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Comparison of the Uniform Hazard Spectra for Korean NPP Sites

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1. Introduction

A site-specific median spectrum has been generally used for a seismic fragility analysis of structures and equipment in Korean nuclear power plants. The site-specific response spectrum, however, does not represent the same probability of an exceedance over the entire frequency range of interest. The uniform hazard spectrum is more appropriate to use in a seismic probabilistic risk assessment than the site-specific spectrum. In this study, the uniform hazard spectra were developed using the available seismic hazard data for Korean NPP sites.

2. Probabilistic Seismic Hazard Analysis

2.1 Seismic Source Map

In Korea, the active faults have not been identified as seismic sources which generate earthquakes at the present time, and the historical data on the recurrence time for a specific earthquake has not been obtained. Therefore, the Poisson typed PSHA method has been used in Korea, in which all the earthquakes are assumed to occur according to the stationary Process in the time domain [1].

In this study, four seismic source models were used for the seismic hazard analysis. Figure 1 shows one of the seismic source models used in this study.

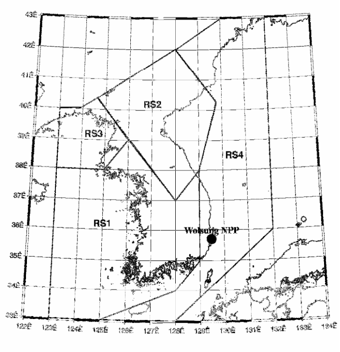


Fig. 1. Example Seismic Source Model

2.2 Ground Motion Attenuation Equation

The ground motion attenuation equation developed by Yun [2] was used in this study. The site specific attenuation equations were developed by regression analyses for the multiple simulations of PGA values obtained by the RVT simulation method [3]. The spectral acceleration can be estimated by the following equation [2].

$$\ln(Y(S_A(g))) = C_1 + C_2 * M_w + (C_3 + C_4 * M_w) * a\log(R_{\text{epi}} + \exp(C_5)) + C_6 * (M_w - 6.0) * (M_w - 6.0) + C_7 * \ln(\min(R,50)) + C_8(\max(R,50))$$

$$R = \sqrt{R_{epi}^2 + 9.8^2} \qquad (Mw \le 6.5)$$

$$= \sqrt{R_{epi}^2 + 9.8^2 * \exp(2.0 * (-1.25 + 0.227 * Mw))} \qquad (Mw > 6.5)$$

where, M_w and R_{epi} denote the earthquake magnitude and the epicentral distance (km), respectively. $C_1 \sim C_8$ are the constants for the attenuation equation.

Figure 2 shows spectral hazard curves for a Korean NPP site at 1 Hz [4]. As shown in this figure, the spectral hazard curves have a large variation according to the seismic source model. Model A gives the highest seismic hazard for the site.

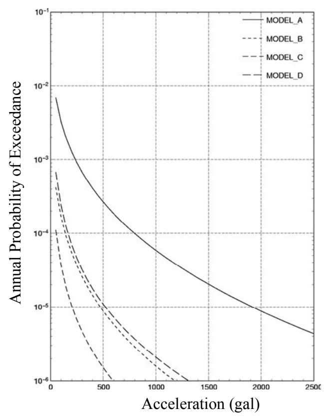
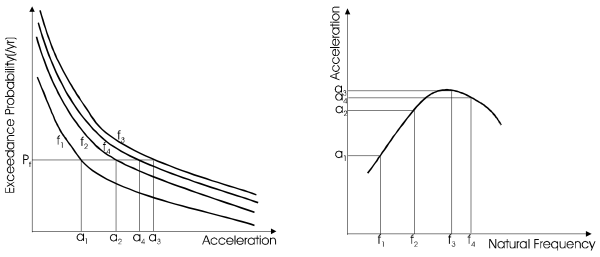


Fig. 2. Spectral Hazard Curves for a NPP Site (1Hz)

3. Uniform Hazard Spectra for NPP Sites

The uniform hazard spectrum is established by generating the first set of seismic hazard curves, each of which expresses an annual frequency of an exceedance as a function of an acceleration response spectral value for a specified discrete value of a frequency and damping (Fig. 3 (a)). Having these sets of spectral hazard curves, the response spectra for a specified probability of an exceedance over the entire frequency range of interest are obtained directly (Fig. 3 (b)).

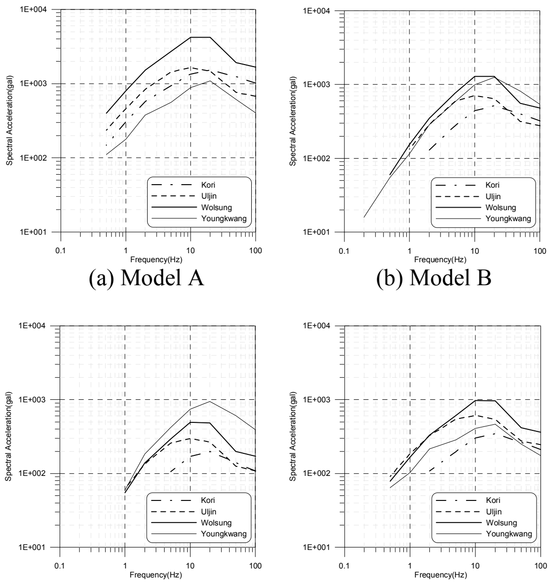


(a) Spectral Hazard Curves (b) UHS

Fig. 3. Procedure for Developing the Uniform Hazard Spectrum

Figure 4 shows the uniform hazard spectra for 4 NPP sites according to the used seismic source model. Model A gives the highest seismic hazard for all the sites and model D gives the lowest seismic hazard. It is shown from this figure that the seismic hazard for a site is strongly dependent on the seismic source model.

In this study, four seismic source models and one ground motion attenuation equation were used for the probabilistic seismic hazard analysis. For the comparison of the uniform hazard spectrum, the average uniform hazard spectrum for a 10^{-4} exceedance probability level was calculated. Figure 5 shows the comparison of the average uniform hazard spectra for the four NPP sites. As shown in this figure, the seismic hazard of the Wolsung NPP site has the highest seismic hazard. The spectral shapes show rich high frequency contents similar to the frequency contents of the earthquake records in Korea.



(a) Model A (b) Model B

(a) Model C (b) Model D

Fig. 4 Uniform Hazard Spectra for NPP Site According to the Seismic Source Models

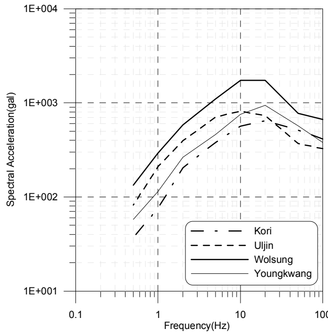


Fig. 5 Comparison of Average Uniform Hazard Spectrum for 4 NPP Sites

4. Conclusion

The uniform hazard spectra for the NPP sites was estimated using four seismic source models and one recently developed attenuation equation. The uniform hazard spectrum for the NPP sites show a different amplification for the whole frequency range and PGA values for the same occurrence probability. The shape and the frequency contents are similar to those of the real earthquake records in Korea.

For the accurate and reasonable estimation of the site specific spectrum, it is necessary to develop realistic and reliable seismic source models and ground attenuation equations suitable for Korean NPP sites.

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