EVALUATION OF THE EFFICIENCY OF GROUND MOTION SELECTION METHODS IN ASSESSMENT OF THE SEISMIC DEMANDS WITH SIGNIFICANT HIGHER MODE EFFECTS

Salar ARIAN MOGHADDAM
PhD Candidate, IIEES, Tehran, Iran
s.arianmoghaddam@iiees.ac.ir

Mohsen GHAFORY-ASHTIANY
Professor, IIEES, Tehran, Iran
ashtiany@iiees.ac.ir

Keywords: Time-History Analysis, Ground Motion Selection, Higher Modes

An important step for the Nonlinear Time History Analysis (NLTHA) of structures is to select a reliable set of ground motions (Shome, 1999). In probabilistic seismic demand analysis of structures based on the Pacific Earthquake Engineering Research (PEER) centre framework, described in FEMA-350 (2000), one of the key points to ensure the reliability of results is to reduce the dispersion in calculated Engineering Demand Parameters (EDPs). An effective selection can reduce the possible scatter in the results due to the intrinsic uncertainties of recorded Strong Ground Motions (SGMs).

Different SGM selection and modification methods have been proposed (Haselton et al., 2009 and Ghafory-Ashtiany et al., 2012). Some traditional approaches such as “site-specific” methods, suggest the application of seismological criteria to determine appropriate ground motions (Bommer and Acevedo, 2004). Code-based procedures highlight the spectral compatibility with the Uniform Hazard Spectrum. New researches confirm the ability of structural response characteristics in representing predetermined levels of seismic hazard (Haselton et al., 2009).

In this paper, the “structure-specific” selection is evaluated quantitatively. Two recently introduced selection methods by Ghafory-Ashtiany et al. (2011) and Mousavi et al. (2011) are chosen and the sensitivity of response characteristics to the selected SGMs in case of MDOF structures is investigated. The first method proposes a precedence list of accelerograms for different periods of vibration which can be used in the IDA process to minimize the statistical dispersion in the results. The second method compares the similarity between spectral shape of an accelerograms and the target spectral shape while a new efficient parameter is proposed to quantify the spectral shape corresponding to an individual ground motion. Since selection methods are based on some simplifying assumptions that may not be true in case of irregular structures, structural models are selected to cover different levels of nonlinearity and irregularity.

The level of irregularity is related to the potential of contribution of higher modes of vibration in the dynamic response of structure, while the application of most of the selection methods is restricted to the first mode dominant structures (Haselton et al., 2009). In practical cases, when the contribution of higher modes is more significant it is recommended that more precise analysis methods such as NLTHA be selected.

As an example, Figure 1 compares seismic collapse capacity curves of a 12-story steel frame computed using Incremental Dynamic Analysis (IDA) with two different sets of SGMs. Structural details of the steel frame are selected from Dimopoulos et al. (2012). Sets of ground motions are selected based on the first and second modal period of vibration. A Selection method using structure groups classified on the basis of their first modal period has been proposed in Ghafory-Ashtiany et al. (2011). Results of the IDA analysis presented in Figure 1 have been normalized to a target value computed from a design response spectrum (Iranian Code of Practice for Seismic Resistant Design of Buildings, standard no. 2800).

The results show that when the selection method consider only the first mode of vibration, significant reduction in the reliability of EDPs is possible. More specifically, it is expected that large dispersion of estimated demands be obtained with increase in higher modes contribution. To resolve the mentioned problem it is suggested that new scaling and selecting methods be designed in which the significant role of higher mode effects as a part of the selection problem is considered.

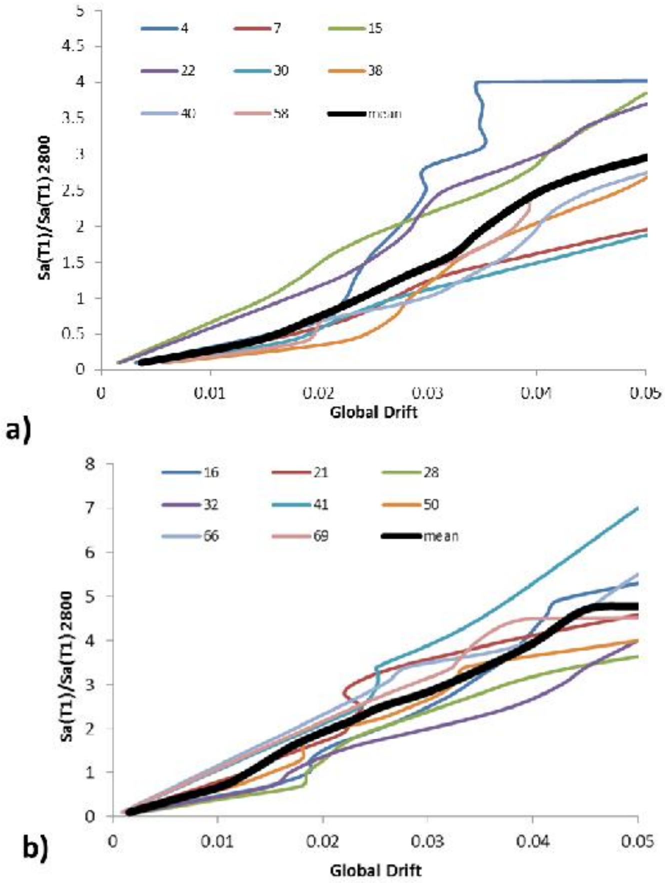

Figure 1. IDA curves computed for 12-story steel frame using a) 8 accelerograms selected based on the second modal period of structure, b) 8 accelerograms selected based on the first modal period of structure

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