Technical Issues and Proposed Solutions in the PSHA for Korean NPP Sites

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1. Introduction

Significant changes in the nuclear and non-nuclear Codes and Standards were made in the mid-2000 in US and Japan to incorporate the recent seismological findings and new design concepts. Since the first PSHA (Probabilistic Seismic Hazard Analysis) study in 1986, many studies have been performed and new site investigation data has been accumulated in Korea. These require a major review of the PSHA method currently used. Several issues and proposed solutions for the Korean specific PSHA are discussed in this paper.

2. Major Issues and Proposed Solution

2.1 PSHA Procedure

To perform a PSHA, an evaluation on various technical subjects is required first by many experts and the results are integrated. The LLNL methodology with very weak interaction among experts has been used for most of the PSHA for NPP sites in Korea. However, a study showed the EPRI method with expert team approach with medium interaction produced comparable results.

There is a need to develop a PSHA procedure that incorporates a technical improvement in this area and Korean specific seismological environments, as we don't have any so far. The SSHAC (Senior Seismic Hazard Analysis Committee) report [1] provides more uniform and up-to-date guidelines and can be used with some modification.

2.2 Earthquake Catalog

There are several earthquake catalogs with a time span of about 2000 years. Uncertainties in the intensity, magnitude, and epicenter are generally large for each event in those catalogs. Several quantitative researches [2-4] were performed to reduce the uncertainties in assessing those parameters. For example, several experimental studies were performed on an ancient house, a castle wall, and a beacon mound. Also, a study was performed on the completeness of the historical earthquake catalog [2]. As an example, Figure 1 compares the Richter-b value for the cases of an incompleteness corrected and uncorrected for the southern Korean Peninsula. The final mean hazard at a 0.2g PGA (Peak Ground Acceleration) showed about a 2.5 times lower level for the incompleteness corrected case for the Wolsong site. The inland epicenters of some major historical earthquakes which caused tsunamis were studied and these were relocated in the offshore of the East Sea [4].

	126-127E	127-128E	128-129E	129-130E
36-37N	.63	.62	.62	.61
35-36N	.63	.63	.62	.62
34-35N	.64	.64	.63	.62
33-34N	.64	.64	.63	.63

(c) Estimate of b from the raw earthquake catalog

	126-127E	127-128E	128-129E	129-130E
36-37N	.90	.90	.89	.89
35-36N	.91	.91	.90	.89
34-35N	.91	.92	.90	.90
33-34N	.92	.91	.91	.90

(d) Estimate of b with the incompleteness corrected

Figure 1. Comparison of the Richter-b value for the southern Korean Peninsula [2]

A logic tree needs to be developed by experts to better integrate the opinion of the technical community on those factors and to obtain a unified earthquake catalog.

2.3 Capable Fault

After the site investigation for Shinwolsong Unit 1 & 2, some of the faults near Wolsong site were found to be capable faults. As these faults are very close to the site, the direction and amount of dip away from or toward the site can have a large impact on the source-to-site distance. A three dimensional geometry of a source is needed in this case. Earthquake magnitude is correlated well with fault rupture dimensions.

A logic tree needs to be developed by experts to determine the maximum magnitude and recurrence of a fault. As the usual PSHA software can't properly model this, it is required to check the adequacy of the software.

2.4 Attenuation Equation

An attenuation equation is a primary parameter for a seismic hazard. Attenuation equations obtained from US, Japan, China and Korea have been used in the PSHA, due to the lack of strong motion data in Korea. Although several attenuation equations for PGA have been developed for Korea based mostly on the RVT (Random Vibration Theory), we still need to modify the equations by considering the variability of the input parameters such as the stress drop, Q, and kappa.

Seismic design requirement in a building code such as ASCE/SEI 7-05 has incorporated Spectral Acceleration (SA) at a specific frequency instead of PGA. Also, the RG 1.208 [5] adopted the SA approach recently. Attenuation equations with respect to SA were introduced by experts during the study of the Wolsong site [2,3]. These equations were for eastern and central North America at a rock site.

We need to modify two types of attenuation equations by considering the differences of the geologic media and source mechanisms between the two regions. A logic tree method needs to be developed by experts and applied to reduce the uncertainties.

2.5 High Frequency Motion

The ground response spectra for small earthquakes recorded at a rock site condition, reveal dominant high frequency components at 10-30 Hz frequency band as shown in Figure 2. Similar trends can be found in eastern and central North America. The damage potential of a high frequency motion is generally less to structures but higher to equipment than a low frequency motion.

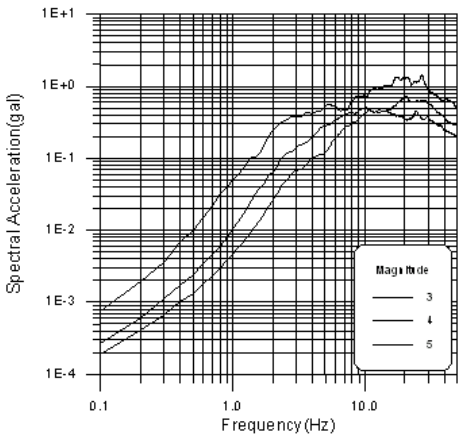

Figure 2. Typical acceleration response spectra for small earthquakes at rock site, horizontal component

2.6 Other Considerations

Several minor issues to be considered are as follows:

-Uniform hazard spectra with mean annual frequency of 10E-4, 10E-5 need to be determined

-Vertical spectrum should be developed separately from the horizontal motion based on the above procedures, however, the attenuation equations are not available in the eastern North America. The procedure of NUREG/CR-6728 [6] can be applied.

-The cut-off frequency of the spectrum can be about 50 Hz.

-The mean seismic hazard should be de-aggregated to produce control earthquakes

3. Conclusion

In this study, technical issues in a PSHA were identified based on 20 years of experience, new findings, new research results and new code requirements. A proposed solution for each issue was briefly described by taking into account the similarity of the seismological environments between Korea and eastern North America.

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