Seismic design of eccentrically braced space frame (EBSF)

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Abstract

case studies of the design of an building employing three dimensional eccentrically braced frames as lateral force resisting system are discussed. The floor framing system consists of composite beams supported by long span trusses, which are then supported by exposed composite columns. The lateral system is a dual system. The primary lateral system is made of four EBFs supported by the eight composite columns and folded around the four corners of the main building. The secondary lateral system is a moment resistant space frame consisting of the floor trusses and the composite columns. Nonlinear pushover and earthquake response history analyses indicate that the dual structural system possesses substantial reserve strength over the code prescribed minimum lateral loads. The member yielding sequence and the distribution, as well as the extent of the plastic hinge rotations observed from the analyses illustrate that the building is likely perform satisfactorily under severe seismic events.
Keywords: seismic design, EBSF, modeling, pushover analyses.

1. INTRODUCTION

During the last decade, eccentrically braced frames (EBFs) have involved (Engelhardt and popov1989)and become fully codified(ICBO 1994) as an effective earthquake resistant framing system for building structures. In particular, a dual structural system employing EBFs around the building perimeter has gained wide acceptance as a efficient choice, as it economically satisfies both architectural and the structural requirements. In most case, a complete EBF, including the link beams, braces, and columns, is located in the same vertical plan. While the EBFs are often the primary lateral system for a building, they are usually built within partition walls and thus are seldom part of the architectural statement.
In this paper, the structural design of an office building employing exposed three-dimensional (3D) EBFs as the primary lateral force resisting system discussed in detail. The building has 13 stories above grade and four levels below grade. The typical above grade floor-to floor height is 4.2 m. A novel design of an eccentrically braced exoskeleton is adopted as the primary lateral system for the building.
The above-grade structure consists of a concrete platform between the ground level and level 3, and a glass box above level 3 with exposed steel framing supported by eight steel and reinforced- concrete composite columns. The typical floor framing system consists of composite beams supported by long span trusses, resulting in a column free interior space. The primary lateral system is made of four 90^0 folded EBFs supported by the composite columns at the four corners of the main building. An isometric view of the superstructure is shown in Fig. 1. The secondary lateral system is made of MRFs in both principal directions. The MRFs are formed by connecting both of the top and bottom chords of the floor trusses to the composite columns.
The design of the building structure is governed by the combination of gravity and earthquake lateral load effects. In addition to the conventional 3D elastic analyses, the post yielding behavior of the lateral system assessed using nonlinear pushover and earthquake response history analyses. The nonlinear analyses are conducted to examine the structural performance in ultimate earthquake events, and to verify the adequacy of the structural design following the code prescribed procedures.

2. STRUCTURAL SYSTEM

The structural framing from the foundation to level 3 is of reinforced concrete. A massive reinforced-concrete floor system at level 3 is incorporated as the transition between the reinforced- concrete structure