SEISMIC PERFORMANCE OF MOMENT-RESISTING STEEL STRUCTURES WITH SLIT-FRICTION HYBRID DAMPER

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INTRODUCTION

Currently two of the most widely used seismic energy dissipation device in structures are metallic yield dampers and friction dampers. The metallic energy dissipative devices have been developed in many forms such as ADAS (Xia et al., 1992). Recently various energy dissipation devices or passive dampers have been widely applied for seismic retrofit of existing structures some researchers investigated simultaneous application of multiple devices to maximize energy dissipation mechanism, for example (Chen et al., 2002) studied combined displacement-dependent and velocity-dependent devices for seismic mitigation of structures to minimize the defects of individual dampers. Lee et al. (2015) investigated the combined the effectiveness of a mixed damper consisting of steel slit plate and rotational friction devices to be used effectively both for small and large earthquake in concrete frame. In this way new dissipation system called slit-friction hybrid damper (SFHD) is introduced this study as the combination of these dampers that can be used in a lateral load resisting system to improve the seismic performance of the steel structures.

MODELLING FOR NONLINEAR ANALYSIS

In this paper energy dissipation device is developed by combining a steel slit damper and rotational friction dampers in parallel to be used for seismic retrofit of steel structures. Rerarding this purpose, 3D models of five and ten stories intermediate steel moment structure are considered in this study for performance assessment. The applied sections are BOX for columns and braces and such IPE for beams as shown in Table 1. Seismic loading for initial analysis and design was carried out according to the ASCE07-16 code. Construction site is considered in Montana with considerably high seismic risk, critical damping ratio in structure 5% and soil type D. In the structures with the hybrid dampers**,** the design of the frame element is to remain elastic and only the damper enters the nonlinear area. After the primary design of the frames with the mentioned loading, the nonlinear static analysis and nonlinear time history analysis were performed by the ETABS2016 software to investigate the behavior of frames without damper and with the hybrid damper during ground motions. Therefore, seven pairs of far-field acceleration records were used as displyed in Table 2. Incremental Dynamic Analysis (IDA), analyzes were performed by SeismoStruct software and the collapse fragility curves were obtained from the results of IDA analysis.

Table 1. Section size of the 5 stories model structure.

Applied sections			
Number of the Stories	**Columns**	**Beams**	**Braces**
First story	BOX:250*250*20	IPE330	BOX:120*120*10
Second story	BOX:250*250*20	IPE330	BOX:120*120*10
Third story	BOX:200*200*20	IPE300	BOX:120*120*10
Fourth story	BOX:200*200*20	IPE300	BOX:120*120*10
Fifth story	BOX:180*180*20	IPE240	BOX:120*120*10

Table 2. Seven pairs of far field accelertion records (FEMA-P695).

PEER-NGA Records Information					Recorded Motions	
ID No.	Record Seq. No.	Lowest Freq(HZ)	Component 1	Component 2	PGA_{max} (g)	PGV_{max} (cm/s)
1	169	0.06	IMPVALL/H-DLT262	IMPVALL/H-DLT352	0.35	33
2	174	0.25	IMPVALL/H-E11140	IMPVALL/H-E11230	0.38	42
3	752	0.13	LOMAP/CAP000	LOMAP/CAP090	0.53	35
4	767	0.13	LOMAP/G03000	LOMAP/G03090	0.56	45
5	848	0.13	LANDERS/CLW-LN	LANDERS/CLW-TR	0.42	42
6	900	0.07	LANDERS/CLW-YER270	LANDERS/CLW-YER360	0.24	52
7	953	0.25	NORTHR/MUL009	NORTHR/MUL279	0.52	63

RESULTS

According to the pushover results, as shown in Figure 1 the force-displacement curve, in the 5 stories structure that equipped with SFHD was increased by 10% compared to the original structure. The results of time history analysis showed that acceleration of the 5 stories structure under Imperial Valley earthquake in the structure including SFHD was reduced by 25% compared to the original structure, as displayed in Figure 2. According to the results presented in Figure 3, it could be observed that the probability of collapse in structure equipped with the SFHD was reduced by 30% compared to the original structures.

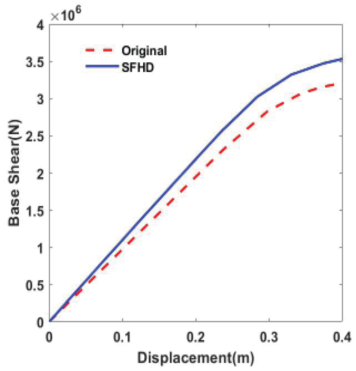

Figure 1. Force-displacement curve.

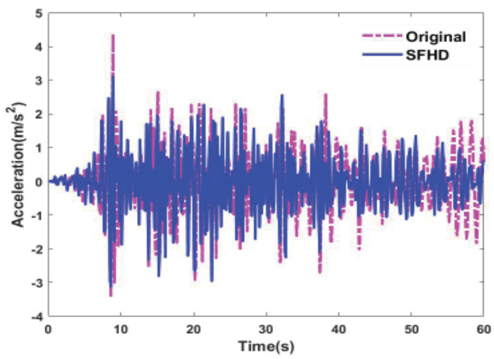

Figure 2. Acceleration under the Imperial Valley earthquake in the 5-story structure.

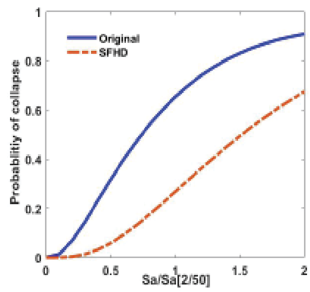

Figure 3. Possibility of collapse curve in the 5 story structure.

REFERENCES

ASCE/SEI 7-16 (2016). *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*. American Society of Civil Engineers, Virginia, U.S.A.

Chen, C.-S., Chen, K.-C., Pong, W.S., and Tasi, C.S. (2002). Parametric study for building with combined displacement-dependent and velocity-dependent energy dissipation devices. *Journal of Struct Eng Mech, 14*(1), 85-98.

FEMA P696 (2009). *Quantification of Building Seismic Performance Factors*, Federal Emergency Management Agency Washington (DC, USA).

Lee, CH. and Kim, J. (2015). Seismic performance evaluation of moment frames with slit-friction hybrid dampers. *Journal of Earthquake Struct, 9*(6), 1291-1311.

Xia, C. and Hanson, RD. (1992). Influence of ADAS element parameters on building seismic response. *Journal of Struct. Eng. ASCE, 118*(7), 1903-1918.