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Scaling and Selection of Recorded Earthquake Time Histories for Nonlinear Analysis about Auxiliary Building

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1. Introduction

As the magnitude and frequency of the earthquake around the world increase, the detailed assessments of the seismic performance on various nuclear power structures, including auxiliary building are required. In particular, to understand the responses to beyond design basis earthquake, the time history analysis considering the system nonlinearity becomes important. Scaling and selection of input earthquake motion are crucial factors when the performance of the structure is evaluated based on the nonlinear dynamic analysis [1,2]. Traditionally, the simulated ground motions have been widely used as input motion, but recently, the research using recorded ground motions also considered in a comparative manner [3]. In this study, the suite of the recorded earthquake time histories, compatible with the uniform hazard spectrum for the nuclear power plant(NPP) in Korea, was selected.

2. Procedure and Results

2.1 Ground Motion Library

Several ground motions were extracted from the PEER-NGA west2 database with considering the characteristics of the earthquake which may occur at the domestic NPP site. The parameters listed in Table 1 were used for the extraction. For determining the range of the earthquake magnitude and source-to-site distance, we take into account the probabilistic seismic hazard analysis result on the Uljin NPP site. The minimum value of shear wave velocity at the station was 760 m/s, which is the boundary of the rock condition. The strong motion duration of a time history was defined as the time required for the Arias Intensity to rise from 5% to 95, and limited to 12 seconds or more.

Table I: Parameters for ground motion library from PEER NGA west2 database

Parameters	Min	Max
Magnitude (M)	4.0	7.0
Distance (R, km)	0	60
Shear Wave Velocity ($V_{S,30}$, m/s)	760	2000
Strong Motion Duration (D_{5-95}, s)	12	100

Fig.1 shows the relationship between the magnitude, distance, and peak ground acceleration (PGA) of the extracted ground motion. Most of the records are located in the vicinity of magnitude 5. PGA tends to increase as the magnitude increase, but PGAs of all records are less than 0.1g.

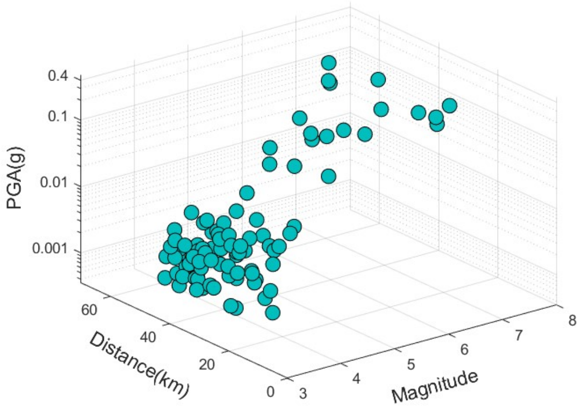

Fig. 1. Relationship between earthquake magnitude, rupture distance and peak ground acceleration for the ground motion library

2.2 Excluding Extracted Records

USNRC SRP 3.7.1 [4] specify several requirements of time histories for structural dynamic analysis. For each earthquake motions, the correlation coefficient is below 0.16, and the strong motion duration is longer than 6 seconds. Therefore, the records which do not meet the criteria were excluded as depicted in Fig.2.

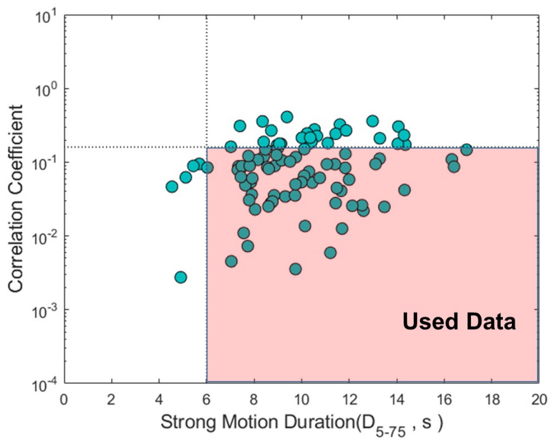

Fig. 2. Classification of the ground motion library data based on correlation coefficient and strong motion duration (D_{5-75})

2.3 Scaling Ground Motion

As previously discussed, the intensities of ground motions in the library are scattered, and it can induce the significant variance between the selected ground motions. So, the scaling was performed for all ground motions before the selection of motion compatible to the target spectrum. The scaling factors were derived from the following equations suggested by Han and Seok [5].

$$\mu_\Delta = \frac{1}{n_p}\sum_{i=1}^{n_p}\Delta_i = \frac{1}{n_p}\sum_{i=1}^{n_p}[lnS_a^{target}(T_i) - lnS_a(T_i)] \quad (1)$$

$$s = \exp(\mu_\Delta) \quad (2)$$

In addition, the three directional earthquake components were combined by square-root-of-sum-of-squares (SRSS) method as specified in ASCE/SEI [6]. Fig.3 describes the example for scaling of the recorded earthquake with SRSS method.

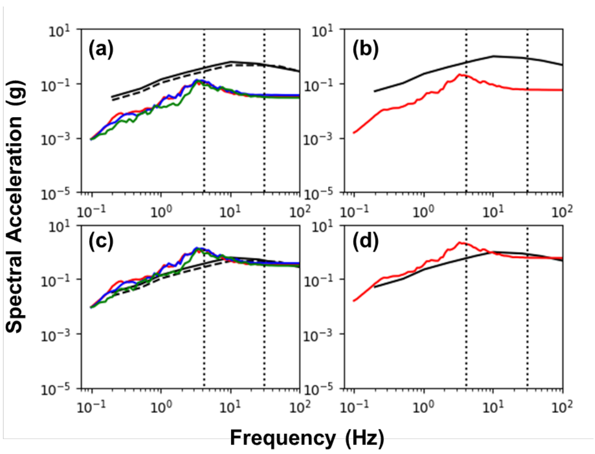

Fig. 3. Example for scaling of the recorded earthquake with SRSS method; (a) unscaled recorded earthquake (3-dir.) (b) SRSS for unscaled recorded earthquake (c) scaled recorded earthquake (3-dir.) (d) SRSS for scaled recorded earthquake

2.4 Selection of Ground Motion

Among the various selection methods, the sequential selection method proposed by Han et al. [7] were utilized. This method sequentially selects the ground motion that minimizes the difference between the target spectrum and the mean spectrum in the frequency range of interests. The frequency range of interest for the comparison of the spectrum was from 0.2Tn to 1.5 Tn, as stated in ASCE/SEI [6]. Tn is the first mode period of the structure, and the primary mode frequency of the target auxiliary building was determined to be about 6Hz through previous modal analysis.

The selected ground motions and mean spectrums are depicted in Fig.4 with target spectrum.

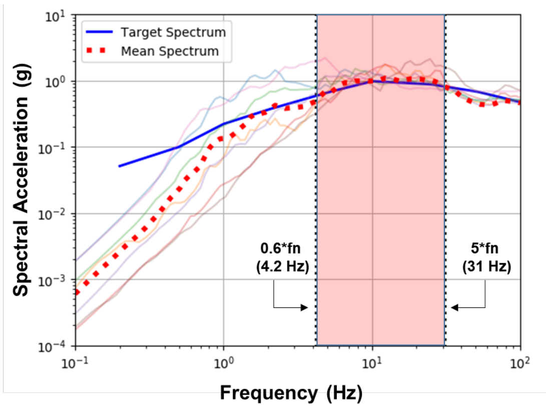

Fig. 4. Spectrums of selected ground motions, mean spectrum and target spectrum.

3. Conclusions

The recorded earthquake time histories were selected compatible with the uniform hazard spectrum for the (NPP) in Korea. The selection process was conducted based on the characteristics of the domestic NPP site and some criteria of standards, but additional consideration for various factors, such as frequency range and variation of the selected earthquake, are necessary.

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