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Global buckling prevention condition of all-steel buckling restrained braces

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Abstract

One of the key requirements for the desirable mechanical behavior of buckling restrained braces (BRBs) under severe lateral loading is to prevent overall buckling until the brace member reaches sufficient plastic deformation and ductility. This paper presents finite element analysis results of proposed all-steel buckling restrained braces. The proposed BRBs have identical core sections but different Buckling Restraining Mechanisms (BRMs). The objective of the analyses is to conduct a parametric study of BRBs with different amounts of gap and core and BRM contact friction coefficients to investigate the global buckling behavior of the brace. The results of the analyses showed that BRM flexural stiffness could significantly affect the global buckling behavior of a BRB. However, the global buckling response was resulted to be strongly dependent upon the magnitude of friction coefficient between the core and the encasing contact surfaces. In addition, the results showed that global buckling response of BRBs with direct contact of core and BRM is more sensitive to the magnitude of contact friction coefficient.

Keywords: All-steel buckling restrained brace; Global buckling; Finite element analysis; Contact friction coefficient; cyclic loading

1. INTRODUCTION

Seismic excitations have led to concerns in structural design in earthquake-prone zones. During a severe ground motion, large amount of kinetic energy is transmitted into a structure. Seismic codes and studies have been recognized that it is not economical to dissipate the seismic energy within the elastic capacity of the materials and as a consequence, it is preferable to anticipate yielding in some controlled elements. Braces are preliminary devices for energy absorption in braced buildings. However, buckling of the brace in compression results in sudden loss of stiffness, strength, and energy dissipation capacity. To overcome this deficiency, various types of innovations have been proposed in steel braces in which the buckling has been inhabited through a mechanism.

Buckling Restrained Braced Frames (BRBFs) have been widely used in recent years. A BRBF differs from a conventionally braced frame because it yields under both tension and compression without significant degradation in compressive capacity. Most buckling restrained brace (BRB) members currently available are built by inserting a steel plate into a steel tube filled with mortar or concrete called conventional BRBs. The steel plate is restrained laterally by the mortar or the steel tube and can yield in compression as well as tension, which results in comparable yield resistance and ductility, as well as a stable hysteretic behavior in BRBs. A large body of knowledge exists on conventional BRBs' performance in the literature. Black et al. [1] performed component testing of BRBs and modeled a hysteretic curve to compare the test results and found that the hysteretic curve of a BRB is stable, symmetrical, and ample. Inoue et al. [2] introduced buckling restrained braces as hysteretic dampers to enhance the seismic response of building structures. A typical BRB member consists of a steel core, a buckling restraining mechanism (BRM), and a separation gap or unbonding agent, allowing independent axial deformation of the inner core relative to the BRM. Numerous researchers have conducted experiments and numerical analyses on BRBs for incorporation into seismic force resisting systems. Qiang [3] investigated the use of BRBs for practical applications for buildings in Asia. Clark et al. [4] suggested a design procedure for buildings incorporating BRBs. Sabelli et al. [5] reported seismic demands on BRBs through a seismic response analysis of BRB frames, and Fahnestock et al. [6] conducted a numerical analysis and pseudo dynamic experiments of large-scale BRB frames in the U.S.

The local buckling behavior of BRBs has been studied by Takeuchi et al. [7]. The effective buckling load of BRBs considering the stiffness of the end connection was recently studied by Tembata et al. [8] and Kinoshita et al. [9]. Previous studies have demonstrated the potential of manufacturing BRB systems made entirely of