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Research Article

Comparative study between structure with and without a fluid viscous damper under seismic excitation

Brahim Athamnia [*], Mohamed Zohair Kaab [2], Farid Boursas[3] and Abdelhafid Ounis [3]

[1]Department of civil engineering, Faculty of Technology Larbi Tebessi University, Tebessa, Algeria
ORCID ID 0000-0003-0525-3499
[2]Department of civil engineering, Faculty of Technology Hamma Lakhdar Eloued University, Eloued, Algeria
[3]Department of civil engineering, Faculty of Technology Larbi Tebessi University, Tebessa, Algeria
ORCID ID 0000-0001-6491-4205
[4]Department of civil engineering and hydraulics, Mohamed Khider University, Biskra, Algeria
ORCID ID 0000-0001-6268-1401

[*](brahim.athamnia@univ-tebess.dz) Email of the corresponding author

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Abstract **–** The effect of fluid viscous damper on the seismic response of building is investigated. Although buildings without fluid viscous damper have a disadvantage in increasing damage to the superstructure under earthquake. The influence of fluid damper in controlling the responses of building is investigated using a multi-storey building frame. Analysis is carried out using ETABS software. The seismic responses are compared with that of the building without and with passive fluid viscous damper. Based on the results, it is concluded that fluid damper is beneficial to achieve reduced the deformation of the superstructure. it is concluded that the distribution of fluid viscous damper in building is the most effective in reducing the base shear forces without significant increase in superstructure forces.

Keywords –seismic response- fluid viscous damper-earthquake- building- damage

I. INTRODUCTION

Building design for the most part includes proportioning the components of the elements to such an extent that the limitations on strength and serviceability limit states are fulfilled. The traditional approach is proportionality of the components to satisfy the strength limit states and then follow it up with serviceability checks. But based on the modern control theory, structural control has occurred to mitigate the negative effects that the external disorders impose on the structures. Structural control has been examined and shown great potential for reducing vibrations in several civil structures under dynamic loading[1].

Energy dissipation devices in the passive and semi-active forms have been progressively applied on civil structures to decrease their seismic demand underground motions. Usually used viscous fluid dampers, typically consisting of a hollow cylinder filled with silicone-based fluid, can efficiently dissipate energy by pushing the fluid through orifice and producing friction forces, which in turn will transform the kinematic energy into the form of heat[2].Figure 1 depicts a typical fluid damper and its parts. On the other hand, the macroscopic behavior of the damper is relatively simple that can be simulated by an idealized linear or nonlinear viscous dashpot[3]. In its linear form, the role of damping brought by the viscous dampers can be easily quantified by the associated damping coefficient[4].

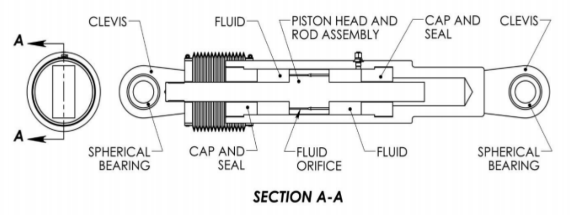

Fig.1Typical Fluid Damper Parts

The design procedure of this type of devices can be limited into the selection of appropriate parameters values (damping coefficient C_D, damping exponent α) and their position along the structure. This procedure is a time-consuming task, and it is more difficult for a nonlinear case, as it needs nonlinear time-history analysis. Inside the obtainable design methods, many speculative assumptions are made in order to simplify the task, which may lead to inaccurate results[5].

Constantinou and Symans [4, 6].Tsai et al. [7] have executed experimental and analytical research on the seismic performance of steel structures with fluid viscous dampers. Uriz and Whittaker [8]found that the use of fluid viscous dampers with the equivalent viscous damping of 40% of critical damping produced a reduction in the displacement of the frame. Dicleli and Mehta [9]compared the seismic performance of steel chevron braced frames (CBFs) with and without fluid viscous dampers in terms of intensity and frequency characteristics of the ground motion and fluid viscous damper parameters. Choung-Yeol Seo et al. [10]designed a steel structure with 100% and 75% of design base shear using linear damper; then, it was compared with a structure without dampers. They found that the use of linear damper could ameliorate the performance of the structure and decrease the possibility of collapse.

This paper investigates the comparison between seismic response of building with and without fluid viscous damper under earthquake ground motions. The main objectives of the study are:(i) to study the effect of fluid viscous damper on the reduction of drift story, (ii) to obtain small displacement compare with there in building without fluid viscous damper.

II. MATHEMATICAL MODELLING OF FLUID VISCOUS DAMPERS

The behavior of a fluid viscous damper is idealized as a pure dashpot as shown in the constitutive equation below:

$$F = C.V^{\alpha} \qquad (1)$$

Equation 1 provides the relationship between the damper output force F and velocity V, where C and α (alpha) are the damping constant and velocity exponent, respectively. An alpha of 1.0 represents linear dampers, whereas values other than 1.0 indicate nonlinear dampers. For alpha typically range from 0.3 to 1.0.

III. A COMPARATIVE NUMERICAL STUDY

The numerical study was performed with a 6-story building frame with and without fluid viscous damper. Figure2 shows the building plan, which is symmetric with three longitudinal spans (4 m each) and two transverse spans (4 m each).

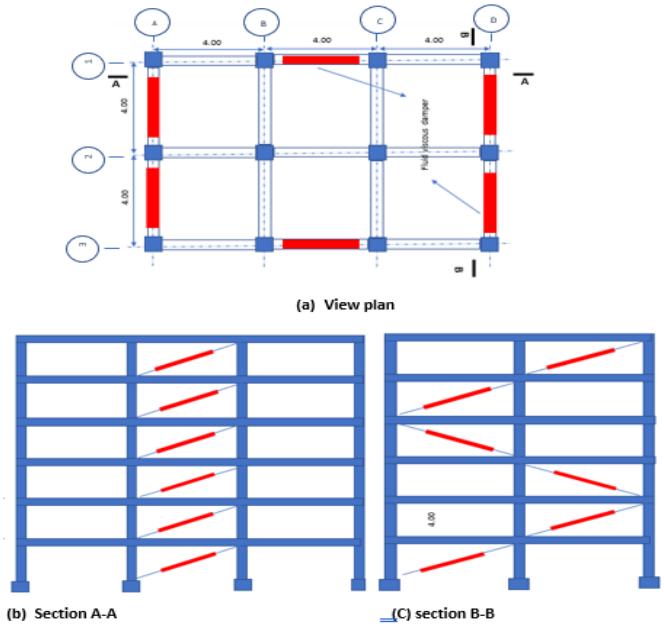

Fig. 2 View plan and sections of the designed structure

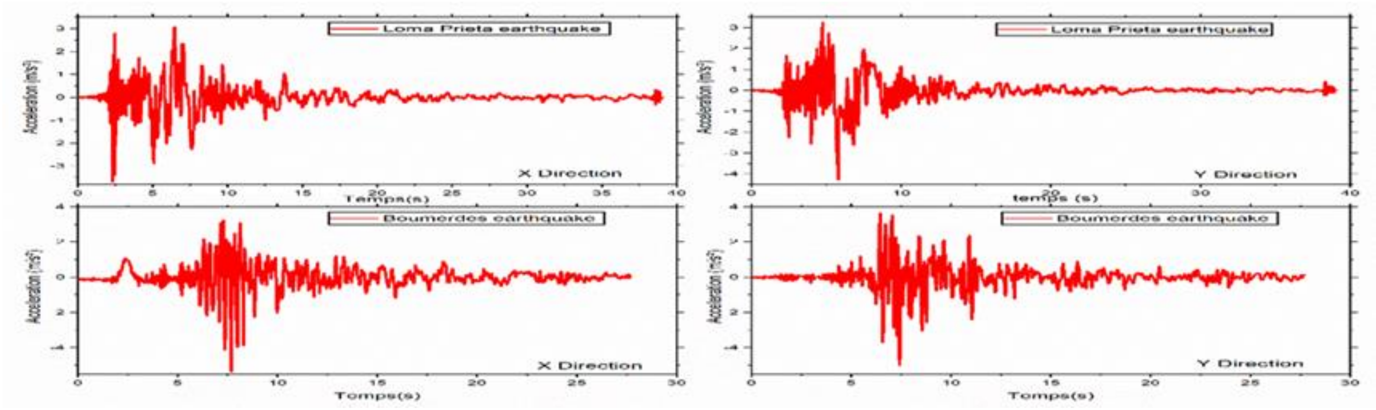

Fig.3 Time history of earthquakes ground motions

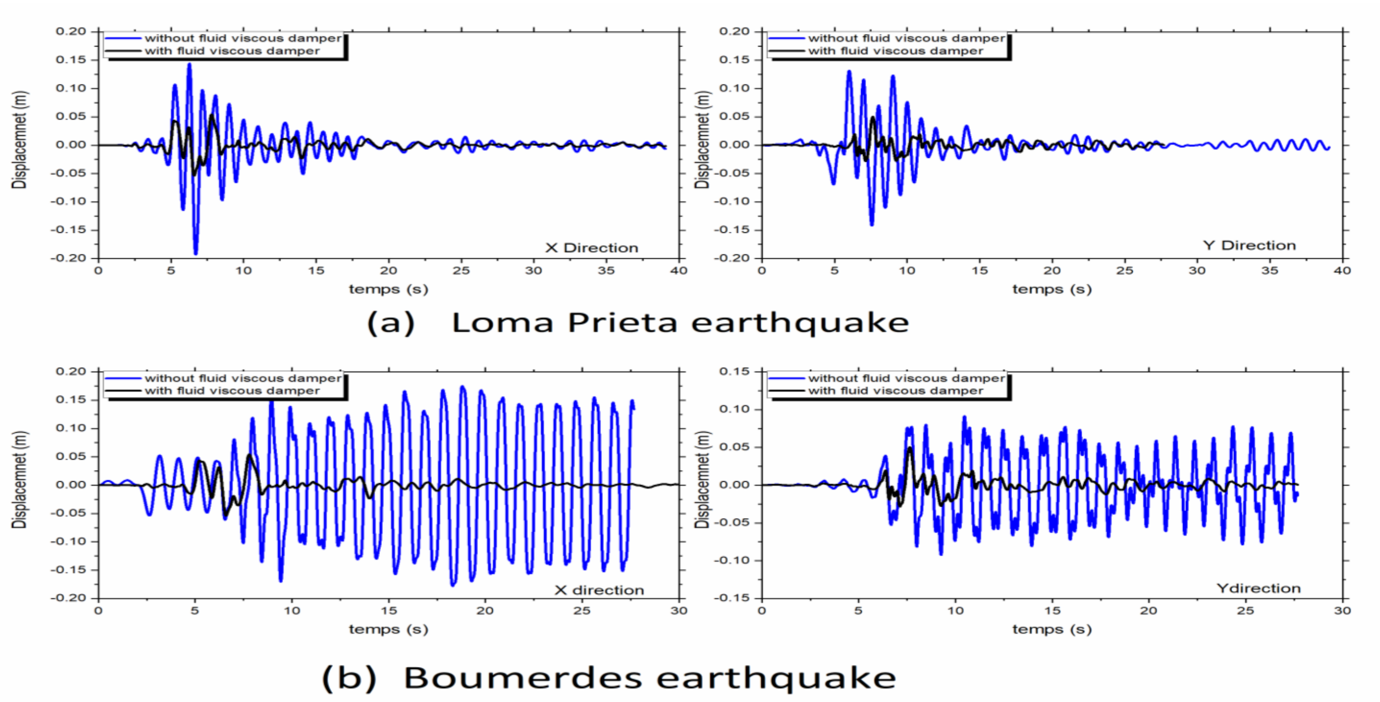

Fig.4. Time history of the top floor displacement under earthquake ground motions

The column size is30 × 30cm, and the beam size is 30 × 40 cm for all floors. The story height is 3.0 m and slab thickness is 15cm for all stories of the building. The earthquake excitations used for time history analysis are as shown in Figure3.The linear viscous dampers will be installed with a diagonal brace configuration Figure2. Each floor will contain four linear dampers. The inherent damping ratio of the structure is assumed to be 5%, and the effective damping ratio resulting from ail added dampers is expected to reach 20%.

That is to say, the total effective damping ratio of the whole System is designated at 25% of critical. This structure is located in a seismic zone with strong seismicity (Zone III), according to the seismic design specifications of building structures in Algeria (RPA’99V2003). In Figure4, the maximum top floor displacement of structures with and without fluid viscous damper are shown, which are obtained from maximum seismic responses of

Loma Prieta and Boumerdes earthquake imposed to structure.

The results show that the structures with viscous damper have significantly smaller displacements compared to the primary structure without damper. The reduction of maximum top floor displacement is evaluated respectively, 54.76% and 82.88% for Loma Prieta earthquake in direction X and Y. while, this reduction, is evaluated respectively, 82.88%

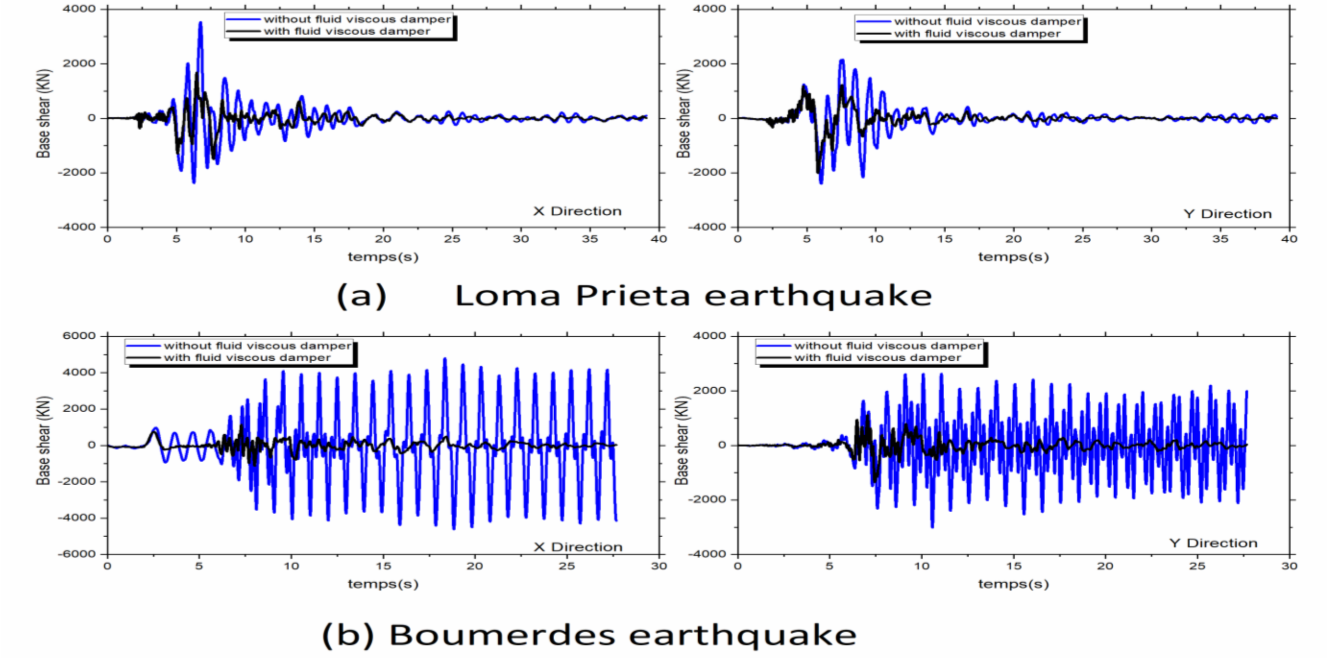

Fig.5 Time history of base shear forces under earthquake ground motions

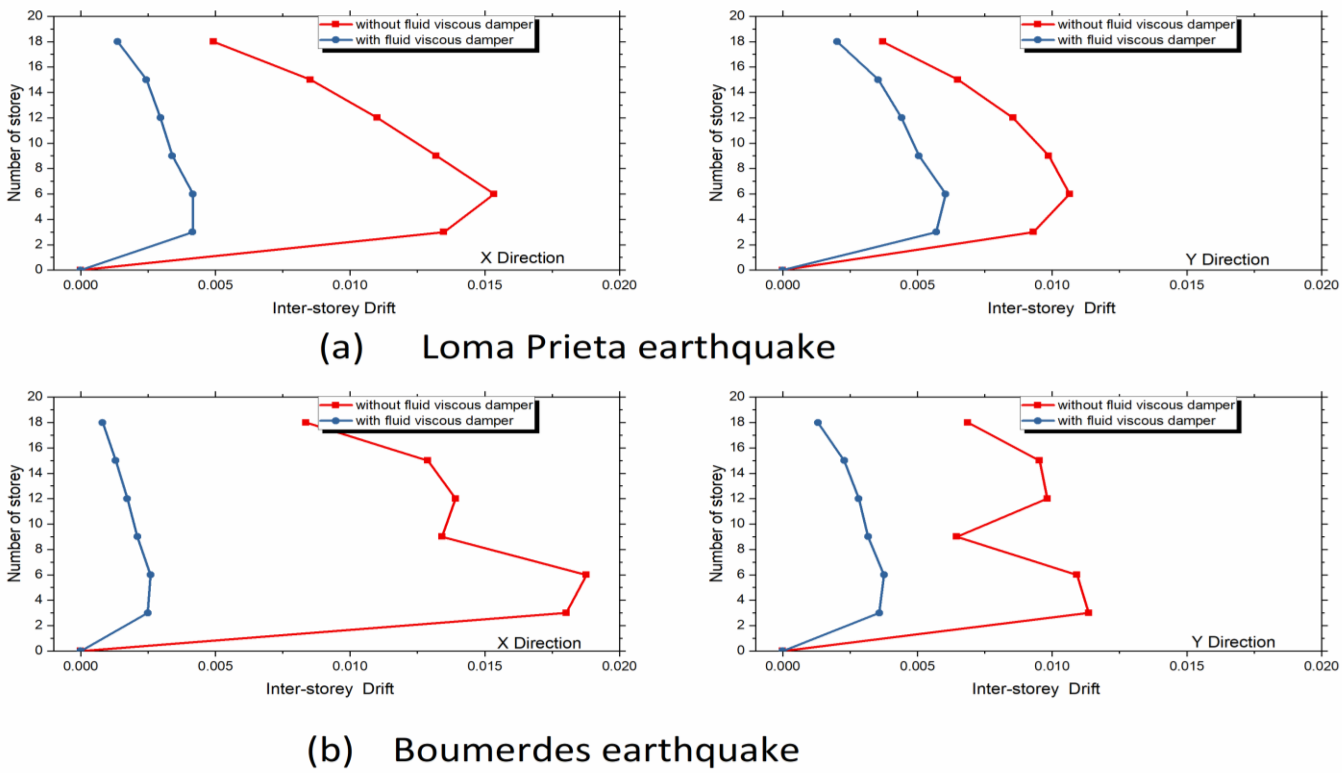

Fig. 6 Maximum inter-storey drift under earthquake ground motions

and 45.02% for Boumerdes earthquake in direction X and Y.

In figure5, base shear forces of structures with and without fluid viscous damper are represented. These results show that the fluid viscous damper is more efficient in reduction seismic response and dissipate much energy of structure. Thereby, the maximum percentage reduction obtained is 76.10 %for Boumerdes earthquake in X direction.

In figure6, maximum inter-storey drift ratio under Loma Prieta and Boumerdes earthquake with and without viscous damper is shown.

The results show that the structures with fluid viscous damper have smaller story drifts compared to without fluid viscous damper structure. Also, the structure with fluid viscous damper has the best performance among the structure without viscous dampers in reducing the story drifts. Besides, the maximum percentage reduction obtained is 90.33 % for Boumerdes earthquake in X direction.

IV. CONCLUSION

The aim of this study is to investigate the behavior of buildings with and without fluid viscous damper, the following observations were made:

The fluid viscous damper was effective in reducing earthquake-induced top floor displacements, base shear forces and inter-story drifts. More specifically, the reduction in the maximum top floor displacements, base shear forces and inter-story drift are observed from Boumerdes earthquake in X direction. Finally, the fluid viscous damper is effectiveness in reducing the seismic response of building with considering the arrangement of fluid viscous damper in superstructure in both direction of building.

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