Estimation of a Seismic Induced Initiating Event Frequency ; Current Status and Proposal

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1. Introduction

The seismic risk of a nuclear power plant can be evaluated based on the core damage frequency (CDF). The CDF is estimated from the earthquake induced sequence model that is presented by the event trees (ET) and fault trees (FT) with the seismic hazard of a plant site. Several quantification programs have been used for the probabilistic seismic risk analysis (SPRA) of Korean nuclear power plants. In this study, the seismic induced initiating events frequencies estimation by using the typical programs are compared with same seismic hazard curves, ET, and FT.

2. Seismic Risk Analysis

In this section, the overall procedure for estimating risk(core damage) from seismic events is presented. The evaluation of seismic risk requires information on seismologic and geologic characteristic of the nuclear power plant site, the capacities of structures and equipment to withstand earthquakes beyond the design bases, and the interaction between the failures of various components and systems of a nuclear power plant.

2.1 Basic Methodology

The seismic risk analysis models for predicting the occurrence frequencies of large earthquakes(i.e., earthquakes well beyond the plant design basis) and estimating the failures frequencies of components subjected to such earthquakes. The basic elements of seismic risk analysis can be identified as analyses of (1) the seismic hazard at the site, (2) the response of plant systems and structures, (3) component fragilities, (4) plant systems and accident sequences and (5) consequences quantification. The results of these analyses are used as input in defining initiating events, in developing system events trees and fault trees, in quantifying the accident sequences models to reflect the unique features of the seismic events.

2.2 Seismic Hazard Analysis

The seismic hazard analysis is usually expressed by the frequency distribution of the peak value of the ground-motion parameter during a specified interval of time. In SPRA of the Korean nuclear power plants(NPP), five and eight hazard curves with individual weighting factors were used for Ulchin(UCN) and Youngkwang(YGN) nuclear plant sites, respectively. Figure 1 shows the mean seismic hazard curves for Ulchin and Youngkwang nuclear power plant sites which are generally used for the SPRA.

2.3 Plant response of plant system and structures

In order to calculate the failure frequencies for a structure, equipment and piping, it is necessary to obtain the seismic response of these components to various levels of the ground-motion parameter. In seismic risk analysis for Korean NPPs, the design drawing and as-built condition are reviewed to develop structural analysis model for critical component and structure. The review results were used to develop the accident sequence model.

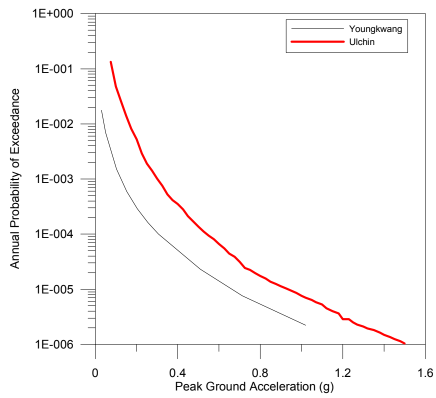

Fig. 1 Comparison of the mean hazard curves for Youngkwang and Ulchin sites

2.4 Seismic Fragility Data

The fragility of a component is defined as the conditional probability of its failure given spectral acceleration. Table 1 shows the component fragility data for the Youngkwang and Ulchin nuclear power plants.

Table 1. Example component fragility data

Component	Median Acc. Capacity(g)	β_R	β_U
SLOOP	0.30	0.22	0.20
SRTSF	1.08	0.35	0.37
SBCRC	1.08	0.30	0.32
SCSTC	0.92	0.16	0.33
SBCSF	1.62	0.35	0.37
SDGCC	1.35	0.35	0.37
SSWRC	1.36	0.30	0.35

SCCSF	1.50	0.35	0.36
SSWSF	1.67	0.35	0.40
CCWAF	1.66	0.37	0.38

2.5 Development model for accident sequence model

The first step in the seismic risk analysis is the identification of earthquake-induced initiating events. To identify the earthquake-induced initiating events, the initiating events considered for internal events were reviewed to identify those are relevant to the seismic risk analysis. The 6 initiating events are identified for the SPRA of Korean NPPs[Table 2]. Only 2 events(for LOOP & General Transient) tree were developed to identified the core damage sequences. The others initiating events are assumed that cause core damage directly, so the event trees for the other initiating events were not developed.

The fault trees were developed to evaluate the used the occurrence frequency of system failure at each branch of an event tree. Fault trees were developed for each safety related system such as emergency core cooling system, auxiliary feedwater system and so on. The non seismic qualified mitigating system considered in internal event PRA were excluded in the seismic risk analysis.

2.6 Quantification Software

Two commercial seismic quantification software (S/W) have been applied for the probabilistic seismic risk analysis of the Korean nuclear power plants. Those programs have the function of a convolution of the seismic hazard curves and system fragility curves based on the Boolean equations. But the uncertainty analysis scheme is different.

3. Sample Calculation

In this study, the seismic induced initiating event frequencies, the main contributor to core damage frequency, for Korean nuclear power plants were estimated by using the two typical program and same input data, same hazard curves and same seismic fragility data. Table 2 shows the results of this analysis respectively.

Table 2. Comparison of initiating event frequencies

Event	UCN		YGN	
	S/W 1	S/W 2	S/W 1	S/W 2
LOSS OF ESSENTIAL POWER	2.64E-06	7.67E-07	3.68E-06	1.28E-06
LOSS OF SECONDARY HEAT REMOVAL	4.80E-07	1.78E-07	1.16E-06	6.08E-07
LOSS OF CCW	1.64E-06	5.77E-07	2.48E-06	8.58E-07
SLOCA	2.74E-08	2.84E-08	3.82E-08	4.77E-08
LOSS OF OFFSITE POWER	4.95E-05	8.34E-06	1.12E-04	1.53E-05
GENERAL TRANSIENT	6.54E-04	8.11E-05	2.79E-03	5.55E-04

4. Conclusions

In this study, the seismic induced initiating event frequencies for Korean nuclear power plants were estimated. The frequencies of each initiating event were estimated differently according to the use of two software as shown in table 2, though the same input such as the hazard curve and component fragility were used. This result could be an obstacle to estimate the accurate risk from an earthquake and make a decision to enhance a plant safety. Therefore a new seismic induced event frequency estimation software for assessing the seismic induced risk is needed.

ACKNOWLEDGMENTS

This work has been carried out under the Nuclear long term R&D Program sponsored by the Korea Ministry of Science and Technology.

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