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Seismic characteristics of a T-shape resistant system

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Abstract

A particular structural lateral resistant system called ‘T-shape resistant system’ (TRS) is introduced. This new form of framing system is constructed through a deep I-shaped steel beam vertically placed in the middle of span, connected with two other deep I-shaped beams to the columns at each storey level. In this paper, the R factor components including ductility reduction factor and over strength factor are extracted from inelastic pushover analysis of TRS having different heights and configurations. Then, by developing a nonlinear finite element model of a simple TRS system, the other properties of this system, such as energy dissipation characteristics, are properly investigated.
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Keywords: R factor, energy dissipation, T-shape resistant system, Finite element model

1. INTRODUCTION

Structures designed to resist moderate and frequently occurring earthquakes must have sufficient stiffness and strength to control deflection and to prevent any possible damage. Selecting a good structural system requires understanding seismic behavior of the systems available. Since stiffness and ductility are generally two opposing properties, it is desirable to devise a structural system that combines these properties in the most effective manner without excessive increase in the cost. Steel structural systems, moment resisting and concentrically braced frames have been widely used to resist earthquake loads. Concentrically braced frames have high stiffness, and are not ductile enough due to the probable buckling of their diagonal members. Versus, moment resisting frames have adequate ductility as their beam sections can undergo elastic deformations, but have low stiffness, thus increase construction cost. To overcome the deficiencies in moment resisting and concentrically braced frames, Roeder and Popov [1] have proposed the Eccentrically Braced Frame (EBF) system. Subsequently, Aristazabal-Ochoa [2] have presented Knee braced frames (KBF) and Zahrai-Bruneau [3] have proposed Shear panel systems (SPS). In recent decades, steel shear wall systems have been widely noticed and researches on increasing their performance and design are still in progress. Although these mentioned systems have good seismic behavior, but, to some extent, they limit architectural design. On the other hand, design and construction difficulties have caused a decrease on their usage tendency in our country regions. In this paper, seismic behavior of a new structural system (TRS) will be evaluated. This system is constructed through a deep I-shaped steel beam vertically placed in the middle of span, connected with two other deep I-shaped beams to the columns at each story level. Section properties of the vertical I-shaped beam have a major effect on the ductility and energy dissipation of the TRS system. It has a sufficient stiffness and decrease structural weight of the moment resisting frames and can be used for retrofitting of existing buildings that architecturally it is not possible to use braced frames as their structural systems.

2. Behavior factor parameters

In forced-based seismic design procedures, behavior factor, R [4] (or Rw) also referred to by other terms including, response modification factor (UBC code [5] and NEHRP provisions [6]), is a force reduction factor used to reduce the linear elastic response spectra to the inelastic response spectra. In other words, behavior factor is the ratio of the strength required to maintain the structure elastic to the inelastic design strength of the structure. The behavior factor, R, therefore accounts for the inherent ductility and over strength of a structure and the difference in the level of stresses considered in its design. It is generally expressed in the following form taking into account the above three components.