AN EFFICIENT ENERGY DISSIPATING DEVICE CALLED COMB-TEETH DAMPER

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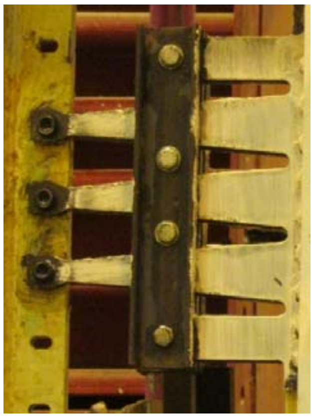
Passive energy dissipation devices have been widely used in structures in the last decades, as effective and relatively low-cost systems to reduce the earthquake damage. Inelastic deformation of ductile metals in metallic dampers, sliding in friction dampers, flow of viscous fluids through narrow orifices in viscous dampers, and deformation of viscoelastic materials in viscoelastic dampers are some alternative mechanisms, which may be used to dissipate seismic energy. Due to simpler manufacturing process, the yielding metallic dampers have found more widespread application in building construction compared to other types of energy dissipation systems.

The research on yielding metallic dampers was started by the pioneering works of Kelly et al. (1972), which was continuously followed by other researchers. Yielding metallic dampers, if used effectively, can dissipate significant portion of seismic energy through inelastic deformation of ductile metals. The main purpose of using such devices is to concentrate seismic damage in predetermined and replaceable structural elements and consequently avoid irreparable damage to main structure. Generally, depending on the yielding mechanism, metallic dampers can be divided into four groups of flexural, axial, shear, and torsional. The most wide spread yielding dampers are Added Damping and Stiffness, ADAS, Triangular-ADAS, TADAS (Bergman and Goel, 1987; Tsai et al., 1993). Yielding shear panels and slit dampers are other types of yielding dampers that are studied more recently.

Slit dampers are known as a special type of metallic dampers, in which plates with a number of slits or openings are subjected to in-plane shear deformations. The slits/openings divide the steel plate to a series of links acting in flexure under the global in-plane shear deformation of damper. Based on the concept of slit dampers, researchers have proposed and tested various types of dampers (Chana and Albermani, 2008; Ghabraie et al., 2010; Ma et al., 2010). In addition some attempts have been made to find out the optimum geometry of openings and usually, rhombus-like openings have found to be more suitable than others.

Considering the results and observations of previous studies on slit dampers, this paper presents a new yielding metallic damper called comb-teeth damper, CTD, which consists of a series of steel links/teeth acting in parallel and dissipating energy through in-plane flexural yielding deformation. Special attention is paid to the geometric design of links in order to generate uniform stress distribution along their length and to prevent strain localization and premature failure. The design is then checked out through a set of nonlinear finite element analyses and finally, experimental specimens are fabricated and tested under cyclic loads.

Figure 1 shows a view of a tested comb teeth damper. The details of damper connection to structure are such that the behavior of each link is similar to a cantilever beam. As can be seen in Figure 1, a clamp is also used to restrain out-of-plane buckling.



(a) CTD before testing

(b) CTD during testing

Figure 1. A view of CTD

Experimental studies have confirmed very stable hysteretic behavior of CTDs under cyclic loading with large displacement amplitudes. For example, a specimen was loaded under twenty fully reversed cycles at amplitude of 40 mm and even after these cycles, hysteretic curves were quite stable and thus displacement amplitude was increased to 60 mm. It should be noted that 40 and 60 mm in amplitude respectively correspond to more than 20 and 30 times the yield displacement of outer fiber of links.

After numerical and experimental investigation of the behavior of CTD specimens, the behavior of three simple steel frames equipped with such dampers is studied under cyclic loading. In this regard, CTDs are installed between beams and Chevron bracing. The results of experiments show that the dampers can reproduce the satisfactory performance observed in the tests on individual devices and as a result the hysteretic behavior of frames is very stable. Therefore this type of dampers has a potential for application in building frames. The experimental set up and results will be reported in detail in the paper.

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