COMPARING NONLINEAR TIME HYSTORY AND NONLINEAR STATIC ANALYSIS OF RC STRUCTURES WITH VERTICAL MASS IRREGULARITY

Mohammad Mehdi ERFANI
M.Sc. Graduate in Structural Engineering, University of Zanjan, Zanjan, Iran
s.m.m.erfani@gmail.com

Mahdi GORZIN
M.Sc. Graduate in Structural Engineering, University of Zanjan, Zanjan, Iran
mahdigorzin@yahoo.com

Hossein TAJMIR RIAHI
Assistant Professor, University of Isfahan, Isfahan, Iran
tajmir@eng.ui.ac.ir

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Investigation on the past earthquakes proved that irregular buildings are vulnerable in accordance with regular ones especially in irregular regions (Valmundsson and Nau, 1997; Al-Ali et al., 1998). The main reason is the concentration of permanent deformation in these parts. Analysis of irregular buildings for design purpose using elastic methods leads to underestimate results in irregular regions (Chintanapakdee and Chopra, 2004). Therefore, some limitations are considered in seismic standards for such buildings. Different applications of stories in a building results in mass change in each level and if these changes are significant, they lead to mass irregularity thorough height. This paper investigates seismic behaviour of reinforced concrete buildings with three irregular regions in bottom, middle and upper levels in height. It also discusses and compares nonlinear static analysis results with different load patterns. Nonlinear time history analyses for these types of structures are also performed in this paper.

Two kinds of lateral resisting systems have been studied in this paper. One series consists of moment resisting frames with 6, 10 and 15 stories with intermediate ductility and the other series has dual system consisting moment resisting frame and shear wall with the same number of stories as previous one. Mass irregularity is considered as 50% extra mass in accordance with adjacent stories. Regular buildings are also analysed and compared with irregular ones.

Value and distribution of interstory drift ratio of stories are considered as a reference of structures behaviour and results are compared because of importance of this parameter in structural seismic assessment (Figure 1). In non-linear static analysis for calculation of target displacement, a solution which is proposed in ASCE 41-06 has been used. Seven ground motions are selected and scaled according to ASCE 41-06 for non-linear time history analysis.

Results of investigations show that nonlinear static analysis method with uniform lateral loading pattern is not suitable for irregular structures especially in moment resisting frames. There is a significant difference between this loading pattern drift response and results of nonlinear time history analysis. This difference is due to inability of this loading pattern for consideration of higher modes. Yet, the difference in frames with dual system is less than moment resisting frames.

The other analysed loading pattern is in accordance with lateral force which is obtained from spectral analysis. The difference of nonlinear static analysis results from this type of loading pattern with non-linear time history analysis in moment resisting frame is increased taller buildings. But, there is not a significant change in frames with shear wall which indicates the important effects of higher modes in moment resisting frame. The difference of results of nonlinear time history analysis and nonlinear static analysis in irregular frames is more than regular ones. This difference indicates the necessity of dynamic analysis in irregular structures. Interstory drift ratios obtained from nonlinear time history analysis are mostly higher than the results of nonlinear static analysis even in regular frames. Distribution of stories relative drift in structure height resulted from nonlinear time history analysis is predicted to an acceptable level by nonlinear static analysis with loading distribution according to lateral force based on spectral analysis. Moreover, difference of the two analysis

increases by raising the mass irregularity position in structure height. In moment resisting frame, uniform lateral loading predicts lesser value in higher stories in comparison with lateral loading distribution based on spectral analysis. It also predicts higher value of relative drift in lower stories.

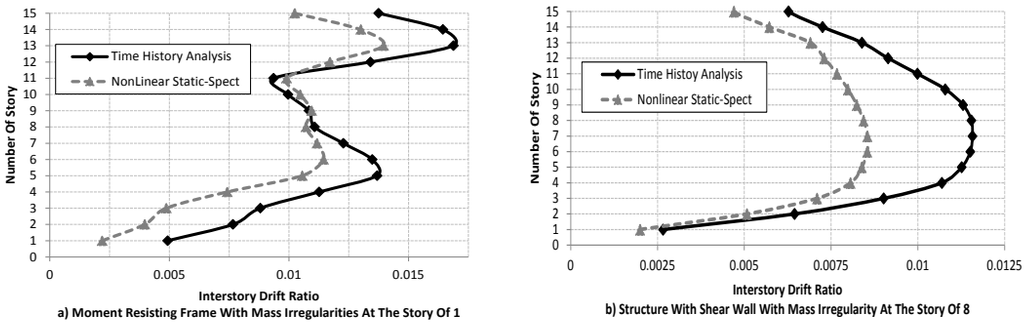

Figure 1. Interstory drift ratio distribution resulted from time history analysis and nonlinear static pushover with spectral lateral loading pattern, in a) moment resisting frame and b) frames with dual system

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