# ECCENTRICALLY KNEE BRACING: IMPROVEMENT IN SEISMIC DESIGN AND BEHAVIOR OF STEEL FRAMES

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## ABSTRACT

The use of passive control systems is widely considered as a reliable approach for controlling earthquake vibrations in steel structures. First, under frequently occurring low to moderate earthquakes, the structure should have sufficient strength and stiffness to control deflection and prevent any structural damage. Second, under rare and severe earthquakes, the structure must have sufficient ductility to prevent collapse. For this case, significant damage of the structure and nonstructural elements is acceptable. In this paper, the performance of a new innovative eccentrically and knee bracing system called Eccentrically Knee Bracing (EKB) is discussed and the behavior is investigated. A combination of eccentrically braced steel frames and knee braced steel frame has been assessed and concepts of the design of defined schemes are reviewed. As the structural fuse of the frame, the knee element will yield first during a moderate earthquake. In large earthquakes, both of them contribute in dissipating energy. Two half-scale EKB were tested using the SAC loading protocol and an innovate loading protocol.

## INTRODUCTION

For some decades now eccentrically braced frames (EBFs) have been indicated as the distinctive elements of a structural typology suitable for satisfying the different design objectives of modern performance-based seismic engineering in medium or high-rise steel buildings. They have often been proposed as a cheaper and more valid alternative to the most common moment resisting frames (MRFs) and concentrically braced frames (CBFs), as they incorporate the good qualities of the abovementioned structures. Indeed, owing to the presence of bracings and links, EBFs are expected to incorporate characteristics of both high lateral stiffness and high energy dissipation capacity. Experimental investigation has gradually persuaded the scientific community of the structural effectiveness of EBFs and, hence, induced building codes to propose rather high values of the behaviour factor for the design of such structures. An alternative system which combines the advantages of the moment resisting frame and those of the concentric braced frames is the knee braced frames (KBFs), where one end of the brace is connected to a knee member (anchor) instead of the beam-column joint. In this system, the knee element acts as a “ductile fuse” to prevent collapse of the structure under extreme seismic excitations by dissipating energy through flexural and shear yielding. A diagonal brace with at least one end connected to the knee element provides most of the elastic lateral stiffness. As the nature and occurrence of earthquakes are random, it is necessary to consider different levels of earthquake intensity in designing earthquake resistant structures. To improve the seismic performance of the steel framed structures, further modification to enhance the structural performance is essential. In this paper, one of the most effective braced frame systems through which a high level of