Evaluation of Seismic Induced CDF & ΔCDF with considering the Uncertainty Reduction Research Results

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1. Introduction

In the seismic probabilistic safety assessment (SPSA) of nuclear power plants (NPPs), the efficient and rational methodology to dealing the uncertainty factors are required to increase the reliability of the SPSA results. To reduce the uncertainties in the SPSA approach, many research activities were performed by Korea Atomic Energy Research Institute (KAERI) during the last 5-years mid- and long-term nuclear research & development program of the ministry of education, science and technology [1,2]. These outcomes can be implemented to the update or re-evaluation of previous NPP's SPSA results. In this study, we applied these uncertainty reduction research results to the update of the SPSA procedure of the target reference plant, i.e., Ulchin unit 5/6 NPP. The refined topics from the SPSA procedure are the seismic fragility, the seismic hazard, and the risk quantification. The detailed process and results are described in the next sections.

2. Methods and Results

2.1 Seismic Fragilities

Fragility capacities and the associated uncertainties of the most critical equipment items have historically been derived from qualification test data from equipment vendors. However, in situations when specific qualification data may not be readily available, generic component capacity data are commonly used. However, most of test and generic fragility is based on pre-1990 vintage components. The applicability of this data for modern components will depend upon the amount of changes that have occurred for any particular component class since 1990. Therefore, U.S.NRC and JNES performed seismic fragility tests for large scaled equipment models [3,4]. In this study, by using the floor response spectra of Ulchin unit 5/6 NPP, we transformed the seismic fragility test results into the data that applicable to SPSA procedure of that NPP. The comparison of seismic fragilities of important components for JNES results and Ulchin unit 5/6 results is depicted in Table I. Using these refined fragility data, we updated the SPSA results of the target reference plant.

Table I: Seismic fragilities of important components: JNES results vs. Ulchin unit 5/6 results

	JNES/SAE06-024				Ulchin5/6 SPSA Rpt.			
	A_m	β_R	β_U	HCLPF	A_m	β_R	β_U	HCLPF
Pressurizer	1.18	0.20	0.10	0.82	4.70	-	-	S/O
Diesel Generator	1.60	0.10	0.10	1.27	1.13	0.36	0.30	0.38
Battery Rack	13.6	0.07	0.10	11.1	1.46	0.33	0.31	0.51
Pressure Transmitter	5.24*	0.03	0.03	4.88	2.74	0.31	0.53	0.69
4.16kV Switch Gear	1.60	0.03	0.03	1.49	1.33	0.33	0.29	0.48
공조 Unit (fan, filter unit)	1.79	0.03	0.03	1.67	1.71**	0.33	0.30	0.60
Offsite Power	-	-	-	-	0.30	0.22	0.20	0.15

2.2 Seismic Hazard

The research on the reduction of uncertainty in probabilistic seismic hazard assessment (PSHA) procedure was performed by KAERI [1]. They proposed an optimal Gutenberg-Richter b value by using the expert panel assessment. Fig. 1 shows the refined seismic hazard curves of the target plant site. Upper blue line depicts the conventional seismic hazard curve while the lower line represented the refined curve proposed by KAERI. By using this PSHA results, we also re-assessed the probabilistic seismic risk of the target plant.

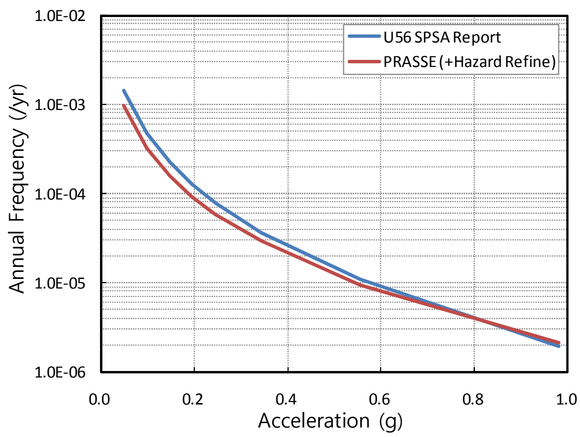

Fig. 1. Seismic hazard curves: conventional vs. refined.

2.3 Seismic Risk Quantification

KAERI also developed the improved seismic risk quantification software for SPSA, PRASSE [5]. The benefits of using that software are well described in the reference [5]. With that PRASSE code and the previously described refined seismic fragility & hazard results, we quantified the seismic risk of the target plant. Fig. 2 shows the tendency of core damage frequency (CDF) for conventional vs. refined results. The detailed values for each initiating event frequency (IEF) and CDF of the target reference plant are depicted in Table II.

From the results, we can find that the total CDF increased significantly by applying the improved SPSA code, PRASSE. It can be inferred that this increase is caused by the under-estimated results of the conventional SPSA code. In Fig. 1, it can be also founded that the most critical IE is changed from loss of essential power (LEP) to loss of core coolant water (LOCCW). In the viewpoint of the adoption of refined seismic hazard, the CDF reduced about 20% (from 1.04E-5 to 8.10E-6). On the other hand, additionally, the CDF decreased about 10% (from 8.10E-6 to 7.19E-6) by implementation the refined seismic fragility data for target plant. Finally, we can conclude that the seismic uncertainty reduction research of KAERI is reduced the CDF result of reference plant about 30%.

Table II: Initiating event frequencies (IEF) and core damage frequencies (CDF) of the target reference plant: conventional results vs. refined results

	U56 SPSA Report		PRASSE (+Fragility Refine)	
	IEF	CDF	IEF	CDF
LEP	2.64E-06	2.64E-06	1.33E-06	1.33E-06
LHR	4.80E-07	4.80E-07	1.01E-06	1.01E-06
LOCCW	1.64E-06	1.64E-06	3.07E-06	3.07E-06
SLOCA	2.74E-08	2.74E-08	1.45E-07	1.45E-07
LOOP	4.95E-05	6.12E-07	4.09E-05	5.06E-07
GTRN	6.54E-04	8.16E-07	9.08E-04	1.13E-06
Total		**6.22E-06**		**7.19E-06**

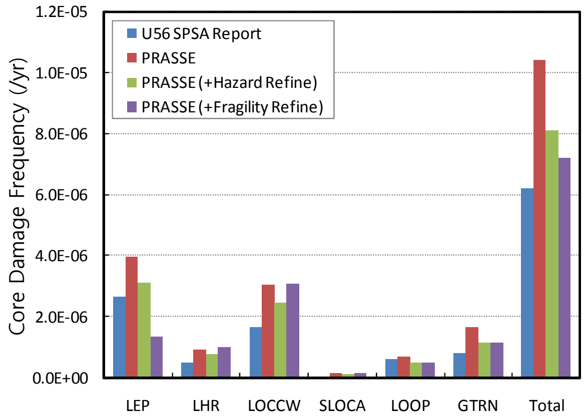

Fig. 2. Core damage frequencies (CDF) induced by each IE for target reference plant.

3. Conclusions

To reduce the uncertainties in the SPSA approach, many research activities were performed by KAERI during the last 5-years. We applied the results of that research into the SPSA procedure of the target reference plant, i.e., Ulchin unit 5/6 NPP. The implemented topics of the SPSA procedure are the seismic fragility, the seismic hazard, and the risk quantification. The CDF of target plant reduced about 20% and 10% by the refined seismic hazard data and fragility data, respectively. It can be concluded that the seismic uncertainty reduction research of KAERI will reduce the CDF result of NPP significantly.

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