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Improving the behavior of the CBF system using an innovative box section damper: Experimental and numerical study

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ABSTRACT

In this study, an innovative shear damper made of a box section with an easily constructed method, lower cost, and higher energy dissipation capacity compared to existing dampers was introduced to address the low energy dissipation capacity of Concentrically Braced Frames (CBFs) resulting from the buckling of their diagonal compression members under earthquake loading. In this regard, firstly, an experimental test was conducted to evaluate the cyclic performance of the proposed damper. Subsequently, a comprehensive parametric study, based on robust finite element analysis validated by experimental results, was carried out to examine the effects of the proposed passive metallic energy damper on the cyclic performance of CBFs. Experimental and numerical results indicated that the proposed damper exhibits suitable performance with stable hysteresis curves and no degradation in stiffness, strength, and energy dissipation. The results also revealed that the proposed damper demonstrates an overstrength exceeding 1.5 (as recommended by AISC341), and therefore, an overstrength of 2.0 was proposed for the damper. Furthermore, limitations of $\rho > 0.55$ and $\psi > 10$ must be applied in the damper design, where…. For optimal performance, it is suggested to design the damper in a way that its web slenderness varies between 67 and 113. Additionally, the proposed equation was in good agreement with finite element results in predicting the ultimate strength of the damper.

1. Introduction

Conventional concentrically braced frame systems (CBFs) possess significant lateral stiffness and strength. However, their behavior under cyclic loading is unsatisfactory due to the buckling of diagonal members under compression loads, leading to a decrease in stiffness and energy absorption capabilities [1–4]. Prior studies have suggested various strategies to overcome this shortcoming, including selecting appropriate demand-to-capacity ratios [5], using specific configurations [6], and incorporating energy dissipation systems [7–9]. Among these strategies, the use of energy dissipation systems has proven to be the most effective in enhancing ductility and reducing seismic demand on structures [9–11]. These systems rely on dampers that absorb the entire earthquake input energy through large inelastic actions developed in specific elements failed by shear, flexural, or shear-flexural mechanism. Researchers have recently expressed increased interest in the use of metallic-hysteretic dampers in CBFs (such as TADAS [12,13], ADAS [14], shear damper [4,15], slit damper [16], bucklingrestrained braces (BRBs) [17–19], and others) as passive control systems, as presented in Fig. 1. These dampers function within an eccentrically braced frame (EBF) system, converting the failure mechanism of CBFs from sudden buckling of diagonal members to yielding of specific elements, resulting in a significant increase in ductility and energy dissipation of the CBF system. Special caution in the welding and construction procedure is required in producing these kind of dampers, which increses the production cost and indicates that they are not economically justified to be used in the conventional buildings.

Pourbaba et al. [20] used a Zipper Braced Frame (ZBF) system to enhance the cyclic performance of CBFs by reducing deflections, improving ductility, and increasing the response modification factor. Fathi et al. [21,22] improved the cyclic performance of CBFs by modifying the connector plate and stiffener, resulting in a delay in the occurrence of buckling at the compression diagonal-members. Bastami and Ahmadi [23] conducted an experimental study to propose a structural fuse with innovative detailing called Centrically Fused Braced Frame (CFBF). The proposed stategy enhances the seismic performance

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