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The State of the Art of Ground Motions Selection and Modification Methods for Response History Analysis

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Abstract

The ground motions selection and modification is one of the most important process in whole procedure of seismic design or performance evaluation of structures. The purpose of the opinion paper is to introduce the trends in the ground motions selection and modification methods for response history analysis. In particular, monte-carlo simulation based approaches to consider ground motion correlation have been developed in recent year. In this paper, benefits, limitations, and alternatives to the methods are given.

Keywords: Response history analysis; Ground motion selection; Monte-carlo simulation

Introduction

There are three well-used methods for evaluating structural responses (displacements, velocities, accelerations, stress etc.) under the seismic excitation - Equivalent static analysis, modal response spectrum analysis, response(time) history analysis (RHA). Among these methods, equivalent static analysis and modal response spectrum analysis have been more widely used than RHA, since they have relatively simple process to evaluate the performances of structure. Moreover, no in-depth knowledge about seismic engineering are needed compare to RHA. On the contrary, RHA is the most precise method among them. But, the method requires extensive analysis time and seismic engineering knowledge.

However, in recent years, with the continuous development of computer software and analysis methods, linear and non-linear RHA of structures has become a very common process for engineers. On this basis, various methods of evaluating the performance of structures have been developed. To ensure reliable analysis results from RHA, it is very important to select the exact ground motions by input seismic forces as well as an accurate numerical model of the structure.

The objective of this paper is to introduce the state of the art of ground motions selection and modification methods (GMSM) for RHA. In this paper, benefits, limitations, and alternatives for some representative methods for GMSM are presented.

Ground Motion Selection and Modification (GMSM) Methods

The GMSM methods have been developed for a long time. However, genetic based method developed by Naiem et al. [1] and the semi-automated method developed by Kottke and Rathje [2] are proposed as the forms of an algorithm, for the first time. These two methods describe detailed and concrete process but they were not widely used since some limitations about the extensive time spend complexity of the procedure, and computer memory and so on.

One of the most used method in recent is monte-carlo simulation based algorithms which was firstly proposed by Jayaram et al. [3] This method is advanced procedure which can consider ground motions mean, variance, and correlations [4] with probabilistic analysis of response spectra of ground motions. Moreover, the monte-carlo simulation based algorithm can reduce required time for selecting ground motions and engineer's effort can be reduced. Especially, USGS [5] provides ground motions for seismic design or performance evaluation to engineers with this GMSM algorithm. Engineers can search and select ground motions directly by USGS website and use the ground motions in practice. Since the method was developed, many researches have proposed simulation based algorithms. Figure 1 shows a sample simulated and selected response spectra of ground motions using simulation based GMSM proposed by Han et al. [6].

However, there are some limitation for the simulation based algorithms. One is the process of the methods are very complicated. When conducting monte-carlo simulation of ground motions, specific computer software and in-depth knowledge of statistics are needed. Therefore, it is not easy for engineers to conduct the methods for GMSM.

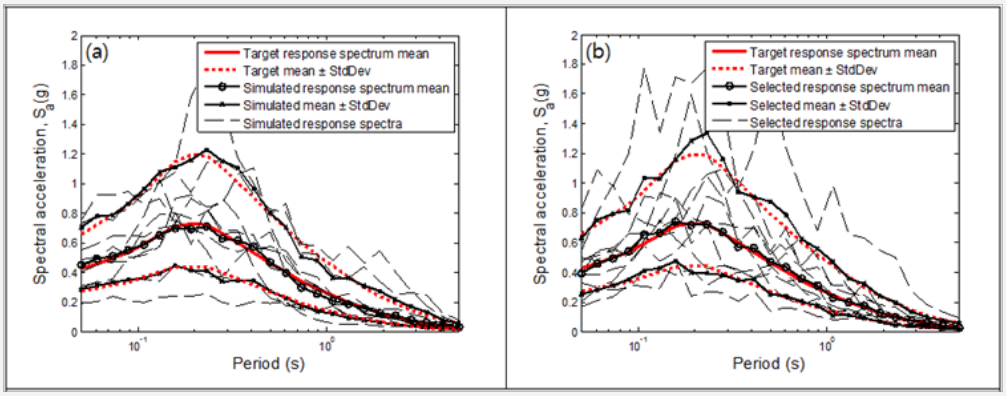

Figure 1: A target and sample response spectra using simulation based GMSM proposed [6]:

a. Simulated response spectra,

b. Selected response spectra of recorded ground motions.

Second, the methods require the prior assessment of ground motions correlation with vast ground motions database. Because monte-carlo simulation is a process which generates additional simulated random variables (for GMSM, response spectrum of ground motions) with parameters of mean, variance, covariance, and correlation. In other words, it is hard to use the methods in sites or countries where the correlation of ground motions is not assessed.

For example, high seismicity regions such as Unite States and Europe have very long history of recording earthquakes so there are vast accumulated ground motions database. Moreover, the recorded ground motions have been well analyzed constantly and updated since the earliest stages of seismic engineering. So, these countries already have specific information of ground motions mean, variance and correlation. Therefore, it is possible to use simulation based GMSM procedures. However, most of low and moderate seismic regions have only few recorded ground motions. Therefore, there is no ground motions correlation information for those countries. Therefore, it is hard to use those simulated based GMSM procedure for those countries.

More recently, Ha and Han [7] proposed the GMSM procedure without monte-carlo simulation process which requires excessive computation. In this procedure, a desired number of ground motions are sequentially selected from first to last using square root of sum of squares (SRSS) method. So the process is conceptually simple and straightforward. Also, it is not need specific or complicate computer software for the process. Moreover, the process can be used for design response spectrum or uniform hazard spectrum which has no information of variance and correlation of ground motions. With this method, therefore, it can be possible to select appropriate ground motions for seismic design of performance evaluation of structure efficiently for low and moderate seismic regions. However, there are still some limitation on the methodology such as modification and scaling of ground motions.

Conclusion

In this paper, the state of the art of GMSM methods for RHA of structures are introduced. Most of the simulation based algorithm or procedure which are used in some high seismicity regions such as Unite States and Europe provides accurate analysis results. However, it is hard to use the procedures for most of low and moderate seismic regions since some limitations. On the other hand, straightforward approach methodology which is proposed by Ha and Han [7] dose not used completed process such as ground motions simulation. And the process is affordable for low and moderate seismic regions. But, the process still has some limitations such as modifications of ground motions. Therefore, when selecting ground motions for conducting seismic design and performance evaluation, it is very important to use appropriate GMSM methods according site characteristics and natures.

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References

1. Naeim F, Alimoradi A, Pezeshk S (2004) Selection and scaling of ground motion time histories for structural design using genetic algorithms. Earthquake Spectra 20(2): 413-426.

2. Kottke AR, Rathje EM (2008) A semi-automated procedure for selecting and scaling recorded earthquake motions for dynamic analysis. Earthquake Spectra 24(4): 911-932.

3. Jayaram N, Lin T, Baker JW (2011) A computationally efficient ground-motion selection algorithm for matching a target response spectrum mean and variance. Earthquake Spectra 27(3): 797-815.

4. Baker JW, Jayaram N (2008) Correlation of spectral acceleration values from NGA ground motion models. Earthquake Spectra 24(1): 299-317.

5. Han SW, Ha SJ, Seok SW (2014) Efficient and accurate procedure for selecting ground motions matching target response spectrum. Nonlinear Dynamics 78(2): 889-905.

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6. Unite State Geological Survey USGS science for a changing World, US.

7. Ha SJ, Han SW (2008) A method for selecting ground motions that considers target response spectrum mean and variance as well as correlation structure. Journal of Earthquake Engineering 20(8): 1263-1277.

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