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Comparative study on seismic performance of steel frame structure with visco elastic dampers at different positions

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Abstract **- Dampers are energy dissipating devices widely used for new and existing structures in earthquake prone areas to control the effect of earthquake on buildings. A new steel frame for seismic energy dissipation and performance is studied. Dissipation of energy is provided for with the use of visco-elastic material that works in shear and of elasto-plastic steel plates that acts in bending. In this study visco-elastic dampers are utilised to improve the seismic performance of the 5 storey steel frame structure. The modelling of frame and the evaluation of the seismic performance of steel frame with dampers in different positions are studied by static equilibrium analysis which is carried out by ETABS software.**

Keywords- **Visco-elastic dampers, seismic performance, steel frame structures, bracings, static equilibrium analysis.**

I. INTRODUCTION

Over the past few decades world has experienced various devasting earthquakes which are resulting in increased loss of human life due to collapse of buildings and structural damages. The traditional approach is to design an earthquake resistance structure is to provide adequate strength and stiffness against seismic lateral forces. In recent years, there have been many proposals to control the damage of structures in events of large earthquakes. Different procedures including active, passive and combined methods are available for the same purpose. In the active methods it is tried to apply external resisting force in a direction opposite to the action of the initial forces at each time step. In contrast, in a passive control the dynamic characteristics of the building including its period and or damping are permanently changed to larger value in order to decrease the potential of large forces from being produced in structural members.

Passive control systems usually are of displacement dependant devices including yielding metal dampers, friction dampers, or of velocity dependent components such as visco-elastic or liquid dampers. Dampers are energy-dissipating devices which are widely applied for new and existing structures in high intensity earthquake areas. Dampers are effectively reduce drift and maintain shear forces at same level or keep them less than those of structures without dampers. Passive dampers are used recently in many medium and high rise buildings. Such passive dampers like visco- elastic dampers also plays a key role in the implementation of structural rehabilitation which is essential for the realisation and promotion of sustainable buildings.

II. OBJECTIVE

The main objectives of this study are presented below in a detailed manner,

1. The major objective is to study seismic behaviour of steel frame with visco-

elastic dampers for evaluating the energy dissipation.

2. To suggest a most suitable location of the visco-elasic damper to avoid the failure of steel frame in such a manner.
3. To reduce the seismic response of structures in an extremely efficient way.

In this study, 2D-frame model were used for moment frames having 5 number of stories as shown in Fig. 1. The structures were designed using ETABS software. A series of standard I-shaped profiles were used to model bending frame including beam and column. The selected model is designed as a commercial building located at seismic zone III. All columns are pinned at the base and the exterior columns at the ground level are also restrained laterally.

III. CONFIGURATION AND PROPERTIES OF THE STEEL FRAME

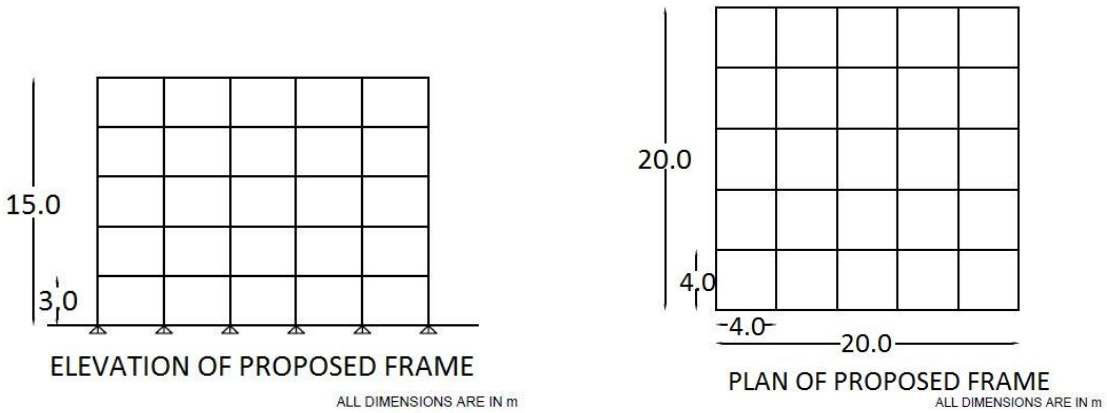

Fig.1. Plan and elevation of 5 storey steel frame structure.

The properties and characteristics of the steel members are used in frame are listed in Table I. The rolled steel sections are used for the beam and column sections.

TABLE I. DETAILS OF STEEL SECTIONS USED IN FRAMES

Column section	**Beam section**	**Bracing section**	**Bolt diameter**
ISMB 350	ISMB 300	ISA 200x200x10	12.5 mm

IV. VISCO ELASIC DAMPERS

Dampers are energy- dissipating devices which are widely applied for new and existing structures in high intensity earthquake areas. Dampers are effectively reduce drift and maintain shear forces at same level or under certain conditions, less than those of structures without dampers. Visco-elastic dampers made of bonded visco-elastic layers and the behaviour of visco-

elastic dampers is controlled by the behaviour in shear of the visco-elastic layers. Visco- elastic materials used in structural applications are usually rubber silicone, co-polymers or plastic substances that dissipate energy through shear deformation. As their name implies, visco- elastic materials exhibit both behaviour of elastic solid and viscous liquid when they experiencing deformation.

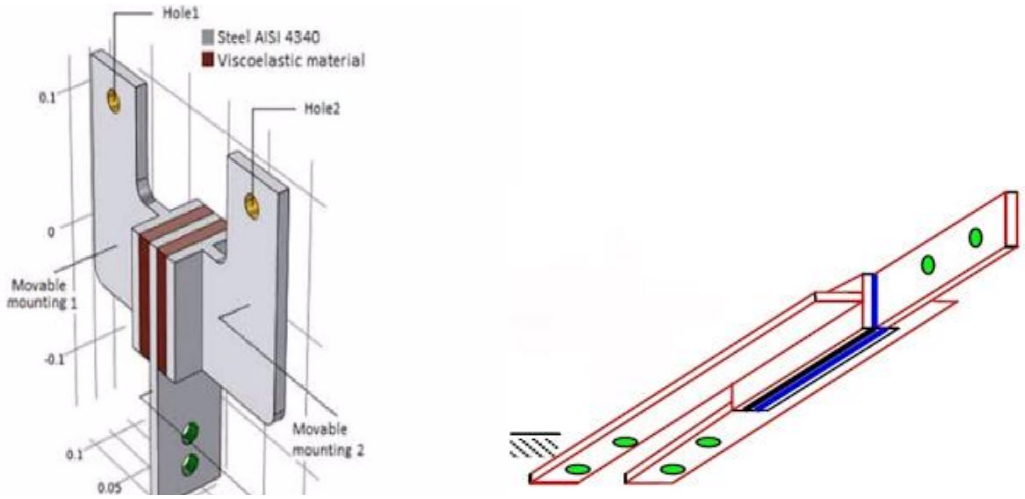

Fig.2. Visco-elastic Damper

V. PROPOSED CONNECTION SYSTEMS

The suggested damper is a combination of viscous and elastic materials. During earth quake motion the frame is undergone the maximum displacement at the base. So in order to arrest the deflection the dampers are provided with bracings at different locations. In this study two types of connection systems are compared.

1. The dampers are provided at the base floor by X bracings
2. The dampers are provided at the end frame of all storeys by X bracings.

The 2D and 3D view of the frame model with damper at base floor and damper in end frame of all storeys are shown in fig 3 and 4 respectively.

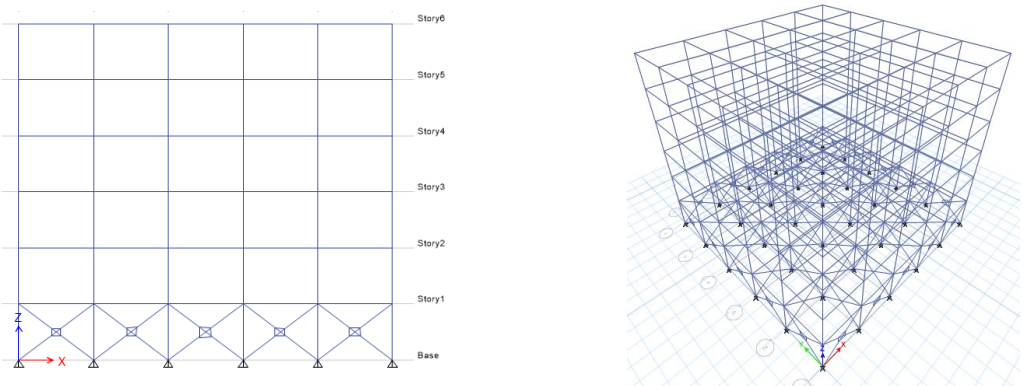

Fig.3. 2D and 3D view of steel frame with dampers at base floor

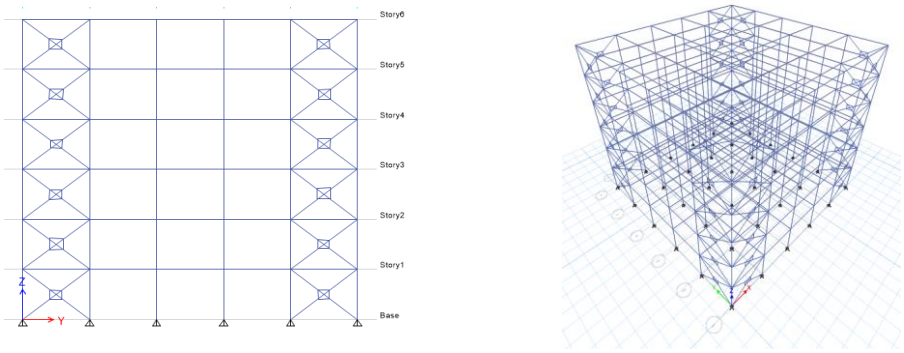

Fig.4. 2D and 3D view of steel frame with dampers at end frame of all storeys

VI. RESULTS AND DISCUSSIONS

The seismic performance of the moment resisting steel building is analysed by static equilibrium analysis in ETABS. From the analysis the displacement and storey drifts at all storey levels under the action of earth quake are observed and noted. Similarly for the same frame section the analysis is carried out with dampers placing at base storey by using bracings, and also the analysis is carried out with dampers placing at end frame of all storeys by using bracings. The displacement and storey drifts are observed by static equilibrium analysis. The results from these cases are compared and shown in table II.

Test results shows that visco- elastic dampers are very efficient in reducing excessive vibration of the test structure under seismic excitations. From the comparison of results shows very good agreement for the visco- elastically damping structure. The results of the maximum displacement for the intended structures, indicating that the maximum story displacement of the structures due to the added damper can be reduced.

TABLE II. COMPARATIVE RESULTS OF DISPLACEMENT AND STOREY DRIFT WITH AND WITHOUT VISCO- ELASTIC DAMPERS

Storey level	**Displacement (mm)**			**Storey drift**		
	Without dampers	***With dampers At base floor***	***With dampers At end frame of all storey***	***Without dampers***	***With dampers At base floor***	***With dampers At end frame of all storey***
Ground floor	46.004	32.982	14.262	0.005171	0.002961	0.001001
First floor	42.885	29.121	11.26	0.00292	0.002704	0.001032
Second floor	37.906	22.933	8.255	0.002433	0.002273	0.00101
Third floor	31.555	15.12	5.354	0.002117	0.001805	0.00905
Fourth floor	24.263	6.697	2.802	0.001663	0.001267	0.00682
Fifth floor	15.502	0.095	0.958	0.00104	0.00088	0.000484

VII.CONCLUSION

A new passive control system consisting of a visco- elastic damper to be installed in a moment resisting steel structure was studied. Static equilibrium analysis were performed by ETABS on a 5 storey steel frame to evaluate the seismic behaviour of the structure. The displacement and storey drift are compared from this analysis. It is concluded that the seismic response of steel frame is considerably reduced with added visco elastic damper placed at end frame of all storeys by X bracings.

Acknowledgment

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References

[1] R. H. Zhang and T. T. Soong, "Seismic design of viscoelastic dampers for structural applications," *Journal of Structural Engineering ASEC* , vol. 118, pp. 1375–92, 1992.

[2] P. Mahmoodi, "Structural dampers," *Journal of Structural Devision, ASCE*, vol. 95, no. 8, pp. 1661–72, 1969.

[3] R. H. Zhang, T. T. Soong, and P. Mahmoodi, "Seismic response of steel frame structures with added viscoelastic dampers," *Earthq Eng Struct Dyn*, vol. 18, pp. 389–96, 1989.

[4] K. C. Chang, T. T. Soong, S. T. Oh, and M. L. Lai, "Seismic response of a 2/5 scale steel structure with viscoelastic dampers," *Technical Report NCEER-91-0012. Buffalo, NY: National Center for Earthquake Engineering Research*; 1991.

[5] R. C. Lin, Z. Liang, T. T. Soong, and R. H. Zhang, "An experimental study on seismic behavior of viscoelastically damped structures," *Eng Struct*, vol. 13, pp. 75–84, 1991.

[6] D. M. Bergman and R. D. Hanson, "Viscoelastic mechanical damping devices tested at real earthquake displacements," *Earthq Spect* , vol. 9, pp. 389–417, 1993.

[7] S. H. Lee, D. I. Son, J. Kim, and K. W. Min, "Optimal design of viscoelastic dampers using eigenvalue assignment," *Earthq Eng Struct Dyn*, vol. 33, pp. 521–42, 2004.

[8] P. Mahmoodi, "Design and analysis of viscoelastic vibration dampers for structures," in *Proc. the \NOVA-73 World Innovation Week Conference*, 1974, pp. 25-39.