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# INVESTIGATION OF FORWARD DIRECTIVITY EFFECT ON THE DUCTILITY DEMAND AND REDUCTION FACTOR OF PBPD EBF FRAMES

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Structures designed by current seismic codes usually undergo large deformations in severe earthquakes since in these codes the design procedure is based on the elastic analysis and the inelastic behavior of the structure is considered indirectly by using R-factor (Leelataviwat et al., 1999; Goel et al., 2010). Experience of past severe earthquakes shows that these structures go under large deformations unpredictably or they even collapse. These problems lead the researchers to develop design procedures with higher levels of performance, safety of an economy (Chao and Goel, 2006; Jonathan et al., 2002). In order to gain these goals, the design parameters such as lateral force, the strength of members, desired yield mechanism, lateral displacement, etc., should be considered in design procedures initially. One of the methods which considers the inelastic behavior of the structure is Performance-Based Plastic Design (PBPD) developed by Goel et al. (2010). Results of inelastic static and dynamic analysis done by researchers on frames design by this method show a high level of seismic performance.

This study aims to investigate the effect of forward-directivity as one the significant characteristics of near-fault records (Khaloo et al., 2015; Nicknam et al., 2013) on the inelastic response of EBF structures designed based on PBPD method in the form of changes in the *ductility demand* and *reduction factor*. Eccentrically braced frames (EBF) combines the advantages of Moment-Frame (high ductility) and Concentrically Braced-Frame (lateral stiffness). While eliminating the shortcomings of those frames by limiting the inelastic activity to ductile shear links and keeping braces essentially elastic without buckling, thus maintaining high lateral stiffness during earthquake events.

In this study, two 12- and 18-story EBF frames were first designed based on current seismic code (Standard No. 2800, 2013) and then these frames were designed using the PBPD method. All frames were analyzed versus 12 near-fault records having predominant forward directivity effect. The IDA analysis approach (Vamvatsikos and Cornell, 2002) was used to determine the changes in *ductility demand* and *reduction factor* for the above-mentioned structures subjected to directivity pulses. Because of high levels of energy imposed by the records with forward-directivity effect, all frames exceeded the allowable drift. Figure 1 shows the result of the 18-story frame versus the Chi-Chi earthquake as a sample.

Consequently, the variation of ductility demand and reduction factor for the selected frames, the two design methods and the mentioned near-fault records will be calculated and reported.

## REFERENCES

Goel, S.C., Liao, W.-C., Bayat, M.R., and Chao, S.-H. (2010). Performance-based plastic design (PBPD) method for earthquake-resistant structures: an overview. *The Structural Design of Tall and Special Buildings*, *19*(1-2), 115-137.

Chao, S.-H. (2006a). Performance-based design of eccentrically braced frames using target drift and yield mechanism. *AISC Engineering Journal Third Quarter*, 173–200.

Iranian Code of Practice for Seismic Resistant Design of Buildings, Standard No. 2800 (2013).

Khaloo, A.R., Khosravi, H., and Hamidi Jamnani, H. (2015). Nonlinear interstory drift contours for idealized forward directivity pulses using "modified fish-bone" models. *Advances in Structural Engineering*, 18.5, 603-627.

Leelataviwat, S., Goel, S.C., and Stojadinovic, B. (1999). Toward performance-based seismic design of structures. *Earthquake Spectra*, *15*(3), 435-461.

Nicknam, A., Barkhodari, M.A., Hamidi Jamnani, H., and Hosseini, A. (2013). Compatible seismogram simulation at near source site using Multi-Taper Spectral Analysis approach (MTSA). *Journal of Vibroengineering*, *15*(2).

Stewart, J.P., Chiou, S.-J., Bray, J.D., Graves, R.W., Somerville, P.G., and Abrahamson, N.A. (2002). Ground motion evaluation procedures for performance-based design. *Soil Dynamics and Earthquake Engineering*, *22*(9-12), 765-772.

Vamvatsikos, D. and Allin Cornell, C. (2002). Incremental Dynamic Analysis. *Earthquake Engineering and Structural Dynamics*. *31*, 491-514.

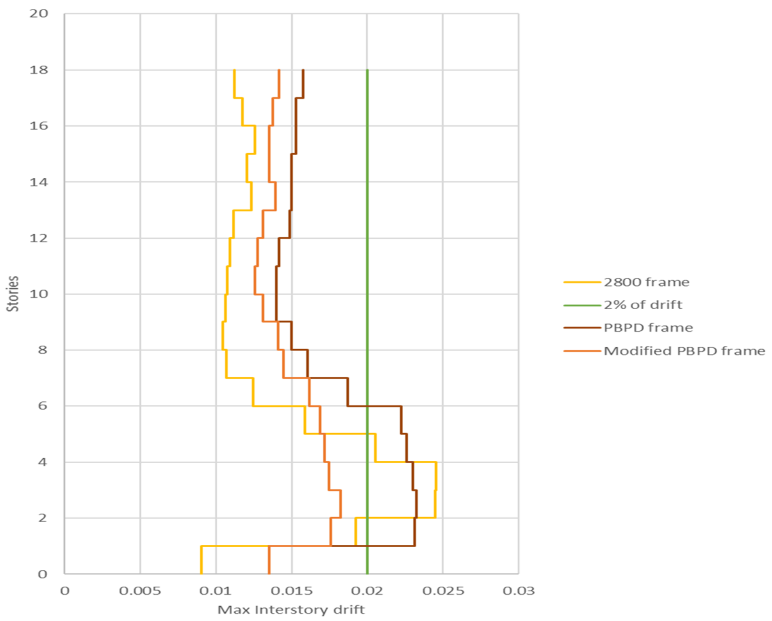


*Figure 1. Comparison of maximum inter story drift ratio (e.g. Chi-Chi-TCU075).*