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Evaluation of Response Modification Factors of Moment Resisting Steel Frames by Different Nonlinear Analyses

Hossein Tajmir Riahi, Setare Seyedain Boroujeni
1- **Assistant Professor, Department of Civil Engineering, University of Isfahan**
2- **Graduated Student, Department of Civil Engineering, University of Isfahan**

tajmir@eng.ui.ac.ir
setare.seyedain@gmail.com

Abstract

Most recent seismic codes include response modification factor in the definition of equivalent lateral forces to reduce the linear elastic design spectrum to account for energy dissipation capacity of structure. In this paper, application of Endurance Time (ET) method in nonlinear seismic analysis has been investigated. A set of three acceleration functions have been applied to various steel moment resisting frames and derived results are compared to Incremental Dynamic Analysis (IDA) results. ET analysis results accuracy in evaluation of response modification factors has been assessed according to frames performances evaluation and compared to IDA accuracy in this regards. It is observed that the response modification factors resulted from ET analysis are compatible with those obtained from IDA in most cases. Considering the great amount of computational efforts that should be done for evaluating response modification factors by IDA, ET analysis can reasonably evaluate them with less analysis.

Keywords: Response modification factor, Endurance time analysis, Steel moment-resisting frame, Incremental dynamic analysis

1. INTRODUCTION

To design and strengthen a building to remain in elastic range (undamaged) is not economical and it is also difficult to predict the behavior of all structures under various earthquake types loading. Therefore, some seismic damages in a building which does not lead to the collapse are accepted in common seismic codes design principles. If the structural components are designed in a ductile manner, collapse can be avoided. The response modification factor, *R*, reflected the capability of a structure to dissipate energy through inelastic behavior. In other words this factor was often referred to as a general "ductility" factor and plays a key role in earthquake resistant design principals.

The Endurance Time (ET) method is a time-history based analysis and design procedure that has recently been introduced, e.g. [1]. When a new method is proposed in any fields of engineering, it should be evaluated in different aspects comprehensively. For ET analysis, it should be evaluated in presenting the important aspects of the hysteretic behavior of different structural systems undergoing inelastic response under severe earthquake events. In this paper, the accuracy of ET results in estimating response modification factor has been explained. The basics of the ET procedure are briefly reviewed and its potential applications are discussed. The results of analysis of some 2D steel moment-resisting frames have been presented and compared to the results of IDA analyses. It has been shown that even though the ET method is a time-history based analysis, its concept and application are quite intuitive and straightforward and this method has the capability to predict demand and capacity of the structures in regions ranging from elasticity to global dynamic instability. Also its results are compatible with the results of IDA analyses. Some of the major problems of ET method are discussed and some techniques to remove them are presented. It is observed that the response modification factors resulted from ET analysis are compatible with those obtained from IDA in most cases and both methods can differentiate between structures. Considering the great amount of computational efforts that should be done for evaluating response modification factors by IDA, ET analysis can reasonably evaluate them with less analysis.

2. BASIC CONCEPTS OF ET METHOD

In ET method, structures are subjecting to predesigned intensifying acceleration functions and their reliabilities are assessed during the time till reaching a desired limiting point. Generation of appropriate