Seismic Response Control of A Building using Viscous Damper

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Abstract

Earthquakes are one of the major natural hazards and responsible for the lives of thousands of people and damage to the structures. The main objective of this paper is to control the seismic response of building subjected to four different types of earthquake ground motions namely Elcentro, Kobe, Northridge and Loma Prieta using viscous dampers. A five storey building is considered and designed is done using E-Tabs software and various response quantities like displacement; acceleration and inter-storey drift are extracted. It is observed that controlled building shows moderate range of reduction for all response quantities as compared to uncontrolled building.

Keywords: Passive Energy Dissipation devices, Response Quantities, Uncontrolled Building and Controlled Building

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I. INTRODUCTION

Structural control is a diverse field of study. Structural control is one area of current research that looks promising in attaining reduced structural vibrations during loadings such as earthquakes and strong winds.The concept of employing structural control to minimize structural vibration was proposed in 1970. The present study is concerned with the control of the seismic response of building. In this paper main objective is to study response reduction of the building subjected to various earthquake excitations using viscous dampers. In this research a five storey building is considered and designed using E-Tabs software. Uncontrolled response and controlled response of even number of floors of buildings using viscous damper are obtained to know the performance of viscous damper. Here we have considered two conditions. In first condition damper is provided at second floor and in second condition, the damper is provided at fourth floor.

II. VISCOUS DAMPER

Viscous damper are considered as a supplement devices of choice to reduce the structural response. This section deals with the analysis, design and modelling of viscous damper as per FEMA 273. E-Tabs software provides tools to model various energy dissipation devices within a building. The distribution is usually done symmetrically so as to avoid the case of non-proportional damping. Damping is distributed in the structure as per formula given in FEMA-273. The mass of the viscous damper is generally taken as 300 kg. The viscous dampers are provided only at ground level.

$$\beta_{eff} = \beta + \frac{T\Sigma_j C_j cos^2\theta_j \phi_{rj}^2}{\Pi\Sigma_i(\frac{w_i}{g})\phi_i^2}$$

where β_{eff} is the equivalent viscous damping, β is the damping in framing system and is set equal to 0.05 for reinforced concrete building, C_j is the damping constant for device j, θ_j is the angle of inclination of device to the horizontal, ϕ_{rj} is the first mode relative displacement between the ends of device j in horizontal direction, w_i is the relative weight of floor level i, ϕ_i is the first mode displacement at floor level i.

III. RESEARCH PROBLEM

A building plan of 12m × 12 m is considered. The building is symmetric in plan.
The building is to be design by using E-Tabs software.
Following are the Building data:

No. of Story = G+4 , Story Height = 3 m, Slab Thickness = 120 mm, No. of Bays in X-Direction = 4, No. of Bays in Y-Direction = 4,Bay Width in X-Direction = 4 m, Bay Width in Y-Direction = 4m, Beam Size = 230mm × 350mm, Column Size = 400 mm × 400 mm, f_{ck}= 25 N/mm^2, f_y = 415 N/mm^2, L.L. = 3 KN/m , F.F. = 1 KN/m^2 .

The dynamic properties of the building that depends on a mass and stiffness of structural elements is determined using lumped mass modelling. Inherent damping is assumed to be Rayleigh type. Damping matrix is determined considering damping of 20% critical damping. The building is subjected to four earthquake ground motions Elcentro, Kobe, Northridge and Loma Prieta earthquake.

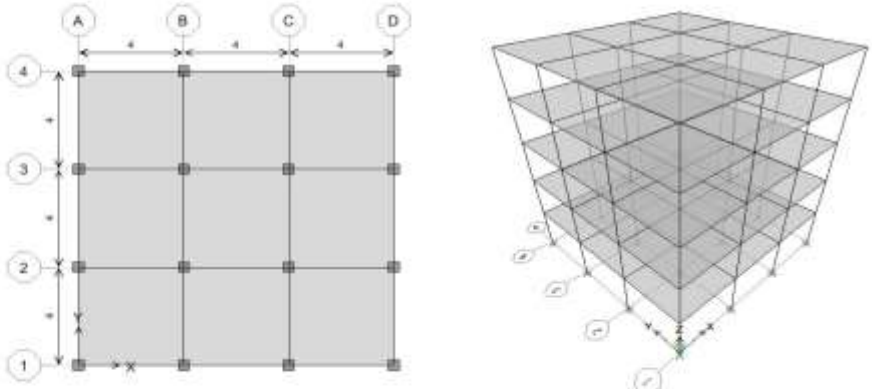

Fig. 1: Plan and 3-D view of building

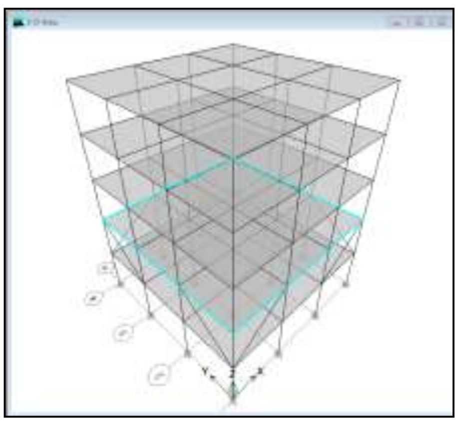

Fig. 2: 3-D View of building – Condition 1

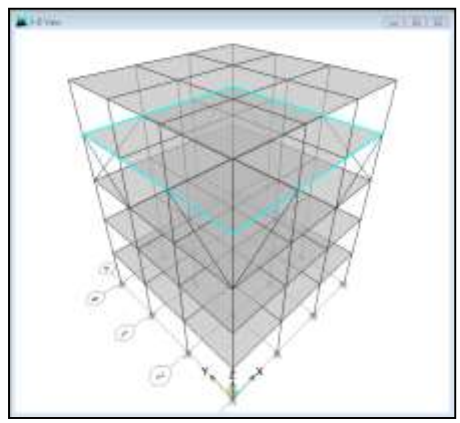

Fig. 3: 3-D View of building – Condition 2

IV. RESULTS AND DISCUSSIONS

Table – 1
Displacement of building under El Centro (PGA 0.3129g) EQ Excitation

Storey	*uncontrolled*	*condition 2*	*condition 4*
2	*0.0362*	*0.01549*	*0.02971*
4	*0.07288*	*0.04508*	*0.04499*

Table – 2
Displacement of building under Kobe (PGA 0.6936g) EQ Excitation

Storey	*uncontrolled*	*condition 2*	*condition 4*
2	*0.05085*	*0.02073*	*0.03626*
4	*0.10601*	*0.0652*	*0.06326*

Table – 3
Displacement of building under Northridge (PGA 1.585g) EQ Excitation

Storey	*uncontrolled*	*condition 2*	*condition 4*
2	*0.1275*	*0.05373*	*0.0976*
4	*0.2557*	*0.1403*	*0.1622*

Table – 4
Displacement of building under Loma Prieta (PGA 0.6437g) EQ Excitation

Storey	*uncontrolled*	*condition 2*	*condition 4*
2	*0.1613*	*0.03685*	*0.0743*
4	*0.3253*	*0.09354*	*0.12081*

Table – 5
Inter-storey Drift of building under El Centro (PGA 0.3129g) EQ Excitation

Storey	*uncontrolled*	*condition 2*	*condition 4*
2	*0.02267*	*0.00783*	*0.01642*
4	*0.01665*	*0.01502*	*0.00537*

Table – 6
Inter-storey Drift of building under Kobe (PGA 0.6936g) EQ Excitation

Storey	*uncontrolled*	*condition 2*	*condition 4*
2	*0.03216*	*0.01089*	*0.02301*
4	*0.02404*	*0.02273*	*0.0076*

Table – 7
Inter-storey Drift of building under Northridge (PGA 1.585g) EQ Excitation

Storey	*uncontrolled*	*condition 2*	*condition 4*
2	*0.09245*	*0.02627*	*0.0602*
4	*0.07378*	*0.04188*	*0.01487*

Table – 8
Inter-storey Drift of under Loma Prieta (PGA 0.6437g) EQ Excitation

Storey	*uncontrolled*	*condition 2*	*condition 4*
2	*0.10081*	*0.01773*	*0.04501*
4	*0.07067*	*0.02753*	*0.01266*

Table – 9
Velocity of building under El Centro (PGA 0.3129g) EQ Excitation

Storey	*uncontrolled*	*condition 2*	*condition 4*
2	*0.299*	*0.1822*	*0.2931*
4	*0.6854*	*0.4782*	*0.5032*

Table – 10
Velocity of building under Kobe (PGA 0.6936g) EQ Excitation

Storey	*uncontrolled*	*condition 2*	*condition 4*
2	*0.4481*	*1.2629*	*0.4138*
4	*0.9505*	*0.7387*	*0.7461*

Table – 11
Velocity of building under Northridge (PGA 1.585g) EQ Excitation

Storey	*uncontrolled*	*condition 2*	*condition 4*
2	*1.456*	*0.3938*	*0.708*
4	*2.19*	*0.9182*	*1.3031*

Table – 12
Velocity of building under Loma Prieta (PGA 0.6437g) EQ Excitation

Storey	*uncontrolled*	*condition 2*	*condition 4*
2	*1.325*	*0.5773*	*0.6163*
4	*2.742*	*1.238*	*1.089*

Table – 13
Acceleration of building under El Centro (PGA 0.3129g) EQ Excitation

Storey	*uncontrolled*	*condition 2*	*condition 4*
2	*4.936*	*3.232*	*3.839*
4	*6.017*	*6.439*	*6.524*

Table – 14
Acceleration of building under Kobe (PGA 0.6936g) EQ Excitation

Storey	*uncontrolled*	*condition 2*	*condition 4*
2	*8.61*	*4.185*	*4.872*
4	*9.546*	*9.798*	*8.655*

Table – 15
Acceleration of building under Northridge (PGA 1.585g) EQ Excitation

Storey	*uncontrolled*	*condition 2*	*condition 4*
2	*27.12*	*18.78*	*22.41*
4	*32.33*	*22.43*	*25.04*

Table – 16
Acceleration of building under Loma Prieta (PGA 0.6437g) EQ Excitation

Storey	*uncontrolled*	*condition 2*	*condition 4*
2	*12.22*	*7.676*	*9.913*
4	*23.18*	*12.15*	*12.56*

V. Conclusion

It has been seen from the table-1 to table-16 that viscous damper is effective in controlling structural response of a building. Reduction in displacement at second and fourth floor is 47.43%, 39.744% respectively as compared to uncontrolled response under El Centro excitation. Similarly, in Kobe earthquake excitation 59.23%, 42%. In Northridge earthquake excitation it is 57.85%, and 48.34%. And in Lomaprieta it is 77.15% and 64.30%. Reduction in velocity at second and fourth floor is 47.46%, 38.73% respectively as compared to uncontrolled response under El Centro excitation. Similarly, in Kobe earthquake excitation 41.33% and 24%. In Northridge earthquake excitation it is 72.95% and 56.87%. And in Lomaprieta it is 59.33% and 61.4%. Reduction in acceleration at second and fourth floor is 34.52%, 30.47% respectively as compared to uncontrolled response under El Centro excitation. Similarly, in Kobe earthquake excitation 51.39% and 52.09%. In Northridge earthquake excitation it is 32.24% and 56.26%. And in Lomaprieta it is 54% and 54.45%. Reduction in inter storey drift at second and fourth floor is 65.46%, 67.75 % respectively as compared to uncontrolled response under El Centro excitation. Similarly, in Kobe earthquake excitation 66.14% and 63.38%. In Northridge earthquake excitation it is 71.58% and 79.84%. And in Lomaprieta it is 82.41% and 82%.

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