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Seismic Response of Multi Storey Building Installed with Dampers

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ABSTRACT:The increased number of multi-storied buildings is the strength of a country in the economic as well as in technical aspect. Nowadays the space requirement was the major problem which results into the conjunction of structures and same way they are very unsafe whenever lateral forces i.e., earthquake forces are experienced by the structures. Seismic response of multi storey building using state space method, installed with dampers subjected to real earthquake ground motions is investigated. The focus is on understanding the dynamic characteristics of dampers, identifying viable semi active control strategies, assessing the merits of the control strategies relative to passive and active control alternatives, analyse the response of the system using displacement, Acceleration, Base shear and velocity and demonstrating the structural control concepts by Analytical, Numerical and Experimental methods using MATLAB Software is employed in this research.

KEYWORDS: Dampers, Earthquake, Velocity, Displacement, Lateral force, Base shear

I. INTRODUCTION

Analysis and engineering of structures as a field of applied science came into existence because of the necessity to incorporate safety and efficiency even while restrictions of resources. Furthermore, main purpose to develop structural engineering is to adapt and dissipate energy projected through natural movement of wind, trembling earth's surface and other aspects that affect the structural stability of the structures. Supplemental Damping Devices are bifurcated into three initial categories as control systems. First of the three classifications are called "Passive Devices", deemed to be non-controllable and does not require energy to be operated. Following this, it is classified into "Active Devices" which can be controlled with the requirement of energy in huge amounts to be operated. Lastly, it is classified into "Semi-Active Devices" that tends to have properties of both passive and active control devices, while they can't be operated without power, like passive devices, but the requirement is remarkably less than active control devices. Active control devices, on the other hand, are at the opposite end of the structural control spectrum. They were the first to propose active structural control of civil structures. These control systems apply force to the structure to counterbalance the energy of dynamic loading, and they may regulate various vibration modes and accommodate various loading situations.conditions in multistoried buildings with the help of state space method.

Fig. 1: Dampers in the Buildings

The dampers are strategically placed in the building structure to control floor vibrations and building displacement, cater for occupancy comfort and mitigate against major seismic events. Dampers may be provided in isolation or coupled with rubber pads in series or parallel. In general, structure using dampers are designed in the different way as normal structure is designed. Structure using dampers have more stiffness than normal RC structures, so that stiffness of structure using dampers is depends upon initial stiffness of the RC frames.

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1.1 PASSIVE CONTROL STRATEGIES:

Structures are dissipated and isolated from the energy of dynamic loadings using passive control systems. Passive devices are inherently stable, require no external energy to operate and are relatively simple to design and build. However, the performance of optimal passive control is sometimes limited, in that they are typically designed to protect the structure from one particular dynamic loading.

1.2 ACTIVE CONTROL STRATEGIES:

To generate the amount of forces required for civil infrastructure applications, active control systems often demand a lot of energy. In an activecontrol system, the signals sent to the control actuators are a function of the response of the system measured with physical sensors.The main differences are the sensors that measure the building responses and the control computer that sends out a control signal to the actuator to provide appropriate force to the structure.

1.3 SEMI ACTIVE CONTROL STRATEGIES:

Semi active control devices, can be known with an alternate name such as "smart devices".Only here, the control actuator does not directly apply force to the structure, but instead it is used to control the properties of a passive energy device. Semi active devices can produce the desired dissipative control forces.

1.4 HYBRID CONTROL STRATEGIES:

The three main types of supplementary damping devices can be used in a variety of ways to create hybrid control schemes. Hybrid techniques often use less energy, although they still require a substantial amount of it. The performance of these strategies is limited by passive and active control measures. The hybrid mass damper is the most frequent hybrid control method (HMD). A passive tuned mass damper is combined with an active control actuator in the HMD.

1.5 BEHAVIOR OF BUILDING WITH OR WITHOUT DAMPERS:

When ground seismic waves reach up and start to penetrate a base of building and the base of building starts moving. Due to inertia the building continue to remain in the previous position. Due to this the building suffers distortion and the distortion wave travels along the height of the structure. Continue shaking of the base causes the building to undergo series of oscillations which ultimately results in collapse of building. To avoid such a circumstance dampers are used.

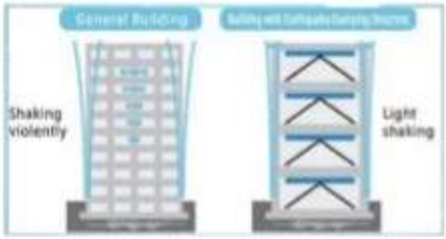

Fig. 2: Effect of Dampers

1.6 STATE SPACE METHOD:

In the state-space formulation, the unknown variables are those quantities that are necessary to completely describe the state of the system at any time. For a structural system, the state variables are the displacements and velocities. Instead of working with N equations of motion for the N degrees of freedom, we break the second order equations into 2N first order equations. The equation for the case of multiple degree of freedom is,

$$X = AX + BF$$

Where, the vector X contains the displacements and velocities,

AContains the system parameters,

FContains the external excitation and

B is called the locator matrix.

Even though, we are changing the form of the differential equation, obviously the solution has to be the same. However, since the form is different, the solution process changes. Also, conceptually this formulation is different, more general although less physical than the second order equation. In the case of the state space formulation, since the equation is of first order, the eigenvalue problem does not have to be truncated and all the characteristics of the system are embedded in the system matrix A. The damping matrix can be arbitrarily chosen and does not have to be proportional to mass or stiffness.This flexibility in representing the damping is convenient for damping based control devices.

II. AIM, OBJECTIVE & SCOPE

2.1AIM OF STUDY:

The aim of my research work is "Studyon Earthquake analysis of multi - storied building installed with Dampers".

2.2 OBJECTIVES OF STUDY:

The main objectives for present work are as follows:

- To investigate seismic response of symmetric structure installed with damper.
- To investigate seismic response of asymmetric structure installed with damper.

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- To develop artificial neural network for symmetric structure.
- To calculate optimum parameters of damper.

2.3 SCOPE OF WORK:
- The focus is on understanding the dynamic characteristics of dampers, identifying viable semi active control strategies, assessing the merits of the control strategies relative to passive and active control alternatives.
- Also demonstrating the structural control concepts by Analytical, numerical and experimental methods are employed in this research.

III. RESEARCH GAP:

From the literature, it is seen that for asymmetric buildings, the torsional, lateral and edge displacements decrease with the increase in stiffness ratio. The semi active damper is quite effective in reducing lateral, torsional and edge displacement and acceleration responses as compared to active and passive strategies for strongly coupled asymmetric building. From the literature it is seen that for asymmetric buildings, the torsional, lateral and edge displacements decrease with the increase in stiffness ratio. The semi active damper is quite effective in reducing lateral, torsional and edge displacement and acceleration responses as compared to active and passive strategies for strongly coupled asymmetric building.

IV. METHODOLOGY IN MATLAB:

The analysis was carried out by considering different fifty types of earthquakes for both controlled and uncontrolled structure. A multi-storied buildings are taken of G+2 storey. The analysis is carried out on total numbers of 50 different types of load act on model using state space analysis in MATLAB 2014a. codal provisions are considered for the analysis. The plan considered for analysis are symmetric shape building.

V. MODEL DATA :

TABLE-1 MODEL DATA MATLAB

Description	**Data values for models**
Building data	
Story	G+3
Loading data	
Mass on Each Floor	$1.5*10^8$ kg
Mass matrix	[1 0 0 ;0 1 0 ; 0 0 0.5]; x mass
Stiffness in kN/m	2.5
Stiffness matrix	[1 0 0 ; 0 1 0 ; 0 0 0.5]; x stiffness
Damping Ration	0.05
Time Duration	0.01 sec

TABLE-2 LIST OF EARTHQUAKE

S. No	**Earthquake**	**Event**	**Duration**	**Time Steps**
51	Montenegro	April 15th, 1979	48.22	0.01
52	Campano Lucano	November 23rd, 1980	30.15	0.01
53	Alkion	February 24th, 1981	41.86	0.01
54	Panisler	October 30th, 1983	28.01	0.01
55	Spitak	December 07th, 1988	22.98	0.01
56	Manjil	June 20th, 1990	29.48	0.01
57	Erzincan	March 13th, 1992	20.74	0.01
58	South Aegean	May 23rd, 1994	30.50	0.01
59	Bitola	September 01st, 1994	21.74	0.01
60	Kozani	May 13th, 1995	29.37	0.01
61	Aigion	June 15th, 1995	39.50	0.01
62	Dinar	October 01st, 1995	27.95	0.01
63	Gulf of Abaka	November 22nd, 1995	59.99	0.01

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64	Umbria Marche	September 26th, 1997	29.42	0.01
65	Kalamata	October 13th, 1997	48.60	0.01
66	Strofades	November 18th, 1997	65.43	0.01
67	Adana	June 27th, 1998	29.18	0.01
68	Izmit	August 17th, 1999	27.17	0.01
69	Ano Liosia	September 07th, 1999	39.05	0.01
70	Duzce	November 12th, 1999	29.99	0.01
71	South Iceland	June 17th, 2000	76.78	0.01
72	Ionian	April 24th, 1988	21.63	0.01
73	Etolia	May 18th, 1988	25.42	0.01
74	Off coast of Levkas	August 24th, 1988	21.59	0.01
75	Kyllini	October 16th, 1988	30.51	0.01
76	Chenoua	October 29th, 1989	23.98	0.02
77	Aigion	May 17th, 1990	16.13	0.01
78	Sicilia-Orientale	December 13th, 1990	43.44	0.01
79	Kefallinia island	January 23rd, 1992	20.69	0.01
80	Pyrgos	March 26th, 1993	25.59	0.01
81	Patras	July 14th, 1993	29.28	0.01
82	Komilion	February 25th, 1994	27.03	0.01
83	Mt. Hengill Area	August 24th, 1997	35.98	0.01

84	Umbria	September 03rd, 1997	26.98	0.01
85	Oelfus	November 14th, 1998	35.98	0.01
86	Ancona	February 04th, 1972	7.70	0.01
87	Azores	November 23rd, 1973	19.20	0.01
88	Denizli	August 19th, 1976	15.85	0.01
89	Izmir	December 16th, 1977	6.50	0.01
90	Preveza	March 10th, 1981	18.30	0.01
91	Levkas	May 27th, 1981	15.99	0.01
92	NE of Banja Luka	August 13th, 1981	32.30	0.02
93	Heraklio	March 19th, 1983	20.30	0.01
94	Ierissos	August 26th, 1983	21.09	0.01
95	Provadja	November 10th, 1983	12.48	0.02
96	Arpiola	March 22nd, 1984	11.23	0.01
97	Balikesir	March 29th, 1984	7.83	0.01
98	Baskoy	August 12th, 1985	10.01	0.01
99	Kalamata	September 13th, 1986	29.86	0.01
100	SE of Tirana	January 09th, 1988	11.96	0.01

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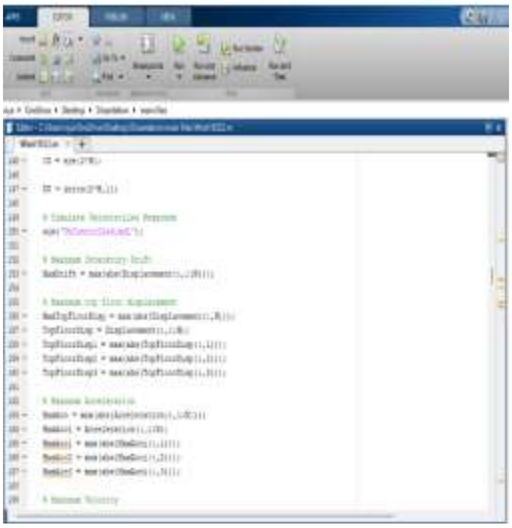

Fig. 3:Editor File in MATLAB

This the code programmed in MATLAB that takes values from 50 previously recorded earthquakes at various locations in the world and derives values of displacement, velocity, base shear and acceleration. Fig. 3 shows the editor file in MATLAB, Fig. 4 shows the command window in MATLAB, Fig. 5 shows the workspace in MATLAB, Fig. 6 shows the results which is obtain from MATLAB. Furthermore, we are able to create a program code using MATLAB commands that can incorporate state space method for seismic analysis and in return get the output of analysis of earthquake response in structures.

Fig. 4: Command Window in MATLAB

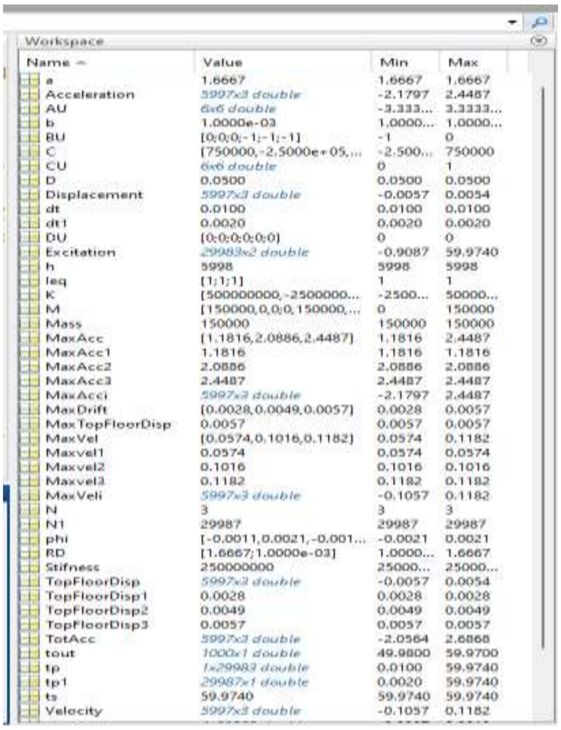

Fig.5: Workspace in MATLAB

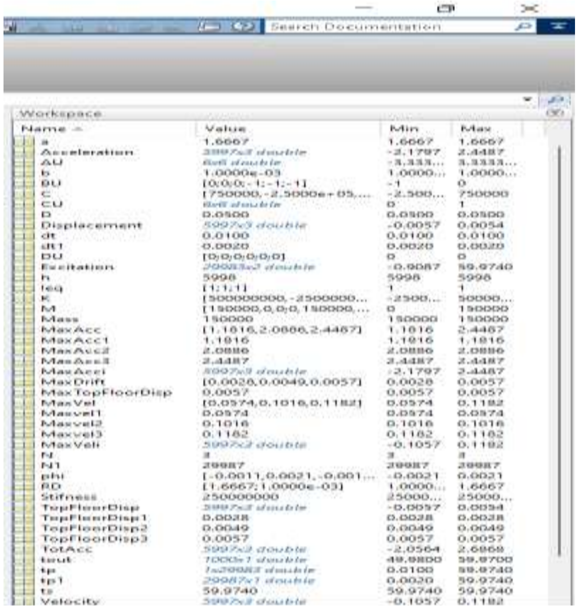

Fig. 6:Result Obtain From MATLAB

VI. CONDITIONAL ANALYSIS IN MATLAB SOFTWARE:

Similarly, the other Earthquake are taken for this thesis work. So that, here different fifty Earthquake are taken into analysis. All structure has same height and different conditions. The conditions are,

- Dampers Provided at Ground Floor
- Dampers Provided at First Floor
- Dampers Provided at Second Floor

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The state space analysis for all structures which is in different zones are taken.Codes used for analysis are IS 875:2015, Code of practice for design loads (other than earthquake) for building and structures are IS 1893: 2016, Criteria for earthquake resistant design of structure.

VII. RESULTS:

Results for story displacement, velocity, acceleration and base shearfrom Earthquakewith andwithout dampers and compare results obtain from the data for various earthquake.

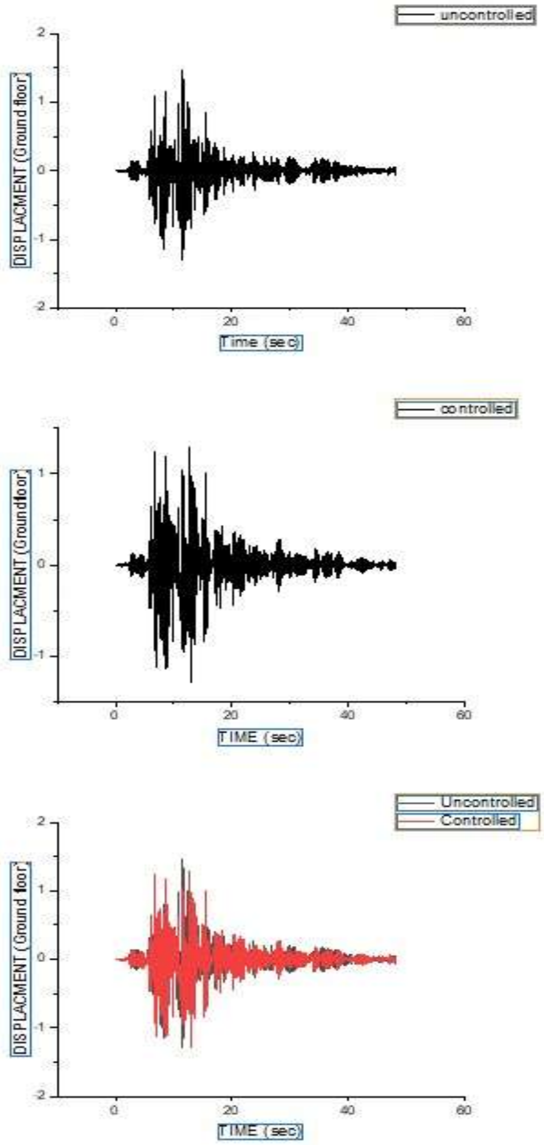

Fig. 7:Ground Floor displacement for G+2 Building With and Without Dampers

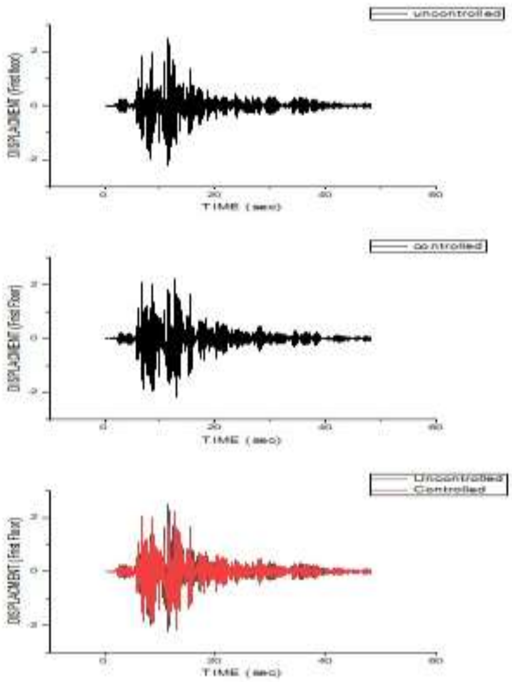

Fig. 8:First Floor displacement for G+2 Building With and Without Dampers

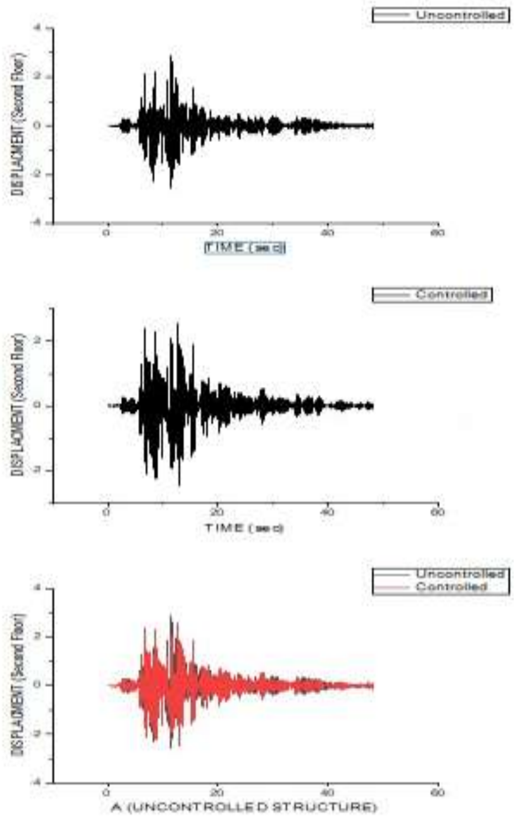

Fig. 9:Second Floor displacement for G+2 Building With and Without Dampers

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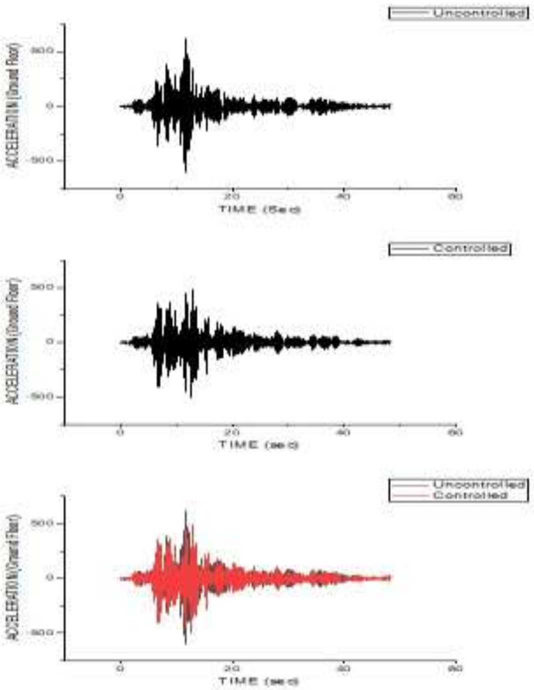

Fig. 10:Ground Floor Acceleration for G+2 Building With and Without Dampers

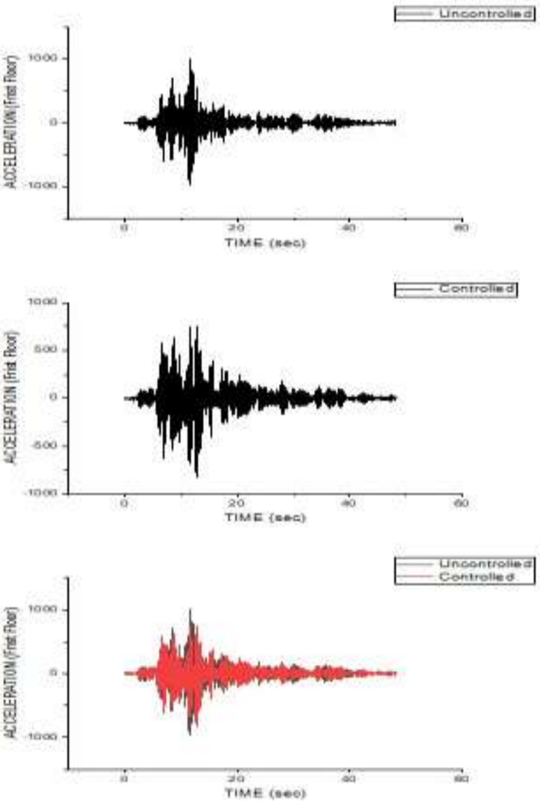

Fig. 11:First Floor Acceleration for G+2 Building With and Without Dampers

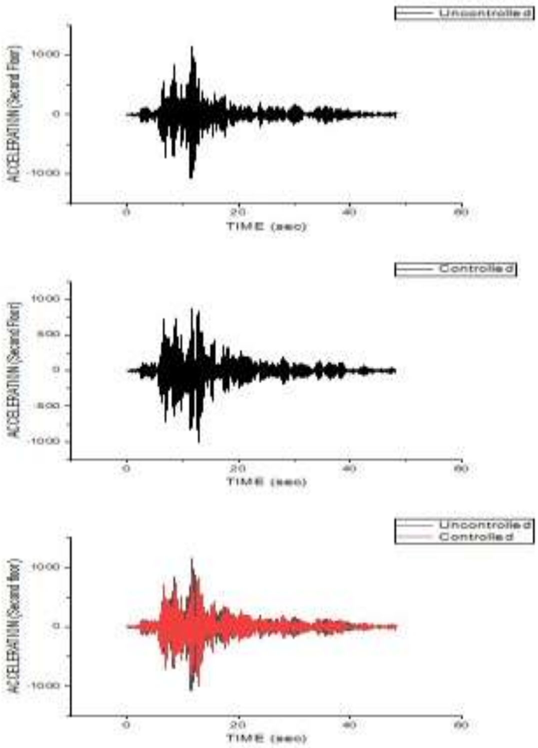

Fig. 12:Second Floor Acceleration for G+2 Building With and Without Dampers

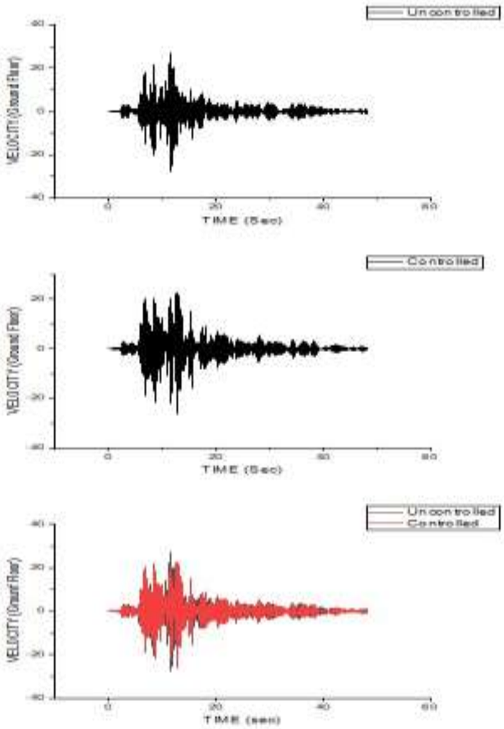

Fig. 13:Ground Floor Velocity for G+2 Building With and Without Dampers

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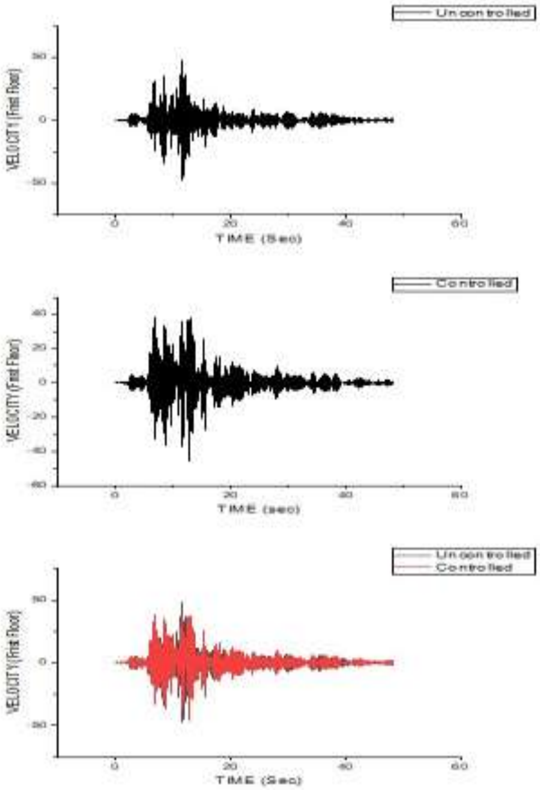

Fig. 14:First floor Velocity for G+2 Building With and Without Dampers

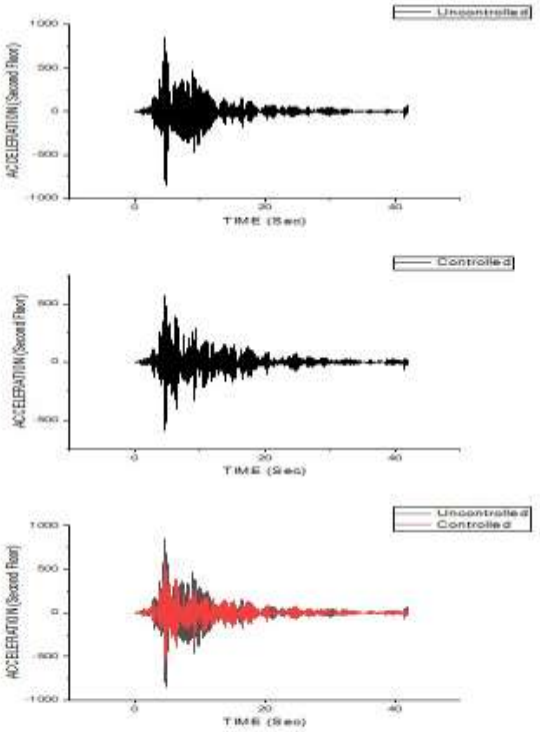

Fig. 15:SecondFloor Velocity for G+2 Building With and Without Dampers

VIII. CONCLUSION:

The viability of adopting a passive damper, to enhance the effectiveness of earthquake visco–elastic dampers were investigated in this work, because these types of dampers are strategically placed in a building structure to control floor vibration, displacement and mitigate against a major seismic event. The energy generated by floor vibration and building displacement is observed by the dampers and dissipated through heat energy. The building occupants will experience less floor vibrations, smaller building displacement and overall better occupancy comfort even in earthquake.

The investigation on seismic response of multi storey, symmetric plan system building installed with dampers responding in the inelastic range of behaviour has led to the following conclusions:

- Use of dampers in structure reduces floor displacement, acceleration and velocity.
- Supplemental viscous damping can be used to reduce displacement, velocity & base shear and hysteretic energy dissipation demands in lateral load resisting elements of symmetric plan systems responding in the inelastic range.
- With proper distribution of energy and positioning of damper, displacement and base shear demands in flexible-side element can be reduced by using of controlled system.
- For symmetric buildings, the displacement and base shear decreases with the increase in the stiffness ratio (ratio between effective damper stiffness to storey stiffness).
- The resetting Passive stiffness dampers perform better in reducing displacement, velocity and base shear as compared to conventional system.
- Low dependency on a temperature and frequency.
- High tolerance to deform.
- Easy to design and detail.

The cost of dampers is initially high but overall life span of structure increases.

IX. FUTURE SCOPE OF THE WORK:

1. Seismic response of bridge with dampers having variable curvature can be found out.
2. Seismic response of liquid storage tank isolated with dampers can be found out.
3. Seismic response of building, when the both of the systems is subjected to two orthogonal components of the ground motion simultaneously.

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