Assessment of Equivalent Static Earthquake Analysis Procedure for Structures with Mass Irregularity in Height

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Abstract

Sudden changes in structural dimensions and mass irregularities are inevitable in urban buildings. Most building codes have different analysis and design previsions for such buildings. In this article, such provisions based on the Iranian seismic code of practice (Standard No. 2800), which is to a great extent similar to UBC-97 model code, are verified in order to assess the provisions for different types of structures.

Thus, four two-dimensional residential type steel structures with 4, 8, 12 and 16 stories and with different forms of mass irregularities in height are designed using the standard equivalent static procedure per the Iranian Seismic Code of practice. The designed structures, then, were subjected to different nonlinear static (pushover) and dynamic analyses. Two levels of irregularities, i.e. 150 and 300 percents, located at the heights equal to 50% and 75% of the overall height of the structures, have been considered.

The results show that the static procedure adapted in the code results in much higher internal forces, story shears and overturning moments in various parts of the structures compared to the dynamic results. Also, this study shows that lateral inter-story drifts obtained using the equivalent static procedure and dynamic analyses are quite comparable for short buildings. For taller buildings, in contrast, dynamic analyses showed less inter-story drifts. It is also observed that mass irregularities in height could be responsible for more contribution of higher modes in seismic response of such structures.

Keywords: Mass irregularity, equivalent static analysis, nonlinear analysis, Iranian seismic code

1. INTRODUCTION

The existing nonlinear approaches are of great accuracy for evaluation and estimation of seismic demands, but due to complexities involved in developing the model, are not generally addressed. The equivalent static analysis is one of the common approaches used for seismic demand analysis of structures, which deemed as one of the fastest and most practical methods in most codes. This procedure is used for common structures (residential buildings with moderate height). Thus, it is necessary to investigate this approach in terms of structural considerations and the effect of different parameters on structural response in addition to the comparison between its analysis results and actual response of the structure.

Given the reasons noted above, validity and results of the equivalent static analysis for different types of structures is unavoidable. In this study, the limitations of this approach cited in the Iranian Code of Practice for Seismic Resistant Design of Buildings (Standard 2800) are addressed.

The limitations include observations regarding height and irregularity in mass, stiffness, etc.

One of the most common types of irregularity is the mass irregularity along the building height. Most of the building codes have cited different provisions for this kind of irregularity, which present and identical concept despite the existing disparities.

This issue is considerably addressed in recent years. According to the Iranian Standard 2800, buildings not complying with the regularity provisions are referred to as irregular buildings. According to Section 1-8-1