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Comparison Study of CBFs and EBFs Bracing in Steel Structures with Nonlinear Time History Analysis

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Abstract

Steel concentrically braced frames (CBFs) and Steel eccentricity braced frames (EBFs) are frequently used as efficient lateral load resisting systems to resist earthquake and wind loads. This paper focuses on high seismic applications where the brace members in CBFs and EBFs dissipate energy through repeated cycles of buckling and yielding. The present study evaluates in detail the design philosophies and provisions used in the United States for these systems. The results of a total of 176 analysis of nonlinear history of seismic behavior of CBFs and EBFs braces have been presented. Notable differences are observed between the performances of the CBFs and EBFs designed using American provisions. The similarities and differences are thoroughly discussed.

Keywords: Steel Structures; CBFs; EBFs; Parameters Studied; Time History Analysis; American Provision.

1. Introduction

Currently, moment resisting frames, concentrically braced frames, eccentrically braced frames, knee braced frames steel plate shear, and zipper braced frames are being commonly used as lateral (i.e. seismic and wind) force resisting systems for steel structures. While new systems such as buckling restrained braced frames are gaining popularity, Moment resisting frames (MRFs) and concentrically braced frames (CBFs) are considered as two of the most popular systems among these alternatives. Although MRFs provide more architectural freedom, compared to the CBFs, they are expensive. CBFs have been quite popular since the 1960s mainly because of their economic advantages over MRFs particularly in cases where the drift requirements govern the design. Furthermore, beam-to-column connections of MRFs suffered premature fractures in the 1995 Kobe and the 1994 Northridge earthquakes [1-2]. In the aftermath of these earthquakes, considerable research and development projects were conducted in the US, Japan, Europe, and elsewhere to develop new moment connections that have sufficient strength, stiffness, and ductility to perform satisfactorily during future strong seismic events. However, the new MRF connections and the modifications made to then existing moment connections have caused their cost of construction and inspection to increase significantly, making the use of CBFs even more economical. More recently, the 2011 Christchurch earthquake in New Zealand resulted in fracture of several eccentrically braced¬ frames (EBFs), further adding to the popularity of CBFs.

The CBF system is currently one of the most widely used seismic load resisting systems in steel structures; it is easy to design and the most efficient especially in controlling lateral drifts of buildings. In recent decades, a significant amount of research has been conducted on the seismic behavior and design of CBFs. A major portion of these studies has focused mainly on the response of bracing members and their connections [3-4]. Extensive experimental [5-7] and numerical [8, 9-24] investigations have also been undertaken to study the behavior of single-story and multi-story CBFs under severe

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