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Effects of Vertical Irregularities on Seismic Shear Demands of Columns in Steel Moment Frames

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Abstract

In the recent years, architectural advances in buildings has resulted in construction of structurally irregular buildings. Herein, a numerical study on effects of single side setback in steel moment frames is presented. SAP software was utilized in numerical modeling of these structures. The structures are analyzed under simultaneous actions of two orthogonal ground motions. Variation of shear demands in members is also studied. Comparisons are made between results of setback and full frame structures. In addition, results obtained from different methods of analysis including linear static analysis, response spectrum analysis and inelastic time history analysis are compared for the case of such structures with different setback configurations. The effects of area ratio and height ratio of setback on shear demand are also discussed. Recommendations are made to ensure uniform distribution of shear demands and consistency of related actions.

Keywords: Setback, Steel moment frames, Irregular building, Nonlinear analysis

1. INTRODUCTION

In the recent years, architectural advances in buildings has resulted in construction of structurally irregular buildings. Most of the building codes consider irregularity in height if horizontal dimension of lateral-force resistant system of one story is larger than 130% of the adjacent story [1]. Each building with setback is assumed to be consisted of two separate portions, a tower and a base. During seismic excitation of setback structures, inconsistent interaction of "tower" and "base" can lead to an increase in shear forces of foundation of tower, causing life-threating and irreparable damages to buildings. Due to sudden change of mass and stiffness in setback portion of structure, load distribution is often complex and unpredictable, requiring complicated analytical procedures. This aspect has been mostly ignored in seismic design codes which are reflected in poor performance of some setback structures during past earthquakes (i.e. Kermanshah, 2017). Moreover, most of the procedures prescribed by the design codes for estimating the deformation demands are formulated from single-degree-of-freedom systems and the use of elastic analysis [2]. Therefore, these procedures may be unsuitable for design of some setback structures due to their complex behavior. However, some building codes do show some sensitivity regarding irregularity and prescribe dynamic analysis for seismic evaluation of such structures.

2. LITERATURE REVIEW

Due to their use in an architectural and urban capacity, setback buildings have been widely used and thus subject of previous research. In the following a brief review of most relevant research are presented. In 1987, Shahrooz and Moehle [1] conducted an experimental study on ¼ models of RC setback structures. The test subjects were 6 stories tall and consisted of two bays in each planar direction. Test specimen had a 50% setback at its mid-height. Specimen were subjected to various earthquake records on the shaking table. Experimental observations were accompanied by analytical studies. The results of this paper suggests that a dynamic analysis is necessary to fully predict the behavior of building with irregularities. Also, a static lateral-load design method