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# Comparison between Seismic Behavior of Suspended Zipper Braced Frames and Various EBF Systems

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## Abstract

Zipper frames are intended to improve on the behavior of conventional inverted-V-braced frames, which show poor performance taking place from the early buckling of braces in the lower story. A zipper frame affords better performance by forcing simultaneous buckling of all braces. In this article, seismic behaviors of zipper braced frames and three types of eccentrically braced frames are evaluated using finite element simulation. Two dimensional finite element models have been created for three-story one-bay frames for various bay lengths and different arrangement of braces. Seismic response of frames subjected to near-fault ground motions (LA21) has been studied through dynamic analysis, considering nonlinearity of geometry and materials. For this purpose, SAP2000 has been used. Results have been compared and structural response of steel frames and some other parameters such as ductility of frames, maximum base shear and optimized link length have been investigated. Against other researches, in this article, the ratio of maximum shear over the weight of structure and its relation to behavior of structure has also been studied. It was found that optimized link length in EBF systems which caused to maximum ductility of frame is about 30 percent of the bay length. Moreover, the results showed that zipper frames provide desirable post buckling behavior and exhibit more ductility.

**Keywords: Suspended Zipper braced frames; eccentrically braced frames; near fault; dynamic analysis;**

## 1. Introduction

Steel is one of the most widely used materials for building construction. The inherent strength and toughness of steel are characteristics that are well suited to a variety of applications, and its high ductility is ideal for seismic design. To utilize these advantages for seismic applications, the design engineer has to be familiar with the relevant steel design provisions and their intent and must ensure that the construction is properly executed.

The braced steel frames are extensively used in middle to high-rise buildings in highly seismic regions due to their advantages in terms of both economy and better seismic performance. These braced steel frames usually include two types: concentrically braced frames (CBFs) and eccentrically braced frames (EBFs). These brace members can be grouped into several patterns: X-type, K-type, V-type and inverted V-type etc. Steel braces are generally used as an economic means of providing lateral-load resistance to steel structures.

In a traditional K braced (Chevron) frame design; the braces resist the lateral earthquake load transmitted by the beam as axial forces. The vertical resultant of two adjacent braces is null and does not affect the frame's beams. Under a strong ground motion one of the braces is expected to buckle under compression while the adjacent one is expected to yield in tension. Compared to a straight member, a buckled member has a lower capacity to carry axial compressive force while its tension capacity remains the same. In such case the vertical resultant from the two adjacent braces is not null and it is transmitted to the beam as a shear force, which makes the design of the beam very costly since the moments at the mid span are enormous and big sections are required to sustain them.

In 1989 Khatib et al. suggested adding a column between the beams connected at same joints where the braces connect; this column will transmit the vertical unbalanced load to the upper floor, where it will be redistributed to its braces. As a consequence, the compression brace will be subjected to an even greater compression, triggering buckling at the second floor level. A new unbalanced vertical force would be created at the upper floor beam. If this floor is linked to the upper one, the process would repeat. The propagation of buckling and yielding to the upper floors seems similar to a "zipper" from which this system derived the name of "zipper frame". The solution is appealing; however, the analytical results show that if all the braces at all floors are allowed to buckle, then collapse of the frame is likely to occur.[1]