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

A NEW PURE BENDING YEILDING DAMPER FOR SEISMIC APPLICATIONS

Hassan ZIBASOKHAN
Ph.D. Student, Department of Civil Engineering, Isfahan University of Technology, Isfahan, Iran
zibasokhan@gmail.com
Farhad BEHNAMFAR
Associate Professor, Department of Civil Engineering, Isfahan University of Technology, Isfahan, Iran
farhad@cc.iut.ac.ir
Mojtaba AZHARI
Professor, Department of Civil Engineering, Isfahan University of Technology, Isfahan, Iran
mojtaba@cc.iut.ac.ir

Keywords: Pure bending, yielding, damper, steel plate, cyclic behavior, Analytical model, Energy dissipation

Yielding dampers are among the most common types of energy dissipation systems. In this paper, a new pure bending yielding device is introduced for use in concentric braced frames. The device is composed of a set of transverse plates. The damper plates are intended to be weld free in their ductile part. The axial force of the bracing is transformed to pure bending in the damper plates using the special geometry configuration of the new device. Therefore, yielding occurs in a significant portion of the damper plates simultaneously. Details of the proposed damper device is shown in Figure 1.

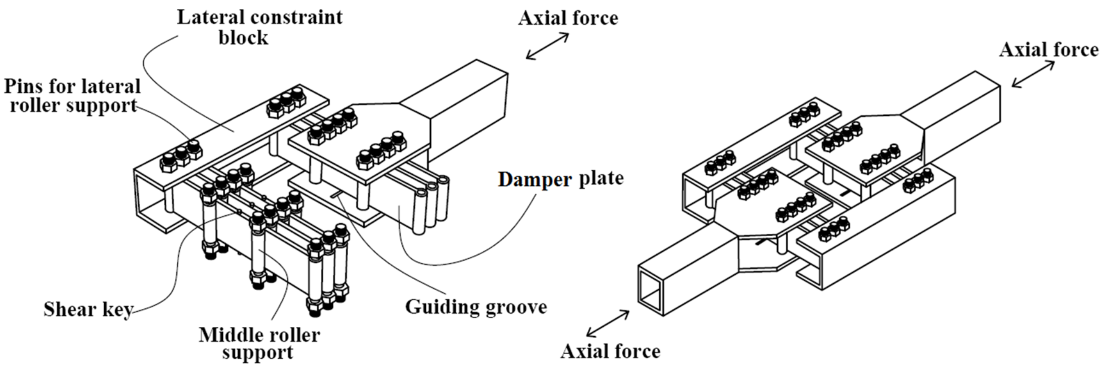

Figure 1. Details of the proposed device for transforming axial force to pure bending in damper plates.

The seismic behavior of the proposed device is studied analytically and experimentally in this research. In the experimental program, 16 specimens of the pure bending yielding damper (PBYD) is tested under cyclic loading. The specimens are designed in two levels of ultimate capacity including 11 specimens with an ultimate design capacity of 50 kN and 5 specimens with an ultimate design capacity of 90 kN. The modified SAC loading protocol is used in this study (SAC, 1997). Also, the material of the damper plate is tested using the standard tensile test (ASTM E8-04, 2004).

The load-displacement hysteresis curves of four specimens of this test program are demonstrated in Figure 2. The experimental results show that the proposed damper device has a stable cyclic behavior and a similar behavior in tension and compression. Moreover, these results indicate the high energy dissipation capacity of the proposed damper due to the use of pure bending to produce widespread plastic deformations in the middle part of the damper plates.

In the analytical study, behavior of the proposed damper is investigated and an analytical model is developed to predict the hysteretic behavior of the device. Behavior of the proposed device is influenced by the behavior of its plates. Various nonlinear factors should be considered in the analytical model including large deformations, nonlinear behavior of material, and the nonlinear behavior caused by slip limitation of the dissipater plate at the middle supports in large deformations. Some relationships are extracted to plot the load-displacement curve of the proposed device using principles of strength of materials considering nonlinear effects. A bilinear stress-strain curve is used in this model as demonstrated in Figure 3. A combined hardening rule including 30% isotropic and 70% kinematic behavior exhibits an optimum conformity with the experimental hysteresis curves. The experimental results are used to calibrate the developed model.

The results of the analytical model are displayed alongside the experimental results for two tested specimens in Figure 2. This comparison shows a very good agreement between the analytical and experimental results.

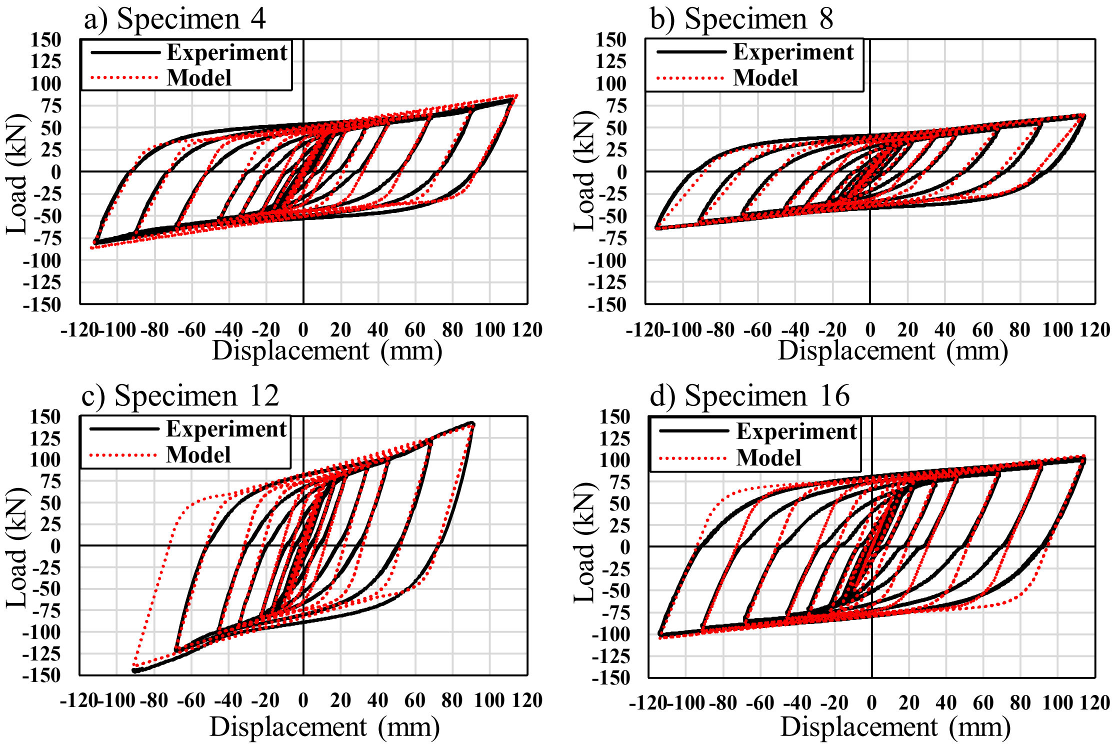

Figure 2. Experimental load-displacement hysteresis curves and analytical predictions of the axial response of the PBYD specimens.

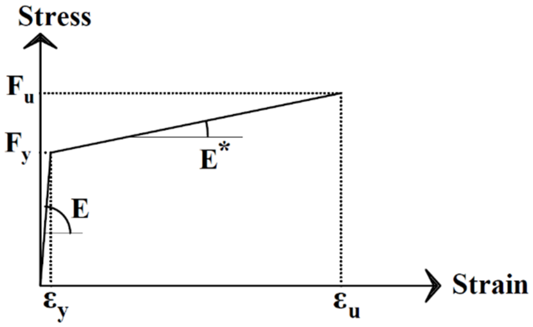

Figure 3. The idealized bi-linear stress-strain path for the analytical model.

REFERENCES

ASTM E8-04 (2004). *Standard Test Methods for Tension Testing of Metallic Materials*. American Society for Testing and Materials (ASTM), Pennsylvania.

SAC (1997). *Protocol for Fabrication, Inspection, Testing and Documentation of Beam-Column Connection Tests and Other Experimental Specimens*. Report No. SAC/BD-97/02, SAC Joint Venture, California.