

# Comparison of seismic performance of steel frames equipped with diagonal and chevron viscous damper under near and far field earthquakes

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**Abstract.** A complete comparison of seismic behavior of the application of Diagonal and Chevron Viscous Damper in steel structures is presented in this paper. OpenSees software is used for the numerical modeling of structures. Fifteen numbers of earthquake records are applied to the structures and full nonlinear time history analysis is done. Force-displacement of chevron braces with and without a damper are compared and the results of IDA curves are also presented for different percentiles.

**Keywords:** steel bracing frame, viscous fluid damper, energy dissipation, nonlinear dynamic analysis.

## 1. Introduction

There are two common types of steel chevron and diagonal bracing frames, equipped with viscous fluid damper are studied in this paper. All dimensional specifications, as well as the specifications of the cross-sections and materials used for the beams, columns, and braces of the frame models, are considered as similar. OpenSees software is used to model the structures and a suit of fifteen earthquake records are used for nonlinear time history analysis. Viscous dampers have a great displacement under strong ground motions and absorb earthquake energy and less damage will occur in structural components. It has been established that the base shear and displacements are decreased by using viscous dampers in steel structures. The main advantages of viscous dampers are on the hysteretic behavior in the main structural members. One of the most practical and effective methods for controlling the behavior of the structures is using viscous dampers. The designed procedures of dampers are based on the structural period, soil type and structural components. [1].

## 2. Structural modeling

In this research, there are four story steel frame structures with chevron and diagonal braces are studied and designed in ETABS software [1]. The height of each floor is 3 meters and the length of each bay is 5 meters. Viscous dampers in the OpenSees software have been placed at the junction of the beam and the column [2-5]. In Table 2, the details information of earthquake records is presented in Table 2. The record selection has been done from FEMA-P695. Incremental dynamic analysis (IDA) is used in this study to obtain the nonlinear behaviour of structures.

**Table 1.** Sections assigned in each of steel frames

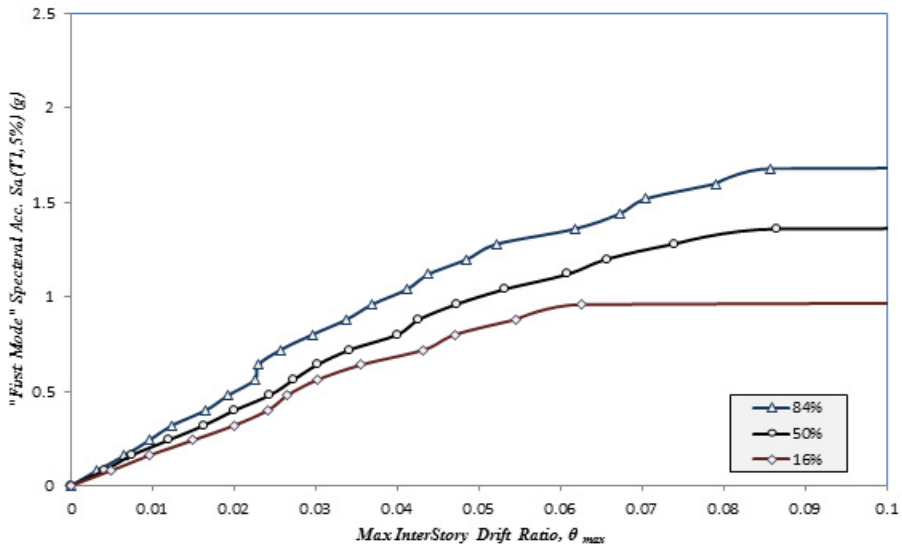
4-story structure with diagonal and chevron braces		
Column sections	Beam sections	Brace sections
IPB 180	IPE270	TUBO 80*80*8

**Table 2.** Specifications of far field and near field accelerograms [2]

Specifications of the Selected Records							
Record No.	Earthquake name	Station name	Year	Magnitude	Soil type	Fault type	PGA
1	Northridge	Beverly Hills-Mulhol-USC	1994	6.7	D	Thrust	0.52
2	Northridge	Canyon Country-WLC-USC	1994	6.7	D	Thrust	0.48
3	Duzce, Turkey	Bolu-ERD	1999	7.1	D	Strike-slip	0.82
4	Hector Mine	Hector-SCSN	1999	7.1	C	Strike-slip	0.34
5	Imperial Valley	Delta-ENAMUCSD	1979	6.5	D	Strike-slip	0.35
6	Imperial Valley	El Centro Array #11-USGS	1979	6.5	D	Strike-slip	0.38
7	Kobe, Japan	Nishi-Akashi-CUE	1995	6.9	C	Strike-slip	0.51
8	Kobe, Japan	Shin-Osaka-CUE	1995	6.9	D	Strike-slip	0.24
9	Kocaeli, Turkey	Duzce-ERD	1999	7.5	D	Strike-slip	0.36
10	Kocaeli, Turkey	Arcelik-KOERI	1999	7.5	C	Strike-slip	0.22
11	Landers	Yermo Fire Station-CDMG	1992	7.3	D	Strike-slip	0.24
12	Landers	Coolwater-SCE	1992	7.3	D	Strike-slip	0.42
13	Loma Prieta	Capitola-CDMG	1989	6.9	D	Strike-slip	0.53
14	Loma Prieta	Gilroy Array #3-CDMG	1989	6.9	D	Strike-slip	0.56
15	Manjil, Iran	Abbar-BHRC	1990	7.4	C	Strike-slip	0.51

### 3. Incremental Dynamic Analysis (IDA)

A full nonlinear time history analysis has been done based on the IDA procedure. The results of nonlinear time history have been shown in Figures 1 and 2. These figures shows the behavior of structures from linear to nonlinear levels. Maximum inter story drift is considered as an Engineering Demand Parameter (EDP) in diagonal and chevron bracing with a viscous damper and  $S_a(T_1, 5\%)$  as an Intensity Measures (IM). The results are for the frame with chevron bracing with a viscous damper and with diagonal bracing with a viscous damper. To better understanding of the performance of the structures, the nonlinear behavior of structural components is studied. Figures 3 is shown the hysteretic behavior of chevron braces with and without viscous dampers. Figure 4 is shown the hysteretic behavior of diagonal braces with and without viscous damper. The tight loops are the better performance of viscous structures.



**Fig. 1.** Summary of IDA curves obtained for a 4-story structural frame with chevron bracing with a viscous damper

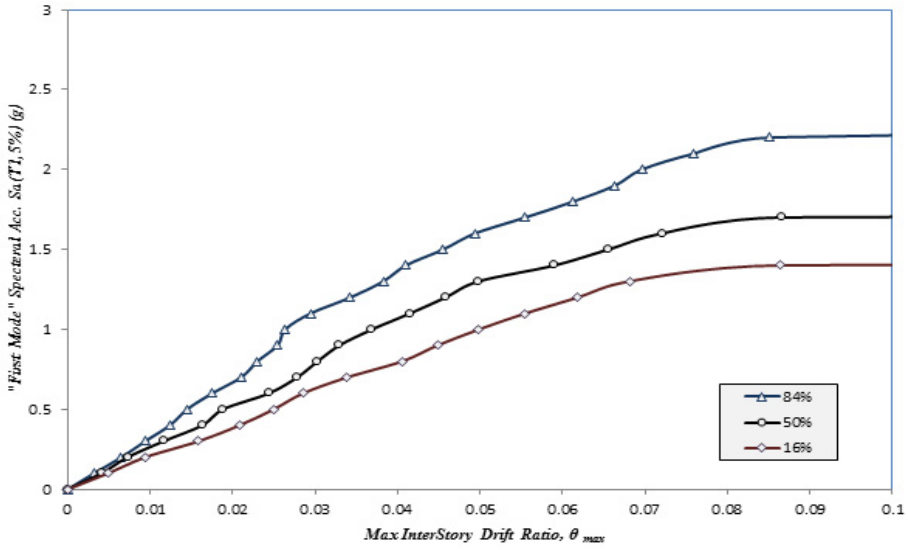


Fig. 2. Summary of IDA curves obtained for a 4-story structural frame with diagonal bracing with a viscous damper

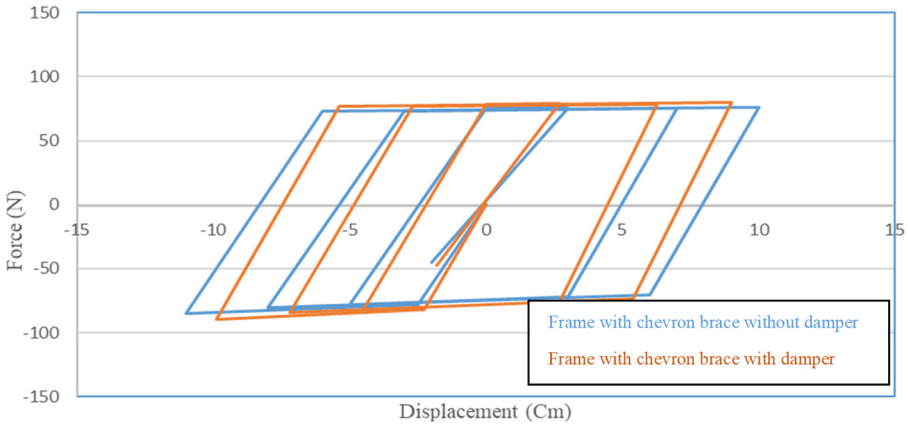


Fig. 3. Comparison of the curves of the frame with chevron braces with and without damper

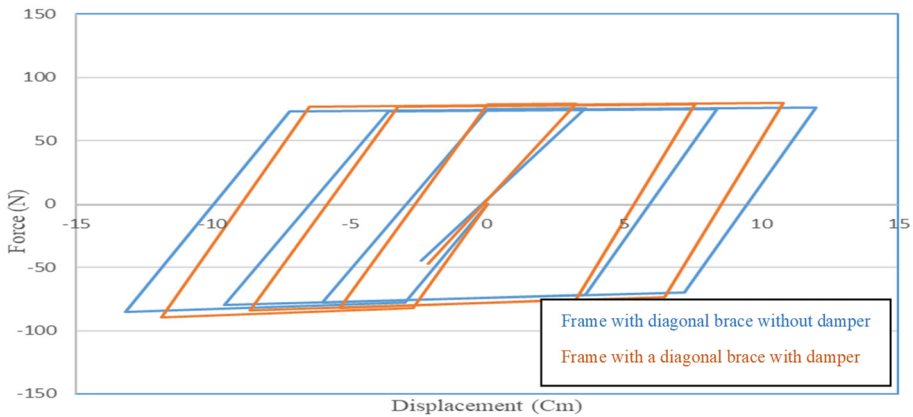


Fig. 4. Comparison of the curves of the frame with diagonal braces with and without damper

#### 4. Conclusions

In this paper, nonlinear behavior of steel frames with chevron and diagonal braces were considered. The effects of viscous dampers were considered in steel frames. The results show that the viscous dampers have a great effects on the hysteretic behavior of the steel frames and has less displacements. Chevron braces has better performance compared to the diagonal braces. The results indicate that the viscous dampers are improved the seismic performance of the structures.

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