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THE EFFECT OF USING ARC-SURFACED DAMPERS ON REDUCTION OF THE COLLAPSE PROBABILITY INDUCED BY FORWARD DIRECTIVITY

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Friction Dampers having appropriate controlling properties have been utilized to mitigate the structural failure for a long time. However, since this kind of dampers have a constant slip force, they are not capable of playing an appropriate role for strong ground motion, and therefore their optimized slip force should be determined. This problem would be solved with utilization of dampers with variable slip force and it hopefully would lead to reduction of the losses induced by damages. Wang et al. (2017) have presented an innovative type of frictional damper called Arc-surfaced Frictional Damper (AFD) whose main advantage is their curved frictional surfaces that lets their damping force change with displacement. In this research, the design parameters of the arc-surfaced-induced frictional force and their influence on the performance of these dampers in reduction of the structural vibration have been investigated. Structural shape of this damper and its hysteretic behavior is shown in Figure 1. It is to be mentioned that some problems with the mathematical equations presented in Wang et al. (2017) representing the hysteresis curve of AFD have been found and a modified version is utilized in case it is needed.

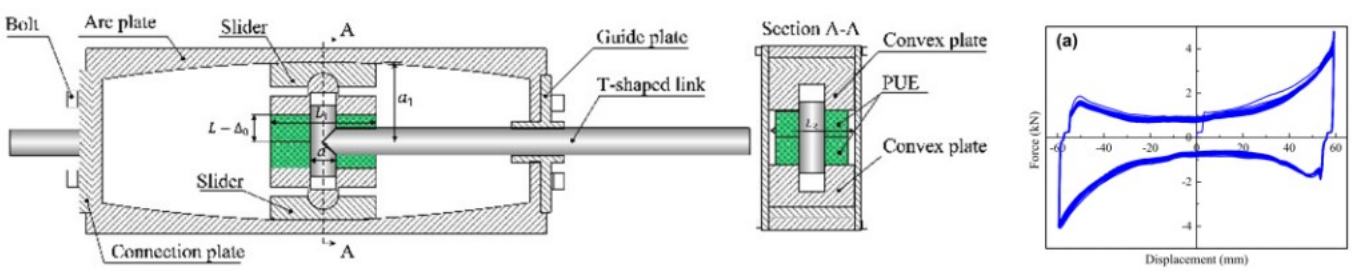

Figure 1. Schematic illustrate of AFD: (a) Longitudinal section and, (b) Cross section. a_1 = value of y coordinate at zero displacement of the slider ; L = thickness of PUE (Polyurethane Elastomer) Δ_0 =pre- compression of PUE ; L_1 = width of PUE; L_2 = length of PUE; d = diameter of T-Shape link (c) hysteretic force-dicplacement curve of AFD (Wang et al., 2017).

In this paper, preliminary studies have been done to investigate the behavior for SDOF structures equipped with AFD dampers. A 4-story structure without damper and two others equipped with an ordinary (constant slip force) and AFD friction damper have been modeled in OpenSees software (PEER, 2006). Based on the seismic performance of the controlled and bare structures subjected to 44 near-field and far-field records of FEMA P-695 (FEMA, 2009), the optimum amount of slip force P_p and arc radius (R) of AFD structure response have been determined using incremental dynamic analysis.

Nonlinear static (pushover) analysis results obtained for the structures without and equipped with AFD damper for different ratio of slip force to base shear $\left(\frac{P_p}{V_b}\right)$ is shown in Figure 2 which signifies the importance of this parameter on the overall performance of the controlled structure. V_b denotes the design base shear of the original structure which is easily calculated from the seismic design code (BHRC, 2014).

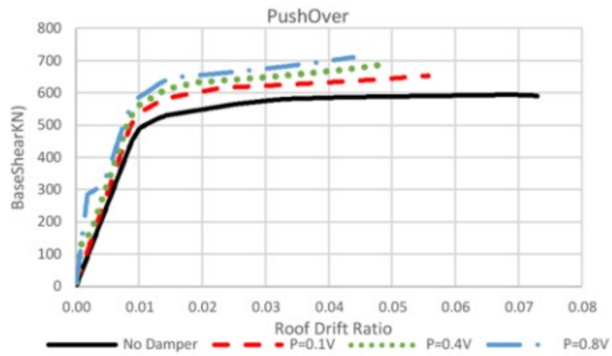

Figure 2. Pushover curve of 4-story without and equipped with AFD for different ratio of $\frac{P_p}{V_b}$.

It is clear that for an AFD damper as the ratio of $\left(\frac{P_p}{V_b}\right)$ increases, capacity of base shear rises while the maximum roof drift corresponding to the onset of structural instability is expected to decrease. This pattern is also seen comparing the uncontrolled and controlled structural output.

The original 4-story structure and another one equipped with AFD is subjected to the incremental dynamic analysis (IDA). According to the IDA results from near-field and far- field records, the average amount of pseudo-acceleration corresponding to the structural side-way collapse of controlled and uncontrolled structures are shown in Figure 3 w.r.t variation of $\left(\frac{P_p}{V_b}\right)$.

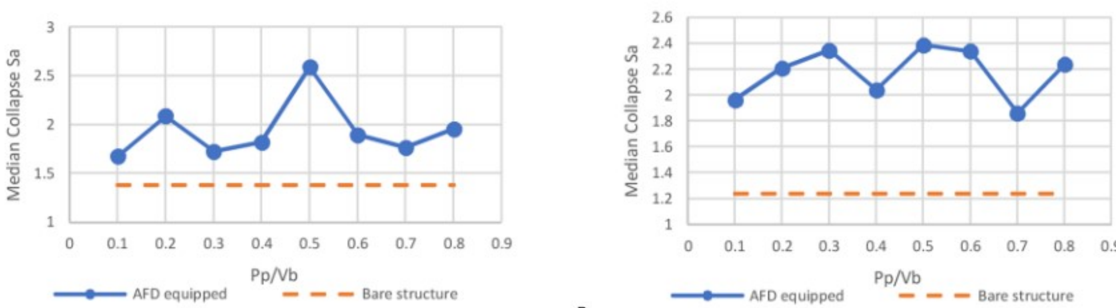

Figure 3. Changes of median of collapse acceleration to due to change of $\frac{P_p}{V_b}$ for 4-story equipped with AFD and with out damper for (a) near-field and (b) far-field records.

As it is illustrated, with the aid of an AFD, the base shear capacity of the structure has been increased slightly and that average amount of collapse acceleration has been increased significantly in comparison to the uncontrolled structure. This can be considered as a measure of the success of the AFD control method.

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