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Seismic Response Evaluation of Reinforced Structure with Embedded Viscous Damper in Shear Wall

Amir Fateh , Farzad Hejazi, Abdilahi Bashir Omer, Mohd Saleh Jaafar
Geospatial Science Research center, Department Of Civil Engineering, Faculty of Engineering,
University Putra Malaysia
Serdang, Selangor Darul Ehsan, Malaysia
farzad@eng.upm.edu.my

Abstract - **Recently implementation of viscous damper devices as seismic energy dissipation attracts a lot of civil engineer interested due to effect of dampers in diminishing of earthquake loading. Furthermore along lateral load resistance systems, shear wall has better resistance performance by providing enough stiffness to the structure. But the overall weight of building is dramatically increased whenever shear walls are used as lateral resistance system.**

So, in present study an attempt has been made to evaluate seismic response of reinforced concrete structure which is equipped with viscous damper inside of shear walls. So, seismic response assessment carried out by aid of time history analysis and the results emerged in terms of average story displacement, axial force, moment and torsion in critical elements. Various models with different shear wall arrangement and embedded viscous damper layouts were subjected to earthquake excitation and response investigated. The results indicated that the best performance achieved when the viscous damper located at the top of the shear wall frame structure with the highest reduction percentage of axial forces, moment at the base of the shear wall, torsion and base shear values.

***Keywords*—viscous damper, shear wall, time history analysis, 3-D earthquake excitation, embedded viscous damper.**

I. Introduction

The usage of the energy dissipation devices in the building structures have been developed in the past decades. Various devices were utilized to protect the various types of structure from excessive seismic energy [1-3]. Previous studies also reveal the interest of researchers to evaluate the seismic performance of these devices through analysis [4-6]. Furthermore, due to importance of energy dissipations implementation in structures, particularly viscous damper, numerous design guidelines were proposed and available in literature [7-8].

In 2003, Madsen studied on the effects of damping systems to improving the seismic design performance of multi storey buildings structures. Madsen used finite element program package to analysis and obtain the response of the structure under seismic. The dampers were located within cut-out sections of shear walls of 9 storey building models analyzed and the effectiveness of the damper placement by subjecting seismic excitation was evaluated. The results showed that the ground floor placement of the damper achieved the highest reduction of the tip deflection and tip acceleration. [9]

In 2006, Marko was carried out a time history analysis of the shear wall model by observing the effects of the three types of damping devices on the seismic response of shear wall structures. The three types of used damping devices consisted of friction dampers, viscous elastic dampers and hybrid dampers. The best performance was achieved in structure where damper installed in top, bottom and middle parts of the model. Then models with dampers placed in the upper, middle, and lower parts, positioned form second to fifth ranks respectively. It means that the location of damper installation played important role on seismic response of structure [10].

The viscous dampers have been utilized most commonly in the frame structures. Mostly the researchers investigated on implementation passive energy dissipation devices into frame structures system but rare investigation had done towards the implementation of the viscous damping devices embedded into shear walls of the building. This study concentrated on seismic response evaluations of the shear wall buildings subjected to seismic loads with viscous damping devices strategically installed into shear wall.

II. Method of Analysis

A 3-storey shear wall frame structure modeled in two different types. General two types of models designed and named by model type 1, and 2. Each type of the models equipped with viscous damper in four locations, inside the shear wall. The model type one represented by a symmetric 3-storey frame with three bays in both directions. In each side the shear wall located at the middle span. A diagonal viscous damper was installed within cut out of shear wall at four different locations, namely bottom, middle and top storey of the structure as well as, all storey of the frame shear wall, as depicted in fig. 1. The model type 2 represented by a symmetric3-storey frame with three spans in each side and the shear wall located at the corner bays of each side. A diagonal

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viscous damper was installed within cut out of shear wall at four different placements as shown in fig. 2. The dimensions of the shear wall in model type one and type two were 10.5 m height, 6 m width and 0.15 m thick. Where the dimensions of the beams were 400 x 250 mm and columns size was 150 x 150 mm. The frame only carried the self weight and 7.21 KN brick wall loads.

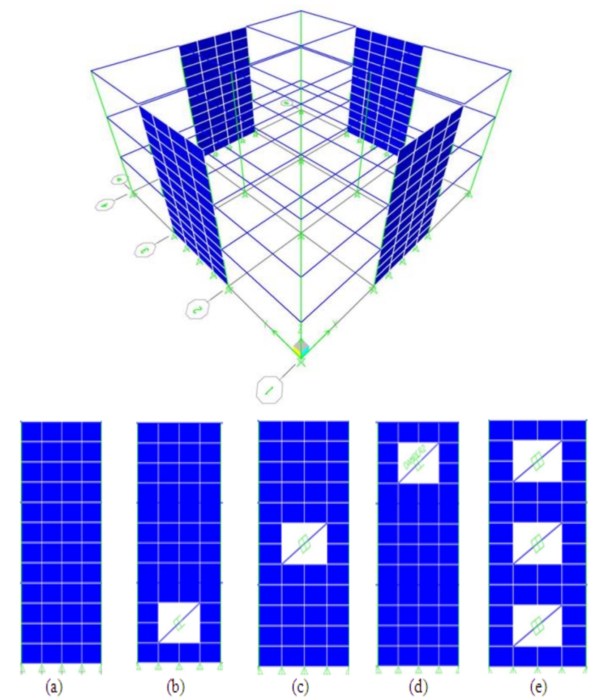


Figure 1. Model type one

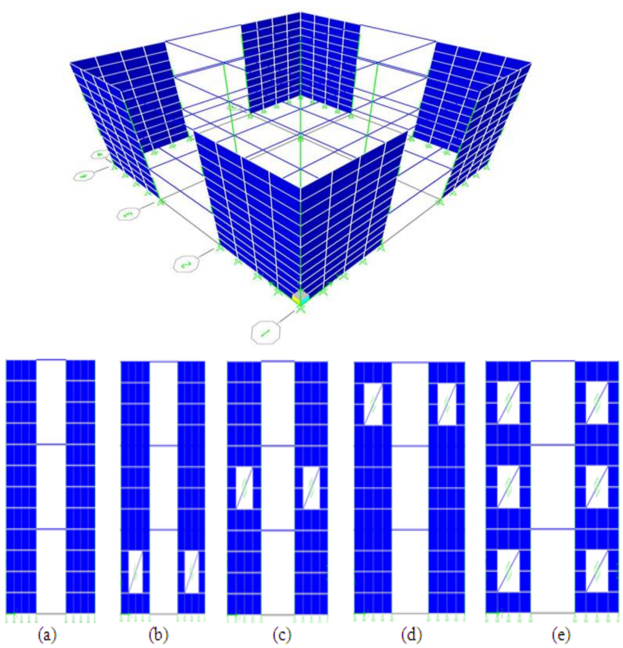


Figure 2. Model type two

As shown in figure 3, the diagonal configuration of the viscous damper was considered for both types of models. Detail of the diagonal viscous damper located within the cut out of the shear wall is shown in fig. 3.The properties of the viscous damper for all models was same. Viscous damper stiffness and damping characteristics presented by $K_d = 10^4$ N/mm and $C_d = 10^6$ N.Sec/mm correspondingly.

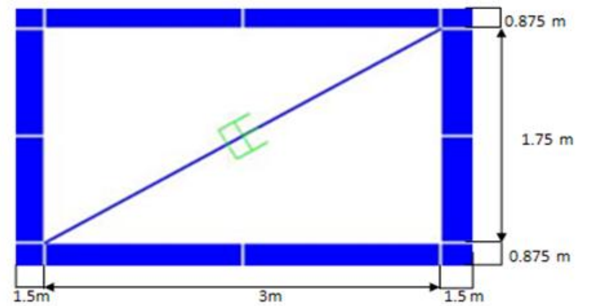
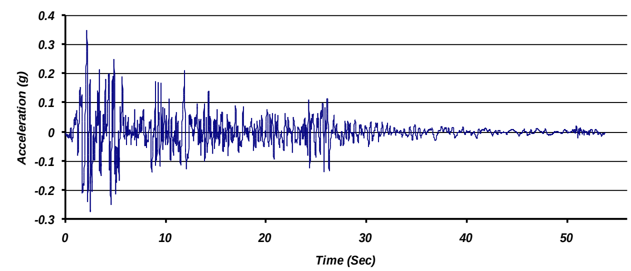
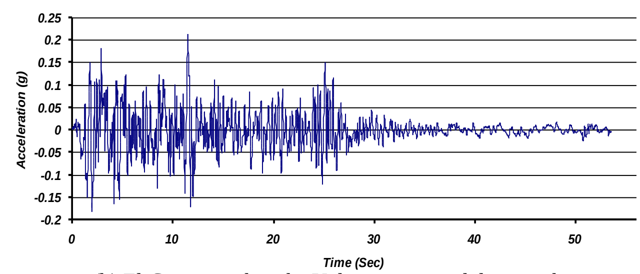


Figure 3. Viscous damping installation in shear wall structures

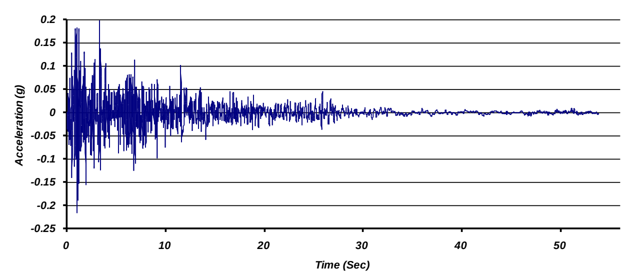
The El-Centro 3-D earthquake records is used for time history analysis, in order to evaluate the seismic response of shear wall frame structures with different shear wall and embedded dampers layouts. The three dimensions of El-Centro (1940) earthquake records plotted in the fig. 4.



(a) El-Centro earthquake north-south direction record data graph



(b) El-Centro earthquake Y direction record data graph



(c)- El-Centro earthquake Z direction record data graph

Figure 4. 3-D El-Centro earthquakes record

III. Result and Discussion

The peak displacement vs. story height plotted in fig.5 and fig.6. As shown in figure 5, the shear wall frame with viscous damper at the top of the structure achieved best performance compared to the frame shear wall and those had viscous damper in other locations. The average peak deflection of shear wall frame equipped with viscous damper at the top of the structure reduced 25.15% compared to the shear wall without damping system. Installation of viscous damper at top of the shear wall frame was the optimum and best location of the viscous damper embedded in shear wall under three dimension of earthquake excitation. In table I and II, maximum structural member forces of shear wall for model type one and two tabulated respectively.

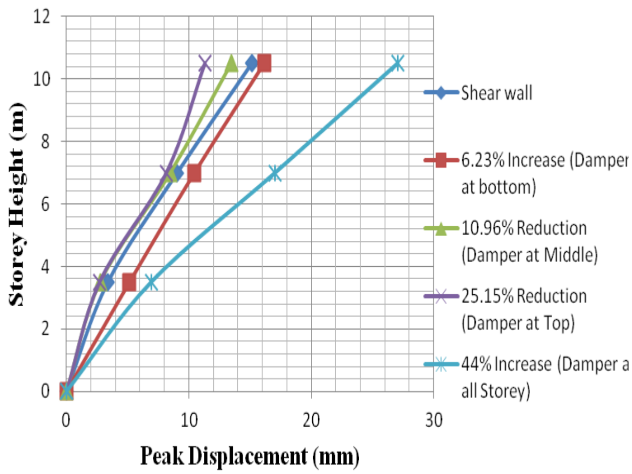


Figure 5.Peak Storey Displacements of Model Type One

Furthermore, as illustrated in table I, the axial forces, moment at base, torsion after installation of viscous damper at top of the shear walls were diminished approximately 32, 13, 16 and 18 percent correspondingly.

The structure member forces of the shear wall equipped viscous damper at the all storey of the structure increased compared to the shear wall without damping systems. For example 29.1% increase of the axial forces after equipped viscous damper at the all storey of the shear wall frame structure. The negative sign represents the increasing trend of value compare with shear wall without any dampers.

In the model type 2, as shown in fig.6, the shear wall frame with installed viscous damper at the top of the structure achieved best performance compared with others. Maximum structure member forces of shear wall frame furnished by viscous damper at the top of the structure decreased all forces compared to the shear wall without damping systems. As can found in table II, results shows 26.84% reduction of the axial forces after installation of viscous damper at the top of the shear wall frame structure.

TABLE I. MAXIMUM STRUCTURAL MEMBER FORCES OF SHEAR WALL MODEL TYPE ONE

Structural Member Forces		**Reduction (%)**			
Model Type One	**Shear wall**	**Damper at Bottom**	**Damper at Middle**	**Damper at Top**	**Damper atAll story**
Axial Force	**176.2 kN**	**28.94**	**17.9**	**32.16**	**-29.1**
Shear Force	**9233.93 kN**	**5**	**7.1**	**12.76**	**-23.2**
Torsion	**83110 kN.m**	**5.33**	**14.2**	**15.9**	**-23.47**
Moment	**76260 kN.m**	**8.1**	**12.65**	**18.12**	**-21.74**

The moment and shear force at the base of the shear wall decreased around 36, and 44 percent respectively, while the torsion also decreased about 29%. The result of peak deflection and structural member force of the frame revealed that the optimum location of the viscous damper in the shear wall frame was at the top of the frame structure, due to highest reduction of peak displacement and all structural member forces.

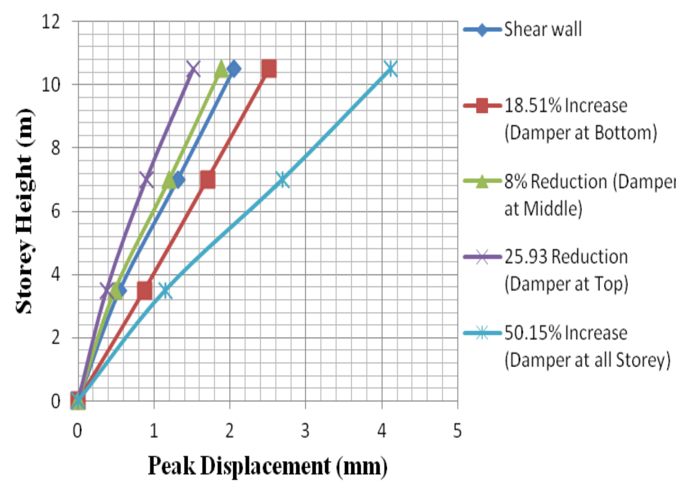


Figure 6. Peak Storey Displacements of Model Type two

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TABLE II. MAXIMUM STRUCTURAL MEMBER FORCES OF SHEAR WALL MODEL TYPE TWO

Structural Member Forces		Reduction (%)			
Model Type Two	**Shear wall**	**Damper at Bottom**	**Damper at Middle**	**Damper at Top**	**Damper At All Storey**
Axial Force	**75.23 kN**	**22.8**	**29.43**	**36.84**	**-69.31**
Shear Force	**4054 kN**	**22.58**	**38.27**	**44.76**	**-17.43**
Torsion	**36320 kN.m**	**0.14**	**12.14**	**29.58**	**-23.3**
Moment	**31960 kN.m**	**3.89**	**19.26**	**32.79**	**-19.88**

The result in Fig. 7, demonstrates the highest peak displacement reduction in both models occurred when Viscous damper installed at top of the shear wall frame structure The average percentage peak deflection reduction achieved by 25.15% and 25.93% in model type one and type two correspondingly.

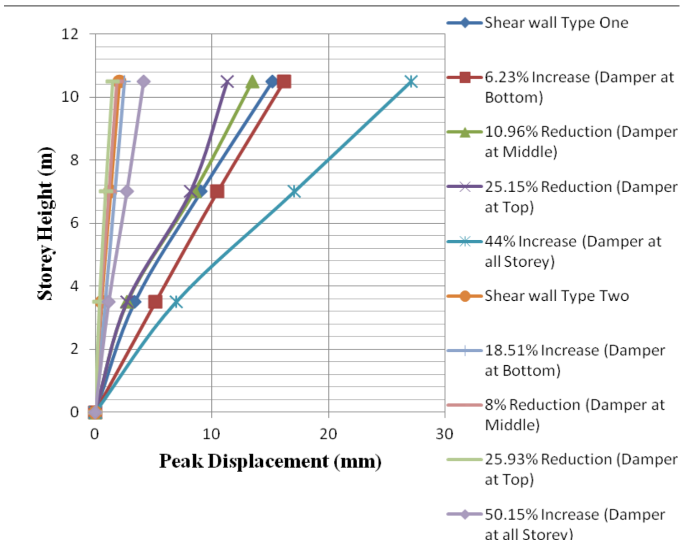

Figure7. Comparison of Peak Storey Displacements of Shear wall Type 1 and Shear wall Type 2

IV. Discussion

In this research seismic response was affected by location of damper inside the shear wall subjected to three dimensional of earthquake excitation. Two general dissimilar models designed and named as model type one (shear wall at middle span) and model type two (shear wall at corner spans). it was considered that each model equipped viscous damper in different locations. The peak displacement reduction in both models with and without viscous damper compared. The damper at top of the shear wall frame structure was achieved highest peak displacement in both models. As conclusion the equipped viscous damper at top is optimum location of the damper under three direction of earthquake excitation.

Structural member forces of frame structures with existence of shear walls at the corners achieved the highest reduction of all structural member forces when the viscous damper embedded at the top shear wall.

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