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INVESTIGATING THE EFFECTS OF LENGTH AND CROSS-SECTION AREA OF THE YIELDING ZONE OF BUCKLING RESTRAINED BRACES ON THE CYCLIC BEHAVIOR OF BUCKLING RESTRAINED BRACED FRAMES

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The steel braces are known as economically efficient elements for providing lateral stiffness for steel frame buildings. However, their ductility and energy dissipation capacity are quite limited when subjected to seismic excitations. Recently, buckling restrained braces (BRBs) are being widely used in steel structures due to their high energy dissipation capacity through yielding of the core in compression and tension. Improving the behaviour of BRB frames (BRBFs) and reducing the associated construction costs are two important factors, which have attracted the attention of many researchers all around the world. Many of the past investigations have looked at the behavior of the BRBF, according to its peak and residual drifts (Zarrineghbal, 2015). Since BRBs are non-prismatic elements (Figure 1), the ratio of the area under the plastic zone to that of the elastic zone (α) and the ratio of the length of the steel core to that of the brace (β) are among the most substantial design parameters.

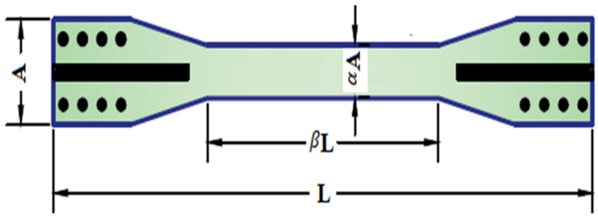

Figure 1. Non-prismatic elements of Buckling-restrained brace (BRB).

In this study, the effects of the aforementioned parameters on the energy dissipation demand of BRBs located in different stories are investigated. For this purpose, two example steel buildings with 5 and 10 stories equipped with BRBs in one direction are designed in accordance with ANSI/AISC 360-16 (2016) and ANSI/AISC 341-16 (2016). The example structures are modelled in OpenSees software to evaluate their behaviour using nonlinear time history analysis. Since BRBs consist of elements with different cross-sectional areas including steel core, transition zone, and connections, the variations of the stiffness in their length should be taken into account. In this regard, a stiffness modification factor, *KF*, is defined as the ratio of the elastic stiffness of the non-prismatic BRB to the elastic stiffness of the Truss element with the cross section area of the steel core. The stiffness modification factor is calculated as follows:

$$KF = \frac{L}{L_i + A_i.(\frac{L_{con}}{A_{con}} + \frac{L_{tr}}{A_{tr}})} \tag{1}$$

where L is the length of the brace, L_i is the length of the yielding zone, A_i is the area of the yielding zone, L_{tr} represents the length of the transition zone, A_{tr} refers to the area of the transition zone, L_{con} is the length of the connection zone, and A_{con} is the area of the connection zone. The value of KF ranges between 1.3 and 1.7 which depends on the geometry of the BRB including its size, length, connection details, and even the manufacturer (NIST, 2015). In this study, to validate the results of frame analysis in OpenSees software, one of the frames is modeled in ABAQUS software. The results of the analysis were compared and the results were close.

In the design of the BRBFs, four different α ratios, the ratio of the area of the yielding zone to the elastic zone, and 4 different β ratios, the ratio of the length of the yielding zone to the entire length of the brace, are considered. Structures with different combinations of α and β ratios are subjected to seven earthquake ground motion records. The energy dissipation demand of each of the braces are determined using their hysteresis curves obtained from nonlinear time history analysis. According to the results, the modification factor KF influences the energy dissipation demand of braces, depending on the story in which the brace is located. Since the energy dissipation demand of braces in different stories can become more uniform by choosing a larger cross-sectional area for bracings of upper stories (Dehghani, 2018), the effect of KF on energy dissipation demand of such BRBFs decrease compared to that of BRBFs with code-conforming cross-sectional areas of braces.

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