Available online at www.CivileJournal.org

Civil Engineering Journal

Vol. 4, No. 6, June, 2018

A Comparative Study on the Behavior of Steel Moment-Resisting Frames with Different Bracing Systems Based on a Response-Based Damage Index

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Received 30 April 2018; Accepted 14 May 2018

Abstract

Seismic rehabilitation of existing buildings is one of the most effective ways to reduce damages under destructive earthquakes. The use of bracings is one of techniques for seismic rehabilitation of steel structures. In this study we aimed to investigate the seismic performance of three 5, 10 and 15-storey steel structures with moment-resisting frames designed three dimensionally in ETABS 2015 application based on first edition of Iranian Standard 2800. Their damage under five ground motions was evaluated using response-based damage model proposed by Ghobara et al. (1999). Then, the structures were rehabilitated with different bracing systems (X, eccentric and concentric V and inverted-V) and, again, their damage under five earthquakes were evaluated and compared with those of moment resisting frames. The pushover analysis results indicated that X-braced frame was the least ductile system but had highest initial stiffness and yield stress. In low-rise building, X-braced frames showed better performance among studied bracing systems compared to moment resisting frames, while mid and high-rise buildings with eccentrically braced frame (EBF) showed the best behavior against earthquakes with the least damage. Moreover, it was found out that EBFs' performance increases by increasing storey height, but for concentrically braced frames (CBFs) it was decreased. We concluded that the use of response-based damage models can be a suitable procedure for estimating the vulnerability of steel structures rehabilitated with bracing system.

Keywords: Steel Moment Resisting Frame; Rehabilitation; Braced Frames; EBF; CBF; Response-Based Damage Model.

1. Introduction

Earthquakes often cause a certain state of damage to structures, the extent of which is generally shown by using a damage index. Various damage indices have been proposed using different parameters such as drift, natural period of structure, energy absorption and cyclic fatigue such as Bozorgnia-Bertero [1], Park-Ang [2], Krawinkler-Zohrei [3], Roufail-Meyer [4], Dipasquale-Cakmak [5], and Ghobara [6] indices. They are divided into two broad categories: non-cumulative and cumulative damage indices. "Non-cumulative indices do not include the effects of cyclic loading and often do not reflect the state of damage accurately, whilst the cumulative indices are rather more rational" [7]. An ideal damage index should be between 0 to 1 where 0 refers to the state of elastic response, and 1 indicates the collapse state. Several damage models exist for characterization of structural failure in terms of damage index including strength-based and response-based models. Strength-based damage models were first proposed by Shiga et al. [8] and later used by Yang and Yang [9]. These models depend on the geometry of structural elements such as the column and wall area and their general material properties. The response-based damage indices are divided into three groups: maximum

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http://dx.doi.org/10.28991/cej-0309178