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Seismic Performance of a Frame with Different Openings Equipped with IPFD

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Abstract: Different types of dampers are used in buildings to reduce effect of earthquakes. This study tends to evaluate seismic performance of IPFD which is a type of friction damper. For this purpose, two cross-braced steel frames with and without dampers in different openings were modelled in SAP 2000 and exposed to accelerograms of important earthquakes for non-linear time history analysis to examine effect of damper and the number of openings on base shear, shear and displacement of stories.

Key words: Damper, accelerogram, earthquake, shear, displacement

INTRODUCTION

During an earthquake, a great deal of energy is applied to the structure. This energy is transferred by kinetic energy and potential energy and the transferred energy is absorbed by structural elements or is dissipated in the form of heat. A structure will constantly vibrate in absence of damping. Thus, there is always an inherent damping in the structure which restores energy from the system. Therefore, vibration amplitude is reduced to decrease movements. If part of the exerted energy is absorbed by additional devices rather than the building itself, structural performance will be improved; higher energy dissipated by energy dissipating system will reduce energy in other parts which leads to lower damage to structural elements. One of the vibration control systems is friction damper which dissipates kinetic energy applied to the structure in the form of heat by friction caused in the damper (Soong and Constantinou,1994). Generally, there are four types of friction dampers: Pall friction damper system; Sumitomo friction damper system; slotted bolted connection damper and rotational friction damper.

Pall Friction Damper (PFD): Pall friction damper was first suggested by Pall and Pall (2004) and developed by Pall, (1996), etc. PFD is installed in intersection of cross, chevron and single diagonal bracings. PFDs have been used in countries such as Canada, India, USA and China. Pall (1996) damper has been approximately used in >90 buildings; currently, there are different types of Pall dampers. Figure 1 shows a typical PFD used in cross bracing (Kullman and Cherry, 1996).

Another type of these dampers was suggested by Wu and Zhang in China. This type of damper is similar to PFDs with a difference that their central core is t-shaped rather than cross-shaped. This damper is shown in Fig. 2. Wu and Zhang called this damper the Improved Pall Friction Damper (IPFD) (Wu *et al*., 2005).

In 2004, IPFD and PFD were compared; it was found that: mechanical performance of both dampers is entirely similar and even they both absorb an equal amount of energy; moreover, most of Pall's assumptions for PFD are true for IPFD; IPFD is better than PFD because its configuration is easier; its motor function is better and thus its analysis is simpler and finally, its construction costs lower (Wu *et al*., 2005).

IPFD modeling: Friction devices have usually stable rectangular hysteresis behavior thus, they can be easily modelled in computer (Sarno and Elnashai, 2002). In modelling, slip load of the damper can be assumed as yield force. In fact, elastic braces with a friction damper can be replaced by braces which yield in slip load (Pall). For computer modeling, a combination of damper and braces can be used; that is hysteresis behavior of the damper can be attributed to elastic stiffness of braces. This is shown in Fig. 3 (Lee and Park, 2008).

Dampers should meet three items:

- Dampers should not slip during a severe wind
- Dampers should slip during a severe earthquake before yield of structural elements
- Energy absorbed in the structure should be maximized by friction

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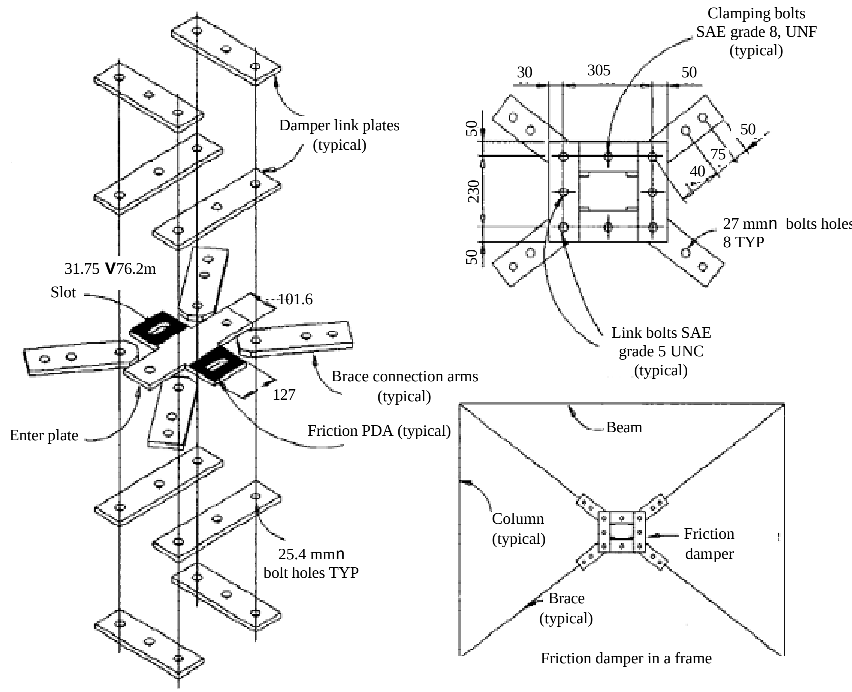

Fig. 1: Pall friction dampers (Kullman and Cherry, 1996)

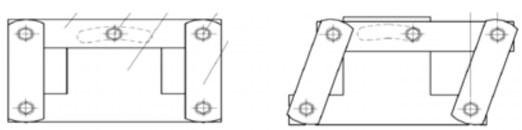

Fig. 2: Pall Friction Dampers (PFDs) (Wu *et al*., 2005)

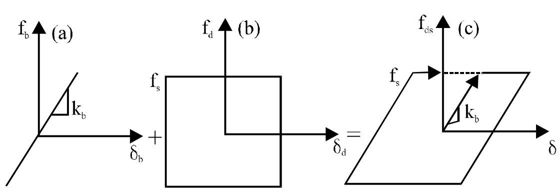

Fig. 3: Hysteresis loop of a braced frame equipped with damper for modeling: a) Brace; b) Firction and c) Bracing-friction damper system (Lee and Park, 2008)

Very low or very high slip load will increase structural response. However, there is an optimal value for slip load for which structural response is reduced. This optimal value can be calculated by considering different values for slip load and performing time-history analysis (Pall and Pall, 2004).

MATERIALS AND METHDOS

The studied frames: This study used two frames with 3 stories and 3 and 5 openings. According to the 6th and

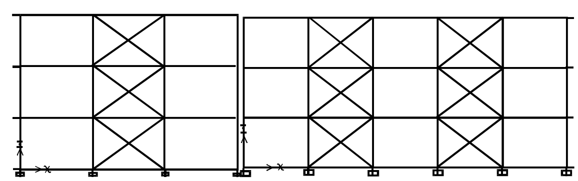

Fig. 4: Geometry of the selected frames

10th topics, the frame was initially designed without damper then, the frame with damper was considered similar to the frame without damper and only a damper was added. Moreover, 6.25 ton slip load was considered for the frames. Figure 4 shows the frames.

RESULTS AND DISCUSSION

Accelerograms used in time-history analysis: The standard 2800 requires at least 10 sec for strong ground movement during earthquake thus, this study used accelerograms of Bam, Kobe, Northridge and Tabas earthquakes. The accelerograms were modified; then, scale factor was estimated at 0.5 based on the standard 2800. Figure 5 and 6 show accelerograms of the Bam and Kobe earthquakes.

Results of frame analysis: Figure 7 compares shear of stories in the 3-opening frames with and without damper under Bam and Kobe earthquakes. In addition, Fig. 8

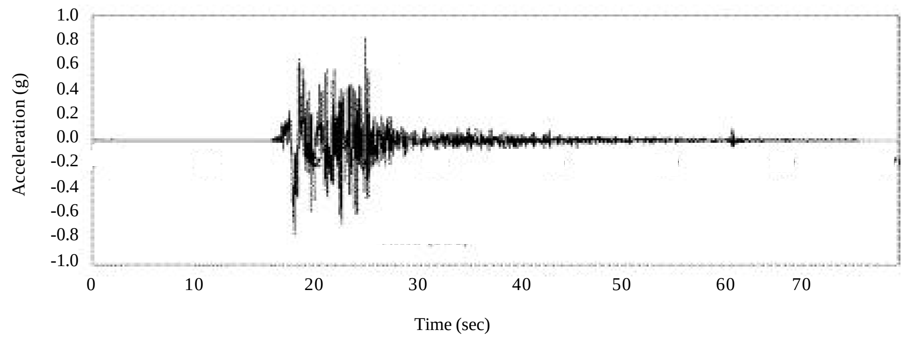

Fig. 5: Accelerogram of the Bam earthquake; record of Bam

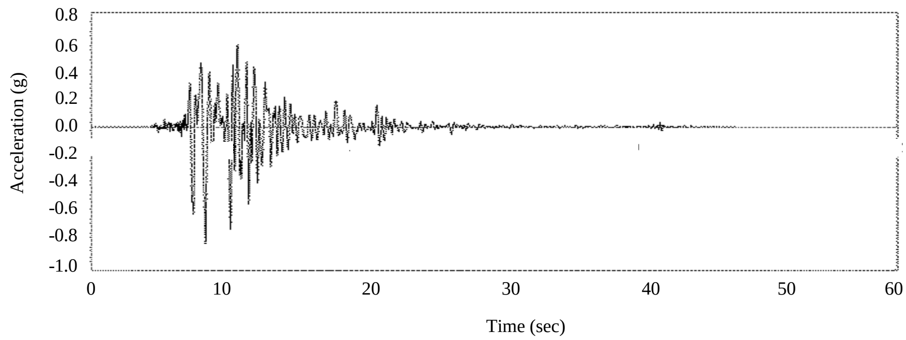

Fig. 6: Accelerogram of the Kobe earthquake; recoerd of Kobe

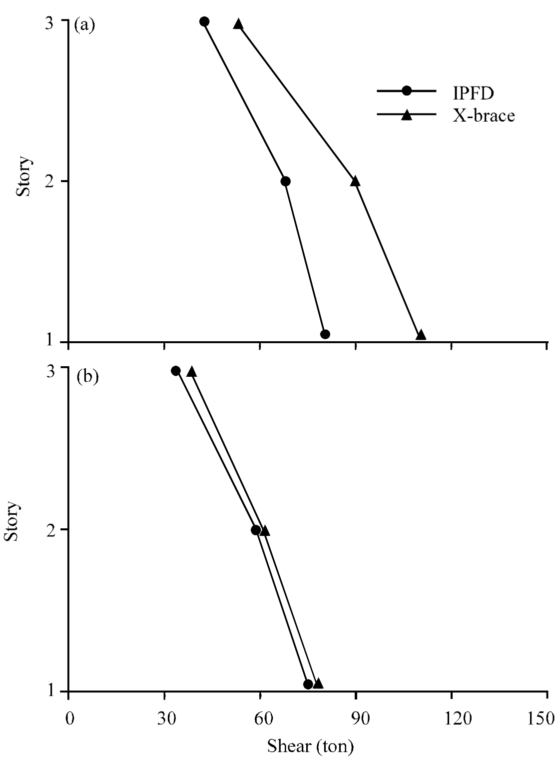

Fig. 7: Shear of stories in 3-story frames with 3 openings: a) 3S3B-Kobe and b) 3S3B-Bam

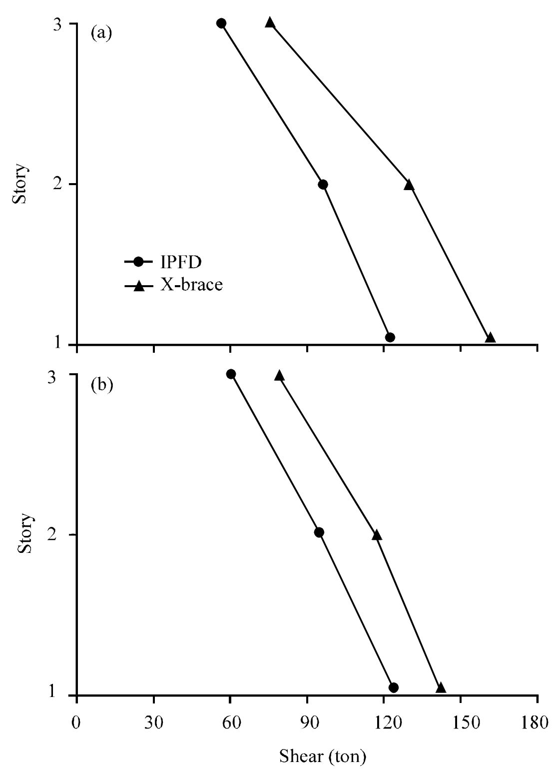

Fig. 8: Shear of stories in 3-story frames with 5 openings: a) 3S5B-Kobe and b) 3S5B-Bam

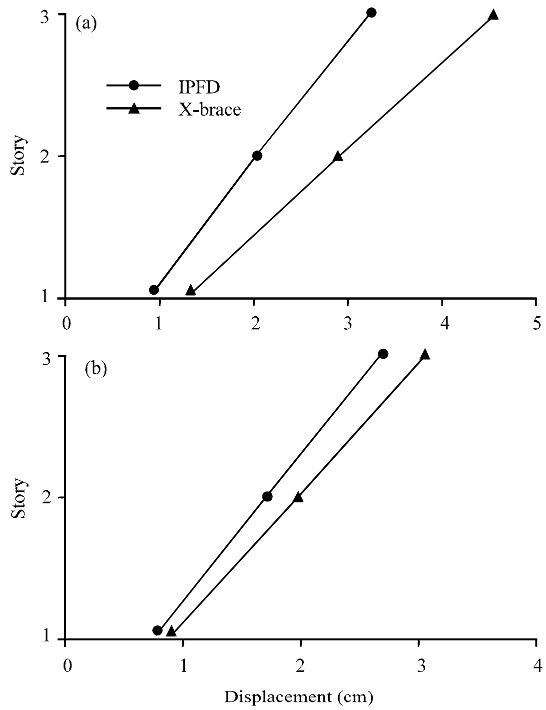

Fig. 9: Displacement of stories in 3-story frames with 3 openings: a) 3S3B-Kobe and b) 3S3B-Bam

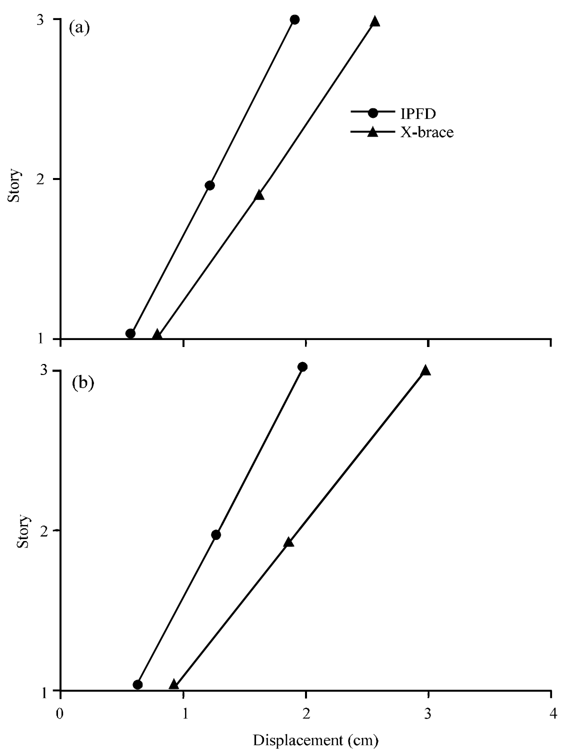

Fig. 10: Displacement of stories in 3-story frames with 5 openings: a) 3S3B-Bam and b) 3S3B-Kobe

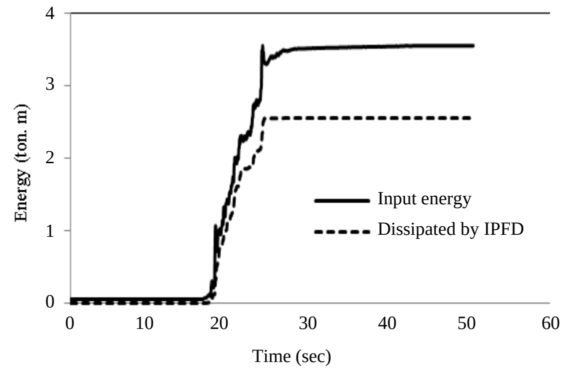

Fig. 11: Input energy and energy dissipated by the damper in the 3-story frame with 3 openings; frame 3S3B-Bam

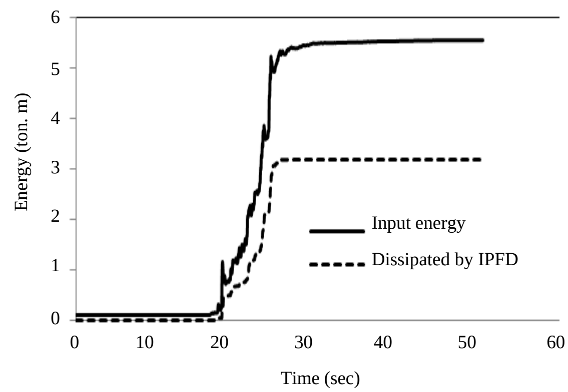

Fig. 12: Input energy and energy dissipated by the damper in the 5-story frame with 3 openings; frame 3S3B-Bam

compares the 5-opening frames. Figure 9 and 10 compare displacement of stories. Figure 11 and 12 show energy exerted to the frames and energy absorbed by dampers under the Bam earthquake.

CONCLUSION

Damper significantly reduced shear and displacement of stories in both frames; Damper dissipated a large amount of energy applied to the frame reduction in shear and displacement of stories was considerably low in the 3-opening frame under the Bam earthquake while the damper was highly effective in frame; Damper significantly reduced shear and displacement of stories in both 3 and 5-opening frames under the Kobe earthquake. In using dampers in frames, it is essential consider type of ground, number of stories and slip force of the damper in order to obtain the best results.

REFERENCES

Kullman, H.G. and S. Cherry, 1996. Full-scale testing of concentrically braced and friction-damped braced steel frames under simulated seismic loading. Proceedings of the 11th World Conference on Earthquake Engineering, June 23-28, 1996, Elsevier, Acapulco, Mexico, pp: 1-8.

Lee, S.K. and J.H. Park, 2008. Design of a bracing-friction damper system for seismic retrofitting. Smart Struct. Syst., 4: 685-696.

Pall, A. and T. Pall, 2004. Performance-based design pall friction dampers-an economical design solution. Proceedings of the 13th World Conference on Earthquake Engineering, August 1-6, 2004, Pall Dynamics Limited, Vancouver, British Columbia, pp: 1-15.

Pall, A.S., 1996. Friction dampers for seismic control of building. Proceedings of the 11th World Conference on Earthquake Engineering, June 23-28, 1996, Elsevier, Acapulco, Mexico, pp: 1-8.

Sarno, L.D.I. and A.S. Elnashai, 2002. Seismic retrofitting of steel and composite building structures. Ph.D Thesis, University of Illinois, Champaign County, Illinois.

Soong, T.T. and M.C. Constantinou, 1994. Passive and active structural vibration control in civil engineering. Master Thesis, Department of Civil, Structural, and Environmental Engineering, Getzville, New York.

Wu, B., J. Zhang and M.S. Williams, 2005. Hysteretic behavior of improved pall-typed frictional dampers. Eng. Struct., 27: 1258-1267.