DEVELOPMENT AND EXPERIMENTAL VALIDATION OF A SELF-CENTERING SYSTEM FOR DAMAGE AVOIDANCE DESIGN

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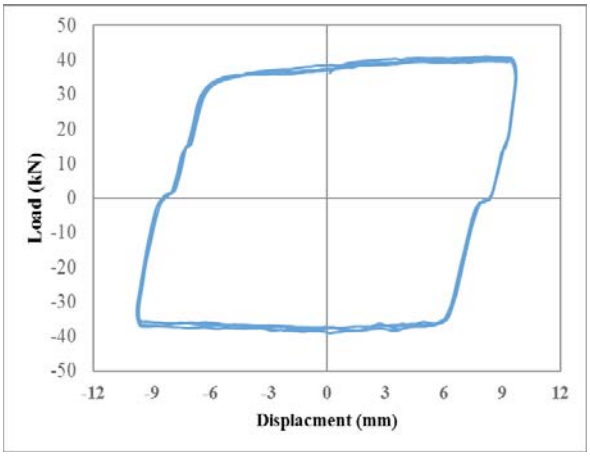
During the past decade, High-Force-to-Volume (HF2V) dampers has been introduced and used as an energy dissipater in seismic applications. Common applications include beam to column connections in steel and reinforced concrete moment resisting frames and bracing members in braced frames systems (Mander et al., 2009). Several studies have been conducted to investigate the characteristics and performance of these dampers more specifically at the University of New Zealand (Rodgers et al., 2018). The dampers enjoy high dissipation energy capacity and high resistance to low cycle fatigue. However due to high unloading stiffness they normally result in high residual deformations under cycle loads and have weak self-centering characteristics (Muir, 2014). In recent years some self-centering strategies have been suggested to improve their behavior and to use them as part of devices for seismic damage avoidance design of structures. For example, they have been used in conjunction with prestressed cables in beams and columns to reduce the residual deformations after intense seismic event. Nevertheless due to low deformation capacity of cables and complexities in their positioning and erection their actual use in buildings is limited.

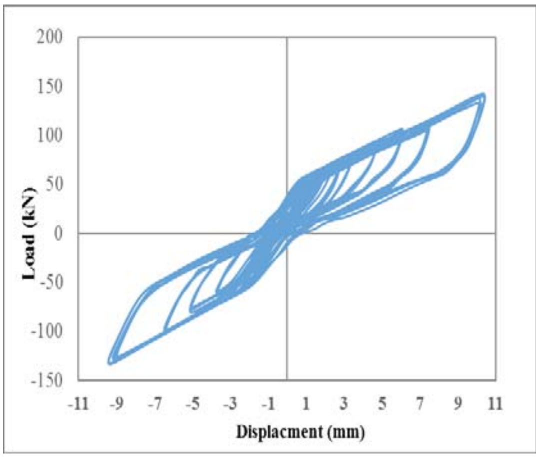
In this research, a new hybrid system is introduced to overcome the weaknesses of HF2V damper and eventually to use it as a damage avoidance mechanism in RC slotted beam connections. The main purpose is to study the behavior and feasibility of combining the lead dampers (HF2V) with pre-pressed disc springs to achieve self-centering characteristics. For this purpose, the cyclic behavior of the parallel damper and disc springs are evaluated considering two different arrangements of the disc springs. At first, the governing equations for the system are developed to predict the behavior of the collection. Then the components of the proposed system are constructed for laboratory tests. Special measures are taken into consideration in the construction of the damper so that to easily apply various pre-pressures on the disc springs. Separate tests are carried out to evaluate the force-deformation behavior of the damper, disc springs and their combinations under quasi-static cyclic condition using a 1000 KN servo hydraulic test system (Figure 1).

Figure 1. Test setup for the self-centering energy dissipater.

Experimental test results demonstrate that the pre-pressed disc springs can significantly improve the self-centering hysteresis behavior of HF2V dampers. Seismic response of hybrid system with the flag-shaped hysterics characteristics indicates that the self-centering forces of the disk springs can act to overcome the high stiffness of the lead dampers during unloading and to reduce the permanent deformations in the hysteresis cycles. In Figure 2, the hysteresis behavior of the lead damper and self-centering energy dissipater (SCED) are compared. It can be seen that adding pre-pressed disk springs to the lead damper has resulted in almost zero permanent displacement on unloading for hybrid system while maintain sufficient dissipation capacity. The study also shows good agreements between experimental test results and the predictive equations of cyclic behavior. Finally, it is concluded that a stable flag-shaped hysteretic response can achieved using self-centering capability of disc springs which paves the road for damage avoidance design of the structures.



(a)



(b)

Figure 1. Test results for comparative hysteresis responses: (a) HF2V lead damper only; (b) SCED device.

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