PROBABILISTIC ASSESSMENT OF VERTICAL IRREGULARITY EFFECTS ON THE SEISMIC PERFORMANCE OF STEEL MOMENT RESISTING BUILDINGS

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ABSTRACT

In this paper, the effects of different types of structural vertical irregularities on the seismic performance of steel moment resisting frame structures are evaluated based on the probabilistic approach. For this purpose, the seismic performance of structures with geometric and non-geometric vertical irregularities are assessed by studying (i) the limit-state capacities, (ii) the mean annual frequency of exceeding different limit-states and (iii) the confidence levels in meeting performance objectives. The results have shown that the non-uniform distribution of lateral resisting properties over the height of structure (i.e. the non-geometric vertical irregularities), influences the seismic performance levels close to collapse prevention (CP) onto global dynamic instability (GI) limit-states. These irregularities can affect the seismic intensity capacity and/or the ductility capacity of the structure based on the type and the position of vertical irregularities. In addition, the assessment of structures with geometric vertical irregularities (i.e. setback structures) demonstrates the poorer seismic performance of these code-designed structures relative to the regular structure, depending on the ratio of irregularities. The confidence levels to satisfy the LS performance objective for the studied code-designed setback structures is decreased more than 10%, compared to the regular structure. It is shown that the more respective limitations for vertical irregular buildings may be essential in the current seismic design code, in order to improve the seismic performance reliability of this type of buildings.

INTRODUCTION

In the past decade of earthquake engineering science, the probabilistic seismic performance assessment of structures has grown as a measurement for predicting the reliability of structural systems under seismic excitations. This methodology assesses the structural performance of buildings by probabilistic estimation of the responses under ground motion records. In particular, the estimation of the mean annual frequencies (MAFs) of exceeding the structural performance levels and the confidence level for satisfying the performance objectives has been applied as a decision making framework for design and assessment of common regular structures (Cornell et al., 2002). On the other hand, the prediction of the seismic performance of structures with special features such as vertical irregular buildings is important for earthquake engineers from viewpoint of designing new structures or rehabilitating existing vulnerable buildings. In general, vertical irregularities can be classified as non-geometric and geometric irregularities. In the geometric irregularity, the plan dimensions suddenly change over the height of building but in the non-geometric irregularity, the distribution of seismic lateral resisting properties, such as mass, lateral stiffness