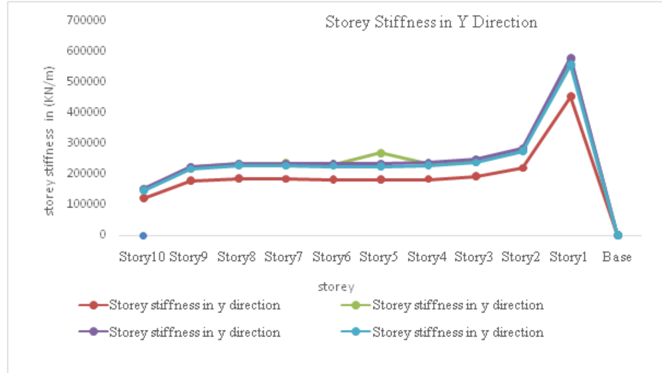

Fig 15 storey stiffness in Y-Direction for adjacent Building with same height

Fig 14& 15 shows storey stiffness in x and y direction..stiffness is increased for building with dampers at various positions.

VI. CONCLUSION

Seismic performance of two adjacent same height multistoried building are analysed by using Response spectrum method in ETABS software. models are considered with and without damper

In order to study its effect on mitifgation. dampers are placed at different positions in building.

Following conclusions are drawn from analysis.

1. 1.On comparision of the result of, The displacement and Drift of the building without damper and with damper ,provision of damper at different location reduces the displacement, Drift along x and y Direction.
2. Provision of damper help in increasing storey stiffness of building thereby reduces the damage.
3. The displacement is exceeding the seismic gap considered in case of model 1 , hence pounding was observed in adjacent building without dampers.

REFERENCES

[1] Ramakrishna Uppari, Mohan Sasalpur Chandrashekar, “Vibration Control of Dynamically Similar Buildings Optimally Connected by Viscoelastic Dampers” The Institution of Engineers (India) 2020 Springer

[2] Majd Armali “Effectiveness of friction dampers on the seismic behavior of high rise building VS shear wall system” WILEY

[3] Farzad Hejazi “Seismic Response of Shear Wall with Viscous Damping System” Springer

[4] Min Zhang, Dong zhuo Wang, "Seismic response analysis of frame with friction" Engineering Computations Vol.36 No.7 ,2019 Emerald Publishing Limited 0264-4401
[5] Ali Naghshineh "Seismic Performance of Reinforced Concrete Frame Buildings Equipped with Friction Dampers" Structures Congress 2018 ASCE
[6] Sahil Arora and Amanullah, "Optimization of bracing and viscous damper and comparison of fluid viscous damper and bracing system for stabilization of high rise building" International Journal of Civil Engineering and Technology (IJCIET). Scopus indexed Volume 10, Issue 03, (March 2019)
[7] S. S. Sanghai, S. N. Khante, "Seismic Response of unsymmetric building with optimally placed Friction Dampers", International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 02, Febraury 2017
[8] A.K. Sinha, Sharad Singh, "Seismic Protection of RC Frames Using Friction Dampers", International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 02, Febraury 2017
[9] IS 1893 (Part 1):2016, Criteria for earthquake resistant design of structure.
[10] IS: 4326, Earthquake Resistant Design and Construction of Buildings- Code of Practice (Second Revision), 1993.
[11] IS 875 (Part 1):1987, "Code of practice for design loads (other than earthquake) for buildings and structures", Part 1, Dead loads, Bureau of Indian standards, New Delhi, 1989.