8th International Conference on Seismology & Earthquake Engineering
11-13 Nov. 2019, Tehran, Iran

INVESTIGATION ON RESIDUAL RESPONSE OF STEEL MOMENT FRAMES EQUIPPED WITH PALL FRICTION DAMPER SUBJECTED TO SEISMIC EXCITATIONS

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Keywords: Residual response, PALL friction damper, Seismic performance, Seismic resilience

Recent developments in earthquake engineering has focused on resilience-based design approach. A key factor to develop acceptable low-damage system is to control the residual displacement of the structural system along with its peak transient displacement. This quantity also helps to decide on whether the system is repairable from both technical and economic views. An acceptable structural system regarding its low-damage and repairable characteristics is steel frame equipped with friction dampers. In this study, the performance of steel moment-resisting frames equipped with the PALL friction damper type is compared with non-equipped moment-resisting frames. To this end, the response of three steel moment-resisting frames, with 3, 6 and 9 stories, each with three spans of 4-meter length and 3-meter in height are investigated. The loading is listed in Table 1. All equipped and non-equipped frames are designed based on regulations of the ASCE7-10 (ASCE, 2010) design code, response modification factor for steel moment frames with special ductility is 8. Also, overstrength factor and the displacement magnification factor are assumed to be 3 and 5.5, respectively.

Table 1. loads in 3, 6 and 9-story buildings.

Story	Dead load (kg/m^2)	Live load (kg/m^2)	Partitions load (kg/m^2)
Stories	510	240	72
Roof	510	90	72

All structures are assumed to be located in San-Diego, US. Site class C, risk category I and seismic design category D are selected for the design process. Also, the yield stress of the mild steel material is assumed to be Fy=220 MPa. All models are evaluated using non-linear response time-history analysis under 13 scaled far-field strong ground motion records. All records are selected from the Pacific Earthquake Engineering Research center (PEER) database. For the scaling process, the average spectrum obtained from all records is scaled with the reference spectrum being the ASCE design spectrum at two intensity levels selected as the Design Base Earthquake (DBE) and Maximum Considered Earthquake (MCE). In nonlinear modeling process, P-Δ effects are taken into account. All diaphragms are also considered as rigid in their plane. The damping ratio is all analysis models is considered to be 3% of critical damping. To simulate the friction damper, Link element with plastic (Wen) hysteretic behavior is used. Results show that the structure stiffness increases after implementing the PALL dampers. Results show that, on average, in 3, 6 and 9-story buildings respectively, a) the maximum inter-story residual drift decreases by 75-83%, 69-70% and 39-62% (shown in Figure 1); b) the maximum story displacement decreased by 49-58%, 43-49% and 29-39% and, c) the base shear value decreases by 16%, 11% and 4% in structures equipped with dampers compared non-equipped models. The Damage States for Residual Story Drift Ratio (DS1, DS2 in Figure 1) are shown in Table C-1 of the Seismic Performance Assessment of Buildings FEMA P-58 (FEMA, 2012). The results demonstrate the effectiveness of PALL friction dampers in enhancing the structural performance in term of reducing both the peak transient and peak residual displacements decreases as the height of the structure increases. It is argued that systems equipped with Pall dampers are much more "seismic-resilient" compared with non-quipped systems.

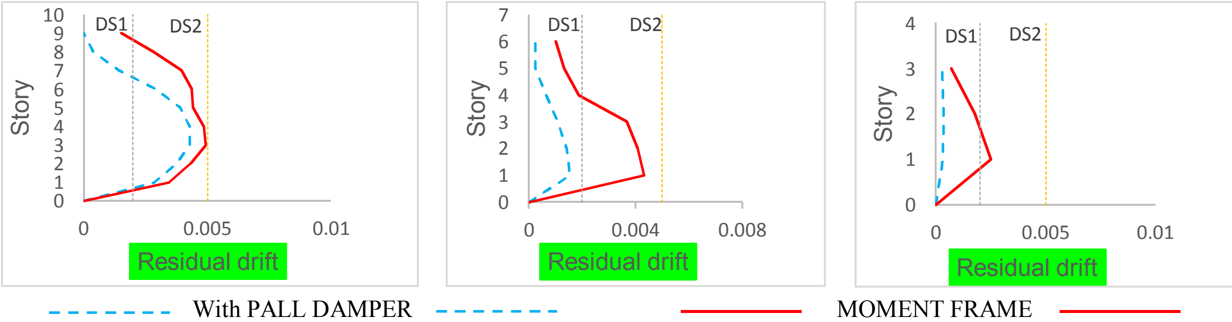

Figure 1. The Residual drift values for 3-, 6- and 9-story buildings in risk level 2.

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