USE OF ASYMMETRIC BUCKLING-RESTRAINED BRACES IN ZIPPER FRAMESFOR IMPROVEMENT OF PEAK AND RESIDUAL RESPONSE

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ABSTRACT

Buckling-restrained braces (BRBs) are known to improve the energy dissipation properties of structures by preventing the bracing elements from buckling in compression. As a result, structures equipped with BRBs exhibit better performance mainly in terms of maximum responses. On the other hand, the bilinear behaviour and usually low post-yield stiffness of these devices may lead to undesirable permanent drifts. An asymmetrical configuration of BRBs along with zipper elements is considered in this study to reduce the residual drifts without increasing the peak response values. This way, the advantages of zipper frames, namely the more uniform distribution of drifts along the elevation and the reduced demands on beams are combined with the enhanced energy dissipation properties of the BRBs to improve the overall seismic response of structures. Nonlinear time-history analyses have been carried out for low- and mid-rise buildings to investigate the effects of the proposed configuration on the response characteristics of the structure. It is shown that the asymmetrical configuration of BRBs together with zipper elements proposed herein is an effective approach for reduction of residual response parameters while keeping the peak demands as low as those of ordinary frames equipped with symmetrical BRBs.

INTRODUCTION

Among the failure modes that are identified for inverted-V (concentric chevron) braced frames, formation of soft story mechanisms is thought to be the most prominent. This usually occurs due to the compression buckling of one of the braces in a story, leading to large amounts of unbalanced forces on beams. Due to their architectural appeals, considerable research has been dedicated to the improvement of these configurations (Uriz and Mahin, 2008). The improved configurations include (i) the addition of zipper struts designed to transfer the unbalanced loads to the upper stories proposed by Khatib et al. (1988) and studied by many others (Yang et al., 2008; Chen and Tirca, 2012, Tirca and Chen, 2012), and (ii) the use of special energy dissipation devices in place of braces such as friction and viscous dampers and buckling-restrained braces (BRBs) (Uang and Nakashima, 2003), designed to show identical behaviors in tension and compression. Particularly, the BRBs are relatively low-cost elements that achieve this goal by encasing the bracing elements in a filled hollow steel pipe that provide an almost continuous lateral bracing to inhibit the lateral buckling in compression.

While the use of BRBs in frames is known to improve the overall energy dissipation capacity of the structure and reduce the peak seismic responses, such frames usually suffer from significant amounts of residual deformations following earthquake events. Sabelli et al. (2003) reported that residual inter-story drifts may reach up to 40% of the maximum inter-story drift. In this study, the mean peak and residual drift