AN EFFECTIVE METHOD FOR SELECTION AND MODIFICATION OF GROUND MOTIONS FOR DYNAMIC TIME HISTORY ANALYSIS

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Keywords: Ground Motion, Selection, Modification, Nonlinear, Time History

The nonlinear time history analysis possesses a special advantage over other dynamic analysis methods due to its ability to simulate a realistic seismic behavior of structures. To implement such an analysis, availability of suitable earthquake records is necessary. It is well known that the structural responses are quite sensitive to the selected earthquake records. On the other hand, any selected record is scaled to be consistent to the seismic environment under study. Various scaling methods are available. Among the methods, the one that results in the least scatter in nonlinear responses under the selected and scaled records can be relied upon more efficiently. Therefore, in a nonlinear dynamic analysis, both the selection and scaling procedures of the ground motions to be used are of prime importance.

In this research a three-phase screening method is presented for selection of seismic records. In such a procedure, from the first to the third screen, the selection criteria become more rigorous and the remaining records become rapidly smaller in number. In the first screen, four parameters including earthquake magnitude, distance to the causative fault, soil type, and PGA are used within a search engine on the Internet like PEER NGA (PEER, 2014). It is shown that this selection based on this screen results in the number of earthquakes being in a range of 40-60. In the second screen, similarity of the spectral intensity of records, defined in Eq. 1 (Housner, 1952), to that of the design spectrum is evaluated. A number of earthquakes, being in the range of 15-25, is the result of this screen.

$$SI = \int_{T_1}^{T_2} S_V \, dT \tag{1}$$

In Eq. 1, SI and S_V are the spectral intensity and spectral velocity, respectively, T is the building period with T_1= 0.1 sec and T_2=2.5 sec. In the third (and last) screen that is the tightest, similarity of the remaining records to the conditional mean spectrum (CMS) of the region (Baker, 2011) is determined using Eq. 2:

$$SSE = \sum_{j=1}^{n} \left(\ln Sa(T_j) - \ln Sa_{CMS}(T_j) \right)^2 \tag{2}$$

where SSE is the criterion of similarity with smaller SSE's showing more similarity, Sa and Sa_{CMS} are the spectral acceleration of the record and the CMS spectral acceleration, respectively, and *n* is number period samples. Equation 2 is usually calculated for the period range of 0.2T to 1.5T. Number of finally selected records being 7-10 is the outcome of Eq. 2.
For scaling of records, again several different criteria have been proposed in the past out of which those of ASCE 7-10 (ASCE, 2010) and CMS (Baker, 2011) have attracted more attention and use. A new procedure is introduced in this research using fundamental periods of the same building designed once only for the average response spectrum of the selected records, resulting in a period T_1^e, and once for the design spectrum, resulting in its fundamental period being T_1^{code}. The new scale factor is shown in Eq. (3):

$$\text{Scale Factor} = \left(T_1^e / T_1^{code} \right)^2 \quad (3)$$

To evaluate effectiveness of the suggested selection and scaling procedure, five example buildings having 2, 4, 6, 8 and 10 story with steel moment frames both ways are selected for nonlinear dynamic response analysis. For each building, 10 records (totally 50 records for all buildings) are selected using the above procedure. The selected records are then scaled according to five different methods (totally 250 scaled records), including the one proposed in this study, to assess the statistical quality of response results. With the main criterion being having less scatter in nonlinear responses, and keeping in mind that no unique statistical index is available for this purpose. Four different statistical measures including Coefficient of Variation, Logarithmic Standard Variation, Average Differences, and Differences Percentile are used for the same purpose. Through a vast numerical study on the responses for the cases defined above, it is shown that in a large majority of cases, the proposed method of record scaling results in the least scatter in the nonlinear structural responses.

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