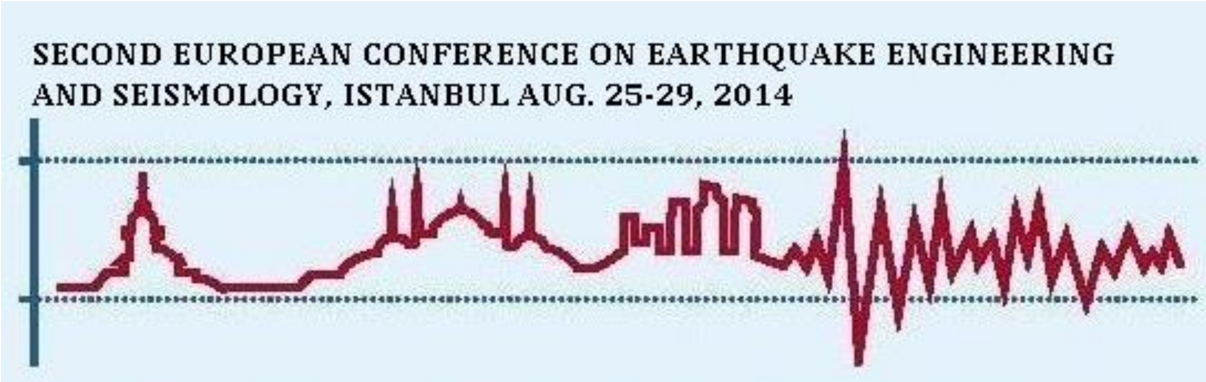

AN ENGINEERING APPROACH FOR STRUCTURE-ORIENTED EARTHQUAKE RECORD SELECTION

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Thanks to the ever-increasing computational capacity of personal computers, nonlinear analysis of structures is gradually becoming more common. Simplified nonlinear analysis methods such as conventional first mode pushover or other derivations of it are useful tools but not able to capture the response of irregular, tall or other type of more complicated structures. Nonlinear analyses in time-domain are thus more handy tools because there is no need to pre-define a load or displacement profile. Besides, the use of spectra in combination with static nonlinear analyses jeopardizes the accuracy of the results because major parameters of the ground shaking, such as the energy content, the number of cycles and the duration, are not apparent in response spectra.

The main challenge in nonlinear time history analysis is the definition of the demand, which is given in acceleration time history format. There have been published several studies on the record selection issue. Iervolino and Cornell (2005), for instance, examined the available dataset, which was pre-PEER NGA, and correlated the compatibility of the selected records with the spectrum to the distance and magnitude parameters. Because the selection is a check-eliminate-optimize process, it is computationally expensive sometimes. Jayaram et al (2010) proposed a new computationally efficient algorithm to overcome this problem. Naem et al (2004) proposed genetic algorithms for improving the selection process. Several other attempts to better the selected suite of records and the selection process itself can be found in the literature.

The record selection approach explained in this paper uses the PEER NGA database where 7025 recorded motions were available. An in-house developed software was used to list and download the records automatically and compute the spectra for acceleration at 5% damping, velocity and displacement. The spectra have been saved into a data file so that every time a filter is applied, spectra are not re-calculated.

12 bins of records are created where, i) Earthquake intensity (2/50, 10/50 or 50/50 earthquakes, 3 bins), ii) Far field or near field issue (2 bins), and iii) Soil type (firm soil and soft soil, 2 bins), parameters are evaluated. Each of these 12 bins is the populated with 20 "the best matching" records per the given criteria.

The criteria set for the selection of records are applied between 0.2T1 and 2.0T1 periods where T1 is the fundamental period of the structure to be analysed. It was aimed to cover the possible range of periods with significance, however it is found that 0.2T1 period limit is quite harsh as a criterion since the spectra exhibit quite ups and downs in that region. 2T1 has been used for the maximum period of the period window, thinking that the effective period is function of the square-root of the ductility if elastic-perfectly-plastic systems are concerned. The 0.2-2.0 range is not compulsory in fact since it may be re-defined for specific structural systems leading thus to better scaling factors and better agreement of the records with the target spectrum.

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In terms of the selection algorithm, first the acceleration spectrum of the original record is compared to that of the target, in the period window of 0.2T1 to 2.0T1. The scale factor needed is calculated by equating the area below and above the target spectrum as shown in Figure 1. The scale factor is applied to the ordinates, so only to the acceleration of the original record. The scale factors applied have been chosen as close as possible to 1.0 so that the original energy input of the record is not modified significantly. In other words, the algorithm gives priority to the records that need scaling factors close to 1.0. This criterion is particularly important for taking into account the energy content of the recorded motion so that parameters for energy based design, for instance, can be derived.

Following the steps explained above, the near field vs far field comparison is made where the distances above 15km are assumed as far field. Finally a comparison is made in terms of the soil type where the records taken on soil with Vs30 higher than 300m/sec are assumed to be recorded on firm soil while records taken on soils with Vs30 lower than 700m/sec are assumed to be recorded on soft soil. There is certainly an overlap in the soil criteria; this is nevertheless unavoidable if one checks the firm and soft soil borders in the guidelines and codes.

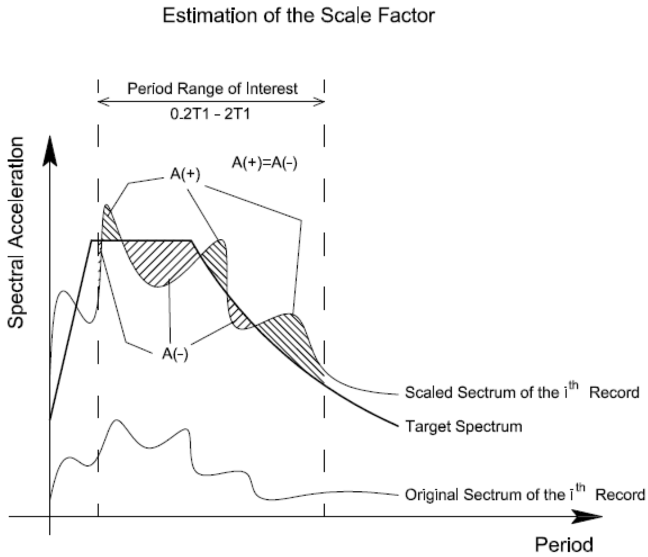

Figure 1. Estimation of the Scale Factor

Several selection outcomes, collected in bins of 20 records each time (see Figure 2 for an example), have been applied to cantilever columns and simple structures to find the variation of the displacement demand from the analyses. The set of selection criteria has been listed against the scatter in the analyses results obtained by using this set of criteria employed in that analysis. It was found that some criteria that are related to duration and energy content have more significant effects on decreasing the scatter. Furthermore, the selection by using the displacement spectrum is more effective for structure with fundamental periods of 1sec or longer.

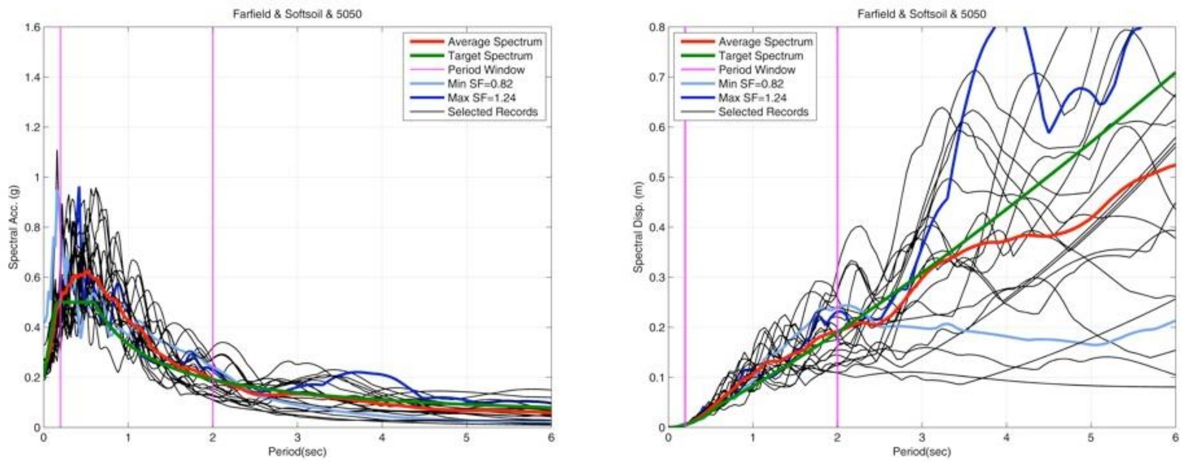

Figure 2. An example set of selected records; the acceleration spectra (left) and the displacement spectra (right)

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