ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 1, January 2018

Analysis of High Rise Buildings with Viscoelastic Dampers

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Abstract: **-- Structures constructed now days are high rise R/C structures, which have very less lateral load carrying capacity due to earthquake and wind loads. The reason behind this is structure cannot dissipate earthquake energy by its inherent damping alone, therefore various seismic response control system for structures are developed. In such control systems, the supplementary damping device is incorporated within the structure, these damping devices are active, passive, semi-active or hybrid types. In this paper feasibility of using viscoelastic dampers to reduce the effect of the earthquake on high rise buildings is studied. Viscoelastic dampers dissipate buildings mechanical energy by converting it into heat. Analytical study of 12 storey R/C office building for finding out response reduction due to viscoelastic dampers is carried out. A non-linear time history analysis is carried out for building with viscoelastic dampers and without dampers and responses are compared. Top story displacements, velocity, acceleration and base shear is studied for building with damper and without a damper.**
Keywords**: - Viscoelastic dampers, Non-linear time history analysis.**

I. INTRODUCTION

Structures constructed now days are RC frame with masonry infill moreover they are build more slender and taller. These structures have little resistance caused by lateral load due to earthquake and wind load, Strong ground motions due to earthquake can cause excessive damage to structure or even can lead to collapse of structure. Those effects of ground motion can be mitigated by providing a supplementary damping device in the primary structure, which absorbs most of seismic energy and restricting the structural response within serviceable limits. These damping devices are of following types

- Active type
- Passive type
- Semi-active type
- Hybrid type
- Seismic base isolation

Active control devices reduce the structural response by means of resistance offered through an external energy source. Passive energy dissipation systems impart indirect damping to a structure through conversion of kinetic energy to heat, or by transferring of energy among vibrating modes. Viscoelastic dampers which are passive energy dissipation devices are used in this study. 12 storey reinforced concrete office building containing viscoelastic dampers is taken for analysis purpose. Non-linear time history analysis is carried out to find out seismic performance of building with and without dampers.

Viscoelastic dampers:
Viscoelastic dampers when undergoing deformation exhibits features of elastic solid as well as viscous liquid, they will come back to their original state with certain amount of mechanical energy loss as heat. Energy dissipated by viscoelastic damper in one cycle of harmonic deformation is given by area of hysteretic loop Fig.1 which is plot of load versus extension [1].

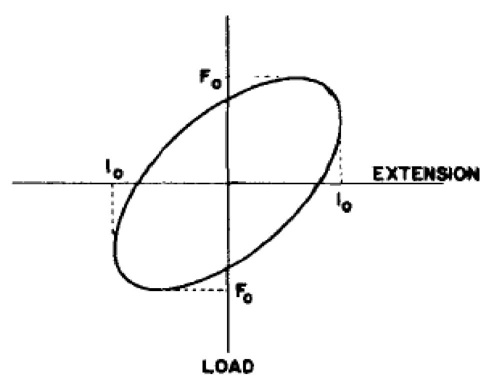

Fig.1 Hysteresis Curve

$$E = E_d = \pi \Upsilon_0^2 G''(\omega) v$$

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ISSN (Online) 2456-1290

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V = Volume of viscoelastic material
ϒ0 = Strain amplitude
G'' = Shear loss modulus
Shear loss modulus and shear storage modulus are frequency dependent. Maxwell model is used for obtaining mechanical behavior of viscoelastic damper Maxwell model consists of spring element in series with dashpot [6]

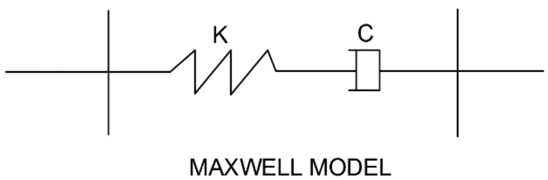

Fig.No.2 Maxwell Model

Building Description:
Building considered for analysis is actual building located in Istanbul, Turkey [2]. Building is Reinforced Concrete 12-storey office building, design is checked according to IS design code. Elevation and plan of building are given in Fig.3. Floor area of each floor is 989m2 and storey height is 2.75 m. Characteristic strength and Young's modulus of structure is taken as 200 Mpa and 27000 Mpa respectively, grade of steel used is Fe415. Structure has design dead load of 6.1 KN/m2 while live load is taken as 2KN/m2. Sizes of beam and column are shown in table no.1.

Frame Properties	Sizes (mm)
Beam	500*600
Column 1	400*700
Column 2	450*750
Column 3	450*900
Column 4	500*750
Column 5	600*1000
Column 6	750*750
Column 7	800*800
Column 8	900*900

Table 1 Sizes of Beam and Column

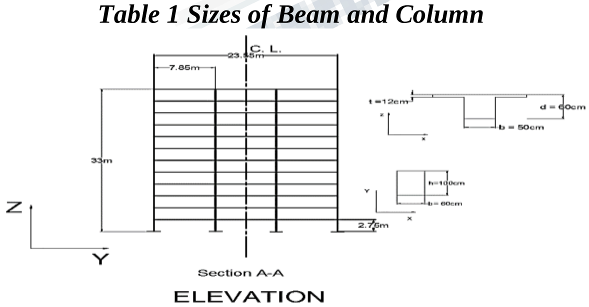

Fig.3 Elevation of 12 storey building

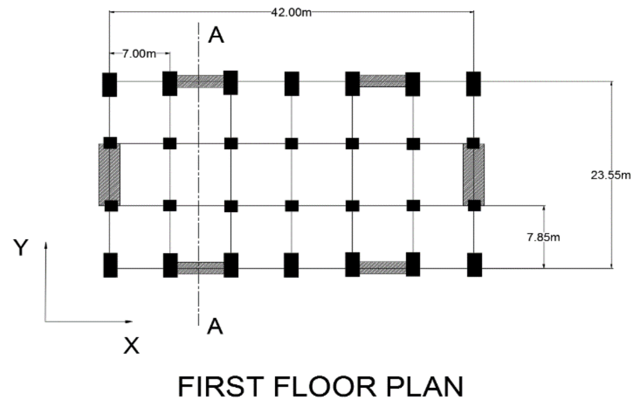

Fig.4 First floor plan of 12 storey building

Analysis of Structure:
Nonlinear time history analysis is carried out for structure using SAP2000, four real ground motions are used for analysis details of the ground motion are given in Table no.2

Name of earthquake	Peak ground acceleration (g)
Imperial Valley 1	0.3483
Imperial Valley 2	0.1342
Kern County	0.1793
Loma Prieta	0.2755

Table 2 Details of ground motion

II. RESULTS

Seismic response of building with and without dampers are plotted for all the four ground motions. Hysteresis curve and energy comparison is also shown for all four ground motions using SAP2000.

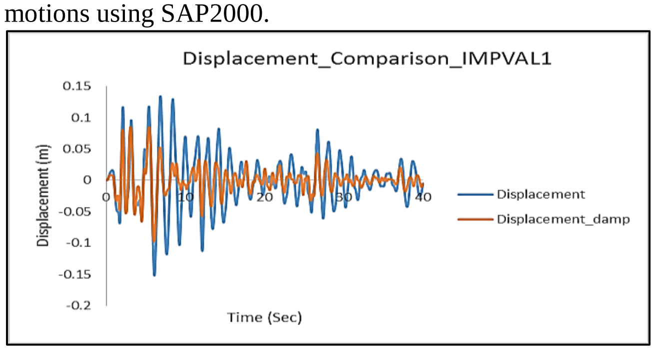

Fig.5 Displacement comparison for Imperial valley 1 earthquake.

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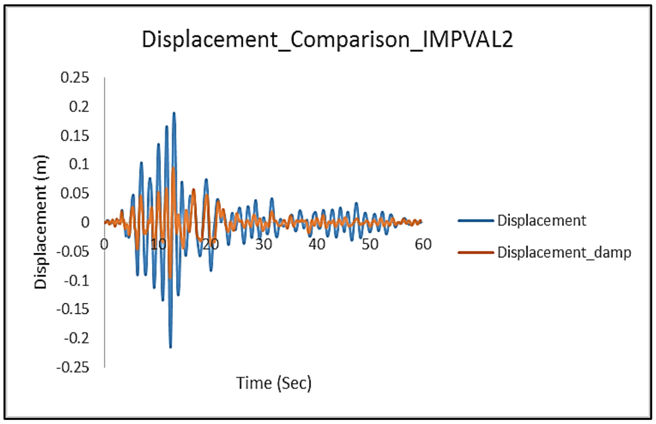

Fig.6 Displacement comparison for Imperial valley 2 earthquake.

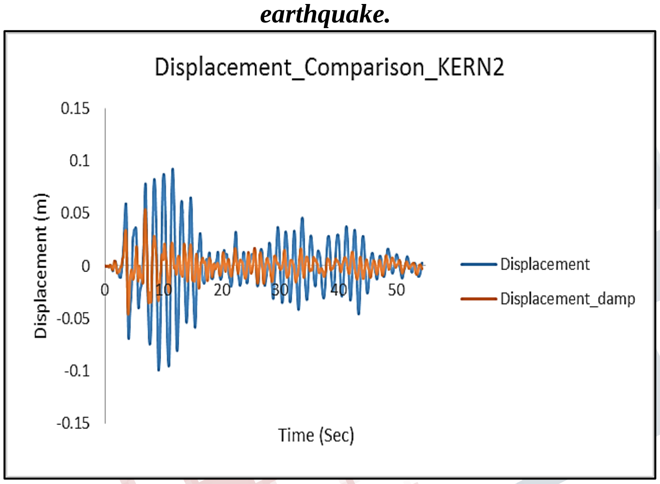

Fig.7 Displacement comparison for Kern county earthquake.

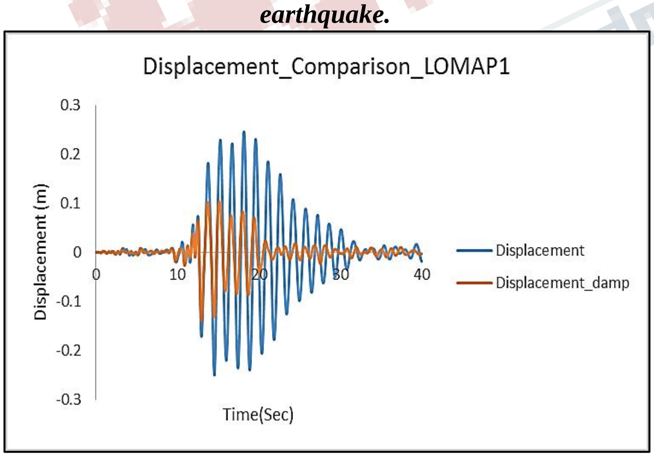

Fig.8 Displacement comparison for Loma Prieta earthquake.

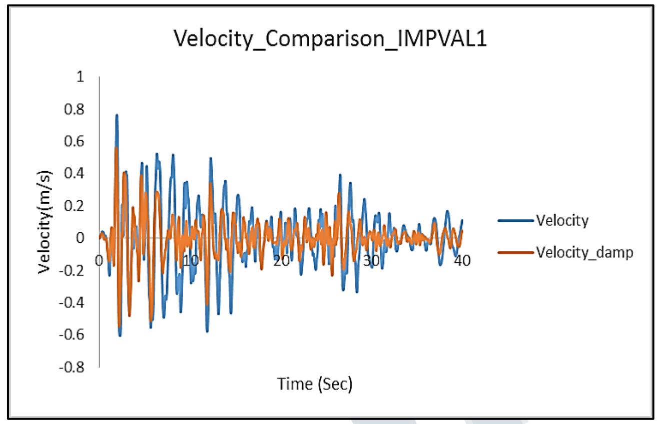

Fig.9 Velocity comparison for Imperial valley 1 earthquake.

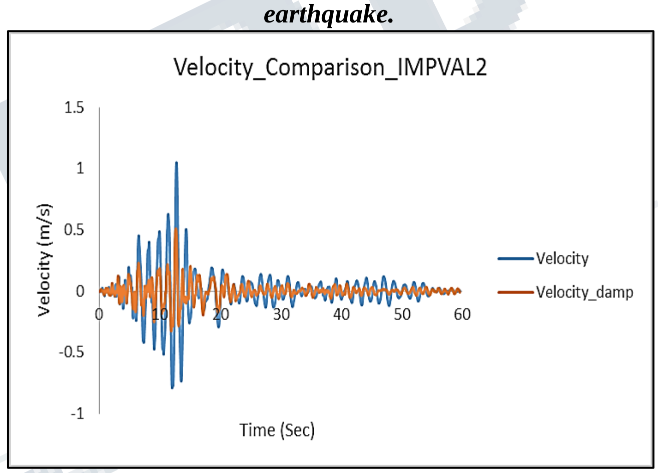

Fig.10 Velocity comparison for Imperial valley 2 earthquake.

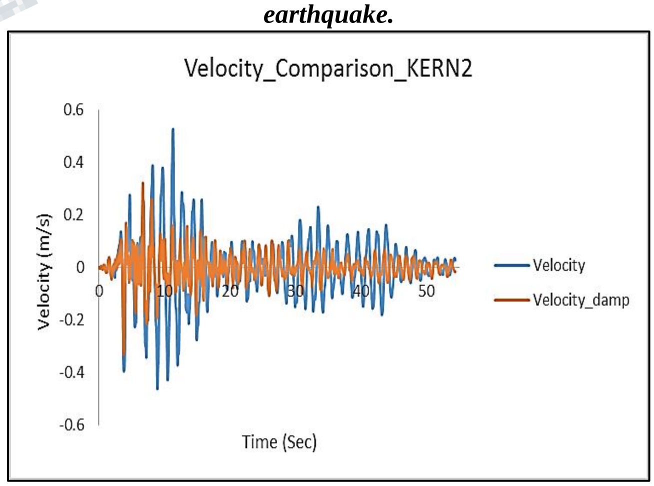

Fig.11 Velocity comparison for Kern County earthquake.

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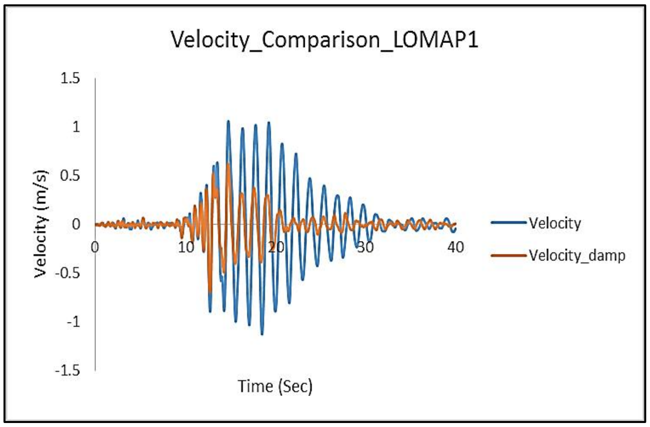

Fig.12 Velocity comparison for Loma Prieta earthquake.

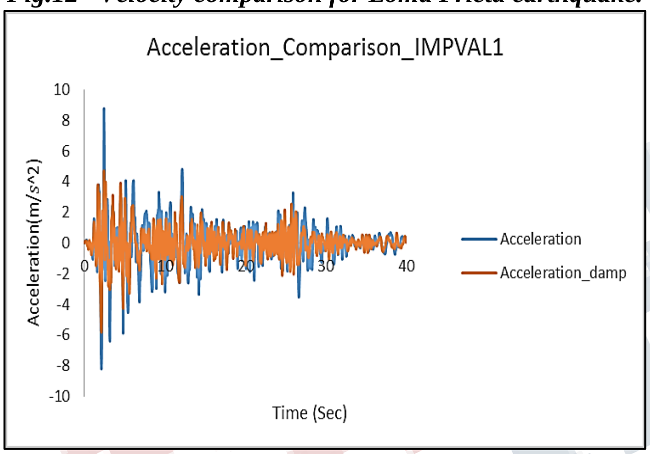

Fig.13 Acceleration comparison for Imperial valley 1 earthquake.

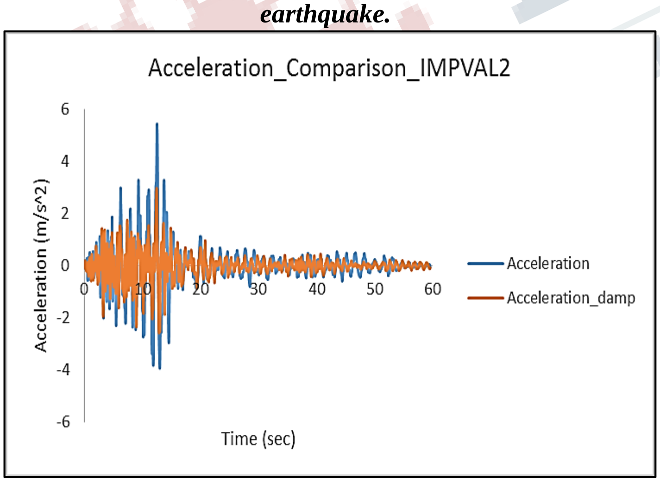

Fig.14 Acceleration comparison for Imperial valley 2 earthquake.

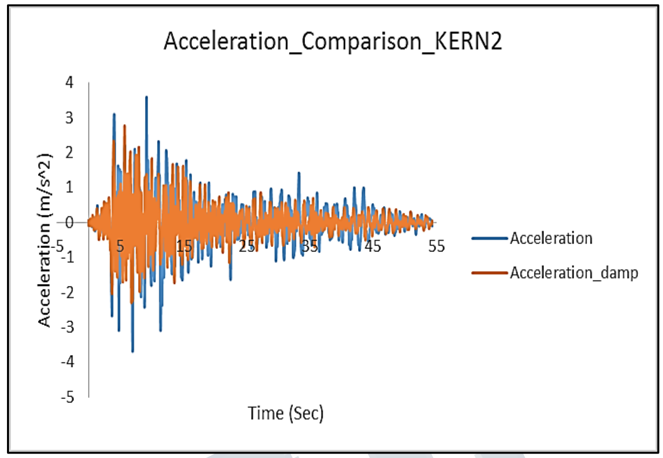

Fig.15 Acceleration comparison for Kern County earthquake.

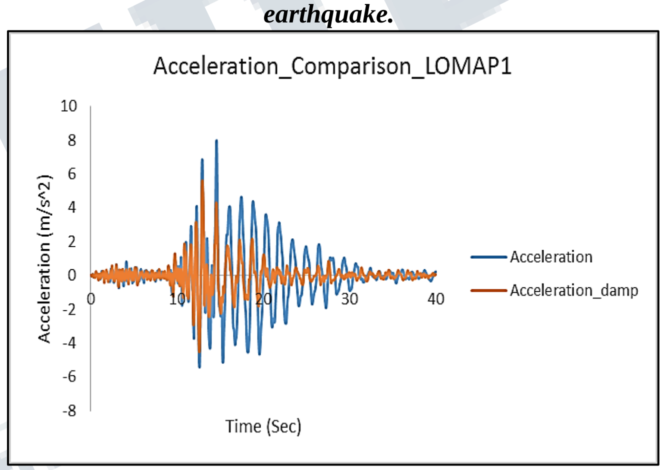

Fig.16 Acceleration comparison for Loma Prieta earthquake.

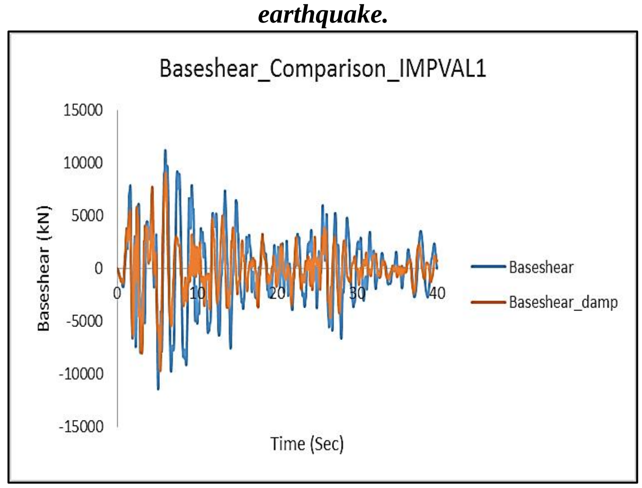

Fig.17 Base shear comparison for Imperial valley 1 earthquake.

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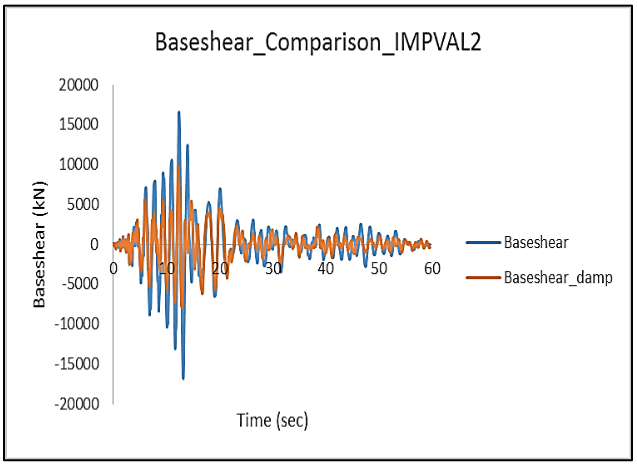

Fig.18 Base shear comparison for Imperial valley 2 earthquake.

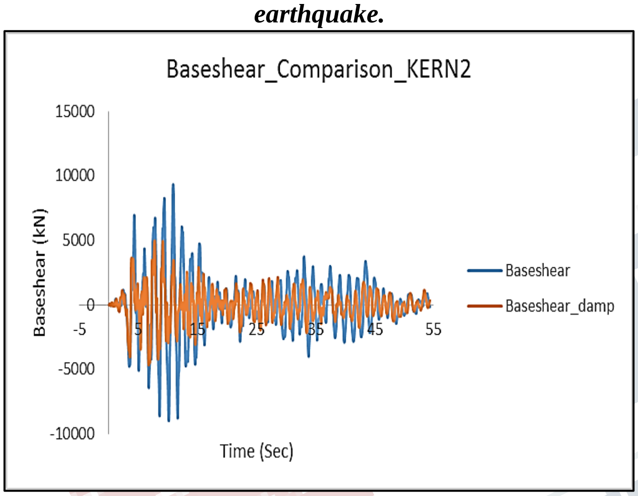

Fig.19 Base shear comparison for Kern County earthquake.

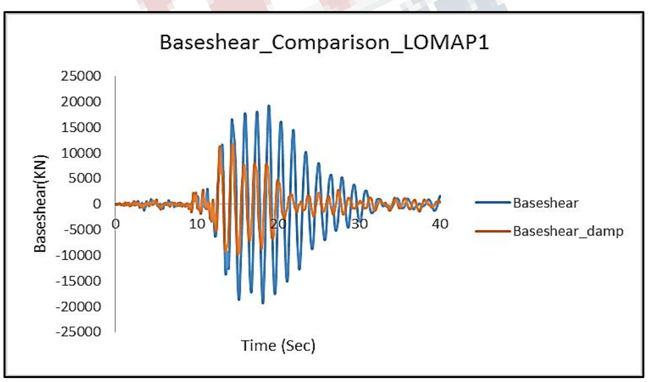

Fig.20 Base shear comparison for Loma Prieta earthquake.

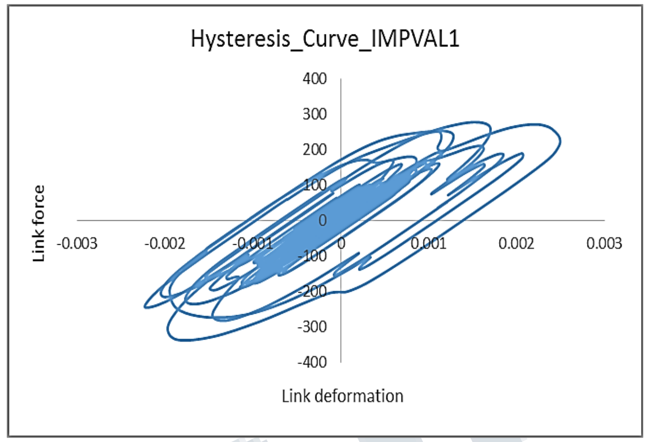

Fig.21 Hysteresis curve for Imperial valley 1 earthquake.

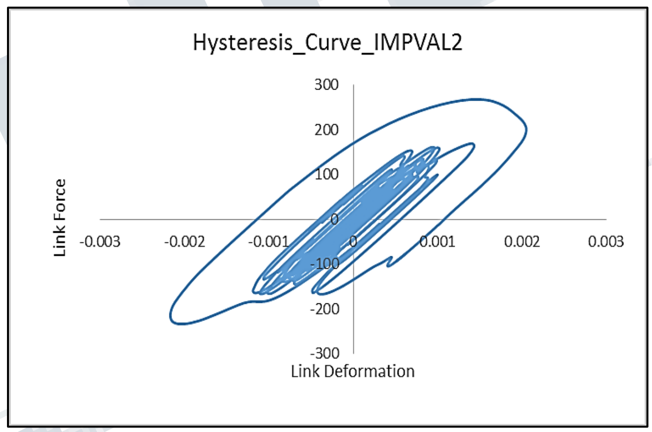

Fig.22 Hysteresis curve for Imperial valley 2 earthquake.

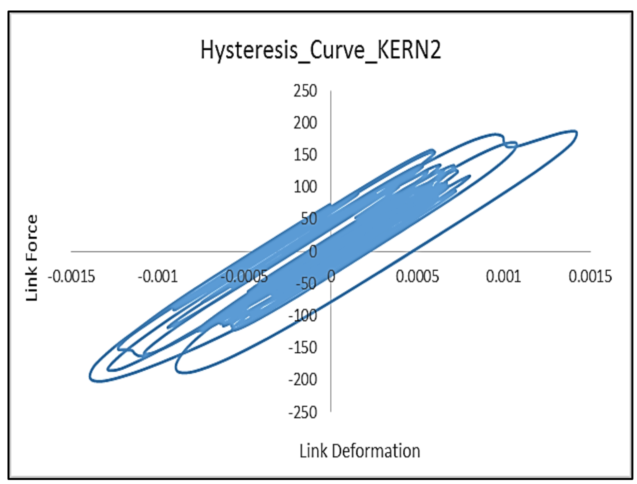

Fig.23 Hysteresis curve for Kern County earthquake.

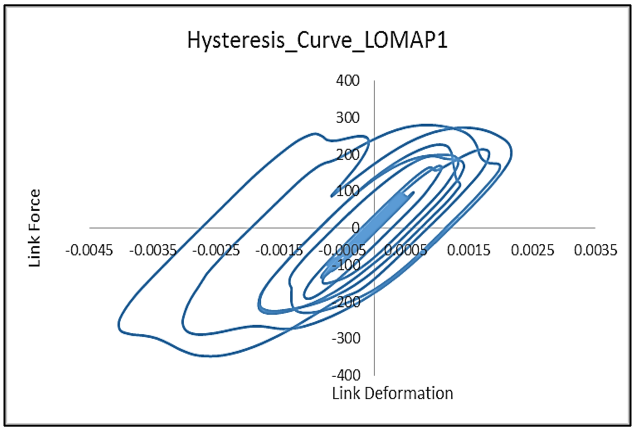

Fig.24 Hysteresis curve for Loma Prieta earthquake.

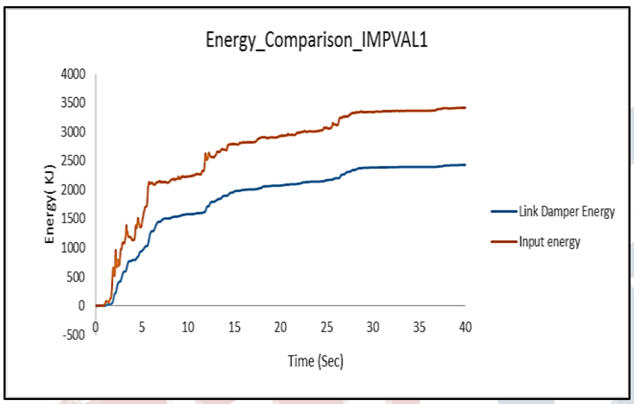

Fig.25 Energy comparison for Imperial valley 1 earthquake.

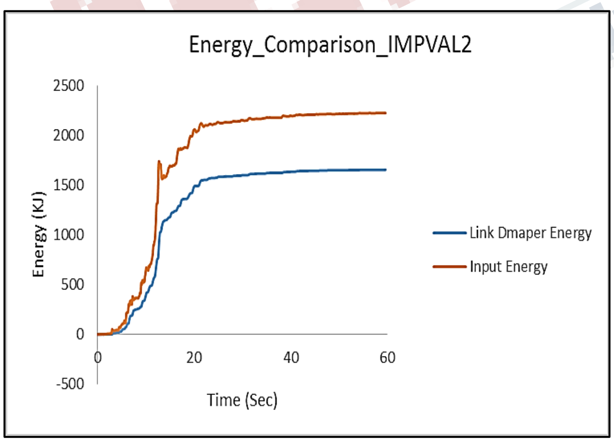

Fig.26 Energy comparison for Imperial valley 2 earthquake.

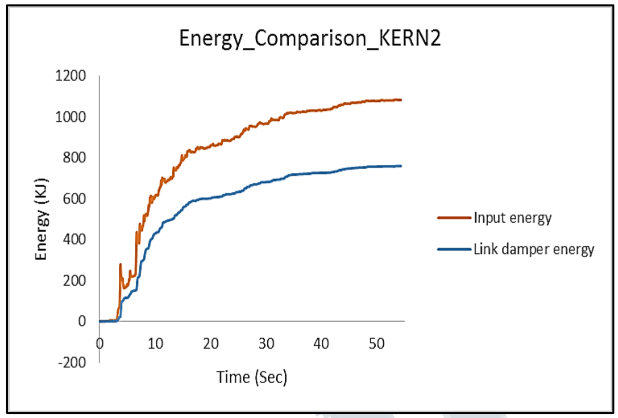

Fig.27 Energy comparison for Kern County earthquake.

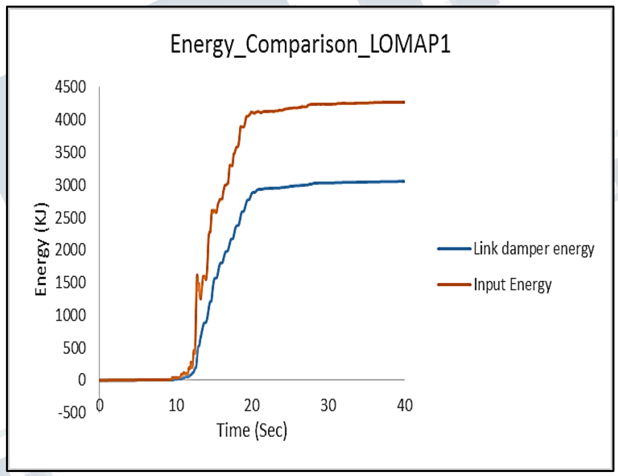

Fig. 28 Energy Comparison for Loma Prieta earthquake.

III. CONCLUSION

The seismic performance of 12 storey reinforced concrete office building has been analysed with and without applying dampers by applying non-linear time history analysis in SAP2000.The results of the analysis are summarised below.

- It has been observed that by placing dampers in the building nearly half of the input energy is dissipated by viscoelastic dampers.
- There has been significant reduction in displacement, acceleration of the top storey of building with viscoelastic dampers.
- By using viscoelastic dampers it is observed that, there is remarkable reduction in base shear of structure.

- The presence of inherent stiffness in the viscoelastic damper can be seen with the help of hysteresis curve.

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