USE OF ASYMMETRIC BUCKLING RESTRAINED BRACES IN ZIPPER FRAMES FOR IMPROVEMENT OF PEAK AND RESIDUAL RESPONSE

Alireza ZARRINEGHBAL
Graduate Research Assistant, Sharif University of Technology, Tehran, Iran
alireza.zarrineghbal@gmail.com

Mehdi AHMADIZADEH
Assistant Professor, Sharif University of Technology, Tehran, Iran
ahmadizadeh@sharif.edu

Keywords: Concentrically Braced Frame, Inverted-V Bracing, Buckling Restrained Brace, Zipper Column, Strength Ratio

This study presents the advantages of using asymmetric buckling restrained braces (BRB) in zipper frames for simultaneous improvement of peak and residual response of low- and mid-rise buildings. It is demonstrated that such combination allows for the utilization of the benefits of each of these systems, namely the significant energy dissipation capacity of buckling restrained braces and better distribution of hysteretic energy dissipation demands through the elevation observed in zipper frames.

It has already been shown that using buckling restrained braces of varying yield strengths within each story of a building can improve the residual response of buckling-restrained-braced frames (BRBF) without severely affecting the peak demands (Vaezzadeh and Ahmadizadeh, 2013). Such configuration, however, will require the use of different buckling restrained braces in an x-braced span, or when dictated by architectural requirements, as multiple symmetric chevron-braced ones to avoid the exertion of large unbalanced force to the beams or formation of soft stories.

Alternatively, as explored in this study, asymmetric buckling restrained braces can be installed in zipper braced frames, where the unbalanced forces at the chevron vertex are handled by vertical zipper elements and braces in the stories above. In addition to substantially reducing the unbalanced force demands on beams and preventing the concentration of damages in a single story, the zipper elements are known to help better distribute the lateral force demands throughout the elevation (Yang et al., 2008). In this study, it is attempted to combine these desirable properties with those of asymmetric buckling restrained braces to reduce the number of occupied spans and reduce the usually-significant residual drift response of the BRBF's (Kiggins and Uang, 2006).

This paper considers two steel buildings with three- and six-story braced frames that were previously studied by Sabelli et al. (2003). Two parallel designs are carried out using two response reduction factor (R) values of 6 and 8 based on ASCE 7 (ASCE 2010). Several configurations of bracing elements with and without zipper elements are examined. For each considered configuration, the bracing cross-sectional areas are first optimized in the elevation to obtain frames having the optimum seismic performance in terms of peak demands. Then, to reduce the residual drifts, the optimizations are repeated for the cross-sectional areas of each brace at each story, resulting in asymmetric configurations. These optimizations have been carried out through nonlinear time-history analyses for minimizing two relative performance indices, one based on peak interstory drifts and absolute accelerations (RPI 1), and the other based on residual drifts (RPI 2). Most ordinarily-configured frames (such as those without zipper elements or those with symmetric horizontal distribution of brace cross-sectional areas) make it impossible to keep both peak and residual demands near their minimum simultaneously.

However, it is shown herein that the proposed configuration of elements, labelled asymmetric inverted-V bracing configuration with zipper columns, is capable of reducing both peak and residual response beyond what can be achieved with ordinary frames equipped with uniformly distributed buckling restrained braces. Figure 1 shows the relative performance index values for these frames, with the comparison basis (with an RPI 1 value of unity) being a symmetric BRBF with buckling restrained braces with cross-sectional areas optimized only in the elevation. The amount of reduction in residual drifts can be as large as 30% while keeping the peak demands near their minimum.

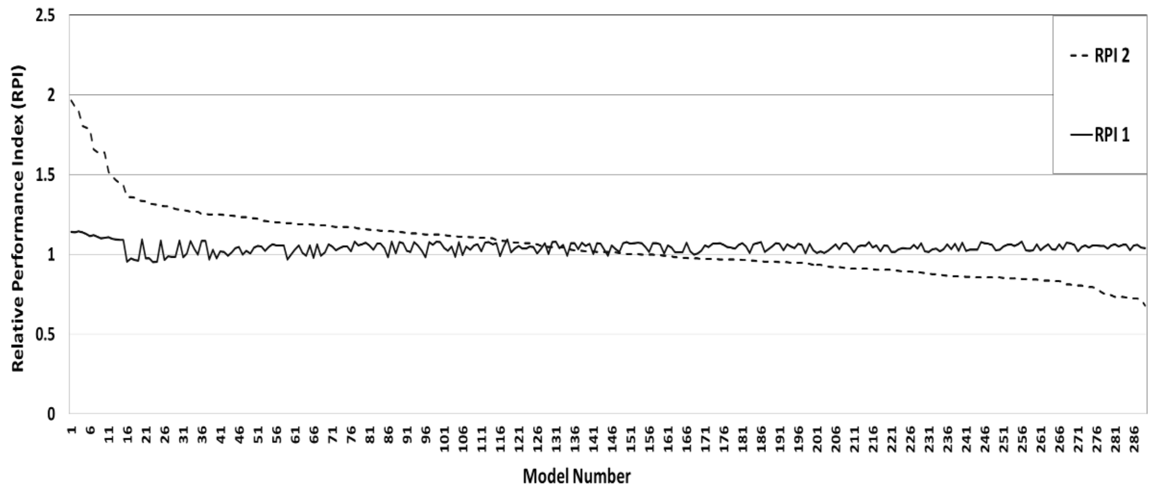

Figure 1. RPI 1 and RPI 2 values for the asymmetric inverted-V bracing configuration with zipper columns

This improvement is observed to be more pronounced in low-rise buildings. Based on these observations, it is asserted that the proposed asymmetric inverted-V bracing configuration with zipper columns can be a suitable arrangement for simultaneous improvement of peak and residual response with the least possible architectural effects.

REFERENCES

ASCE (2010) Minimum design loads for buildings and other structures, ASCE/SEI-7-10

Kiggins S and Uang CM (2006) Reducing Residual Interstory Drift of Buckling-Restrained Braced Frames as a Dual System, *Journal of Engineering Structures*, 28(11): 1525-1532

Sabelli R, Mahin S and Chang C (2003) Seismic Demands on Steel Braced Frame Buildings with Buckling-Restrained Braces, *Journal of Engineering Structures*, 25(5): 655-666

Vaezzadeh A and Ahmadizadeh M (2013) Selection of suitable arrangements of buckling-restrained braces for reducing residual and maximum drift of structures, M.Sc. Thesis, Sharif University of Technology, Tehran, Iran

Yang CS, Leon RT and DesRoches R (2008) Design and Behaviour of Zipper-Braced Frames, *Journal of Engineering Structures*, 30(4): 1092-1100