Preliminary Tsunami Hazard Analysis for the Uljin NPP Site using Tsunami Propagation Analysis Results

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1. Introduction

The necessity of study on the tsunami hazard assessment for Nuclear Power Plant (NPP) site was emphasized since the event of Fukushima in 2011 had been occurred. The tsunami hazard analysis is based on the seismic hazard analysis method. The seismic hazard analysis had been performed by using the deterministic or probabilistic method. Recently, the probabilistic method has been received more attention than the deterministic method because the probabilistic approach can be considered well uncertainties of hazard analysis. Therefore the studies on the probabilistic tsunami hazard analysis (PTHA) have been performed in this study. This study was focused on the wave propagation analysis which was the most different thing between seismic hazard analysis and tsunami hazard analysis. The wave parameters were calculated from the results of tsunami simulations by using the fault sources which were suggested by atomic energy society of Japan (AESJ). In this study, the preliminary PTHA was applied for Uljin NPP site.

2. Methods

The PTHA is based on the logic-tree approach that was used in the probabilistic seismic hazard analysis (PSHA). The logic-tree approach is an excellent method for the consideration of uncertainties in the PTHA. There are two kinds of uncertainties in PSHA. One is the aleatory uncertainty caused by the random nature of earthquake occurrence and its effect. Another one is the epistemic uncertainty caused by incomplete knowledge and data about the earthquake process. Uncertainties in various model parameters and alternatives about PTHA model treated as the epistemic uncertainty. A hazard curve is estimated from integration over the aleatory uncertainties. A number of hazard curves are estimated from different branches of logic-trees representing the epistemic uncertainties. Fig. 1 shows an outline of logic-tree approach used in this study [1].

Tsunami hazard would be calculated by combining the tsunami source model and the tsunami height estimation. For evaluating the tsunami hazard, the annual frequency λ of tsunami height exceeding h is written as eq (1).

$$\lambda = \sum_{k=1}^{n} \nu_k P_k \;\; [\, H \geq h \mid \text{one tsunami}] \qquad (1)$$

where ν_k is the annual frequency of tsunami estimated from the mean recurrence interval in zone k and P_k [$H \geq h$ | one tsunami] is the probability of exceedance for one tsunami in zone k .

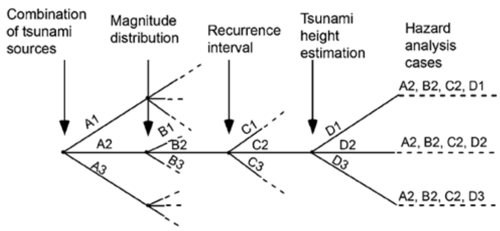

Fig. 1. Outline of a logic-tree approach used for the tsunami hazard analysis [1]

3. Input Parameters for Tsunami Propagation Analysis

3.1 Fault Model

The NPP sites in the Korea are mostly located at the east coast of Korean Peninsula. For the analysis of the PTHA for the NPP sites, it should be considered the seismic source in the East Sea and the western part of Japan. In this study, the fault sources in the western part of Japan were selected for the PTHA since the information on the source of the East Sea is insufficient to analyze the tsunami hazard. The locations of the fault sources are shown in Fig. 2.

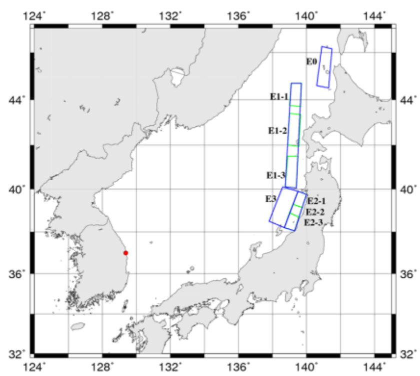

Fig. 2. The location of the fault sources for tsunami hazard analysis and target NPP site

For the tsunami propagation analysis the information of the fault sources in the western part of Japan which were suggested by Atomic Energy Society of Japan (AESJ) [2], were used. The potential maximum moment magnitude M_w and recurrence interval ν for the each fault sources were summarized in Table I.

Table I: The magnitude and recurrence interval of the fault sources in the western part of Japan

source	M_W	ν (yr)
E0	7.8	1300 / 3000 / 8500
E1-1	7.5	1400 / 3900
E1-2	7.8	500 / 1400
E1-3	7.7	500 / 1400
E2-1	7.5	1000 / 1500
E2-2	7.7	1000 / 1500
E2-3	7.5	1000 / 1500
E3	7.8	500 / 1000

A tsunami source model for the PTHA has been regarded as the composite model in Fig. 3 which was combined the truncated exponential and characteristic model [4]. Magnitudes are exponentially distributed up to the magnitude m'. The characteristic earthquake is uniformly distributed in the magnitude range from $m^u - \Delta m_c$ to m^u. For consider these characteristics, the magnitudes of fault sources were applied the range of magnitude. Therefore the tsunami simulations were performed by using the fault parameters which were estimated from the range of magnitude. And a tsunami hazard was calculated by using the wave parameters which was estimated from the tsunami simulations. In this study, the ranges of magnitude are assumed the range of maximum magnitude-0.2 to maximum magnitude+0.2.

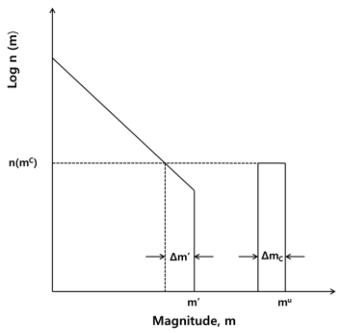

Fig. 3. Generalized frequency magnitude density function for the characteristic earthquake model [4]

3.2 Tsunami Propagation Analysis

For the estimate a tsunami height as the input parameters for tsunami hazard analysis, the tsunami propagation analysis was performed by using the TSUNAMI_ver1.0 which was developed by Japan Nuclear Energy Safety Organization (JNES) [3]. For the tsunami propagation analysis, the fault parameters had been estimated from the maximum magnitude by applying the scaling law [2]. The fault parameters which were used to the simulation, were defined in Fig. 4. And parameters which were calculated from each magnitude were organized in Table II.

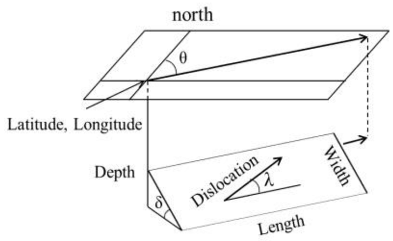

Fig. 4. Definition of fault parameters [5]

Table II: Fault parameters

M_W	Length (km)	Width (km)	Dislocation (m)	
			30°	60°
7.3	50.7	2.1	30	17.3
7.4	60.3	2.5	30	17.3
7.5	71.6	3.0	30	17.3
7.6	85.1	3.5	30	17.3
7.7	101.2	4.2	30	17.3
7.8	120.2	5.0	30	17.3
7.9	142.9	5.9	30	17.3
8.0	169.8	7.1	30	17.3

The 80 tsunami propagation analyses which were consist of the 8 fault sources, the 2 dips (30°, 60°), and the range of maximum magnitude±0.2, were performed for the Uljin NPP site [5]. The variation of wave height by the E3 (J_80) fault source shows the largest value than the variations of wave height by other fault sources. It made clear that the maximum potential magnitude and location are most important factor to the wave height.

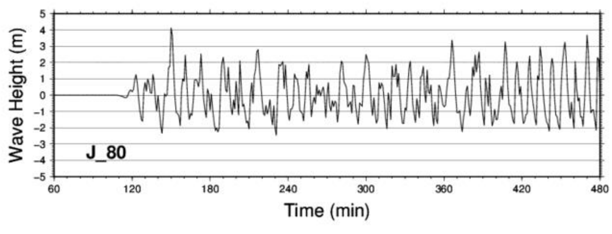

Fig. 5. The time histogram of the E3 fault source [5]

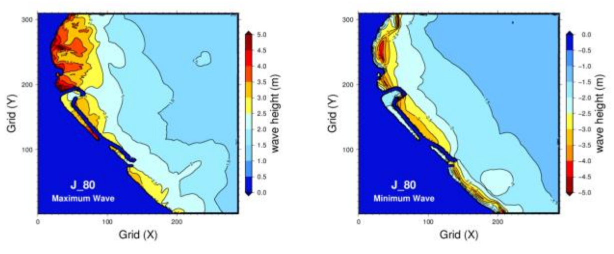

Fig. 6. The maximum and minimum wave height distribution of the E3 fault source [5]

Fig. 5 shows the time histogram of wave propagation on the E3 fault source. And the maximum and minimum wave height distributions of the E3 fault source are illustrated in Fig. 6.

4. Tsunami Hazard Assessment

After performing the tsunami propagation analysis, the results had been suggested as spatial distributions like Fig. 6. There is strong dependence on the sampling point since the wave parameters are estimated from these spatial distributions. The wave parameters were estimated from the groups of sampling points to reduce the sensitivity on the sampling point in this study. Fig. 7 shows the groups of sampling points and each sampling point.

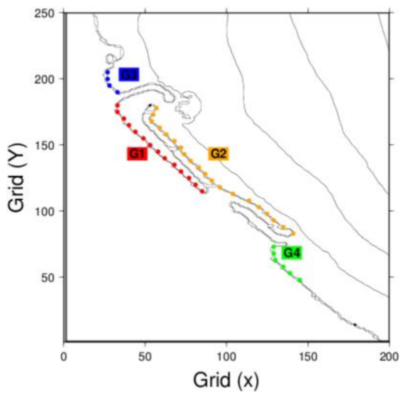

Fig. 7. The group of wave height sampling points (G1:front of intake, G2:front of breakwater, G3:left side of breakwater, G4:right side of breakwater) [5]

In the previous study [5], the wave parameters on these sampling groups were estimated. The probability density function on the tsunami height was computed by using the recurrence intervals and the wave parameters. And then the exceedance probability distribution was calculated from the probability density function. This process is illustrated in Fig. 8.

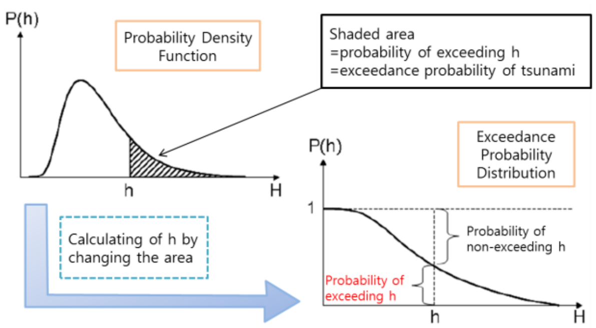

Fig. 8. Concept of exceedance probability distribution [2]

The tsunami hazards for the sampling groups were calculated. The fractile curves which were shown the uncertainties of input parameters were estimated from the hazards by using the round-robin algorithm. Fig. 9 shows the tsunami hazard and their fractile curves for the front of intake (G1). In general, tsunami hazard analysis is focused on the maximum wave heights. But the minimum wave height should be considered for the tsunami hazard analysis on the NPP site since it is connected with water intake system. The results of tsunami hazard analysis for the NPP site was suggested by the annual exceedance probability with the wave heights. The solid lines of the right side of Fig. 9 are showing the hazard of the runup heights, and the dashed lines of the left side of Fig. 9 are showing the hazard of the drawdown. The numerical results does not expressed on Fig. 9. This preliminary study was performed to research the possibility of application on the PTHA method for NPP site. Therefor the numerical results have not much significant implications.

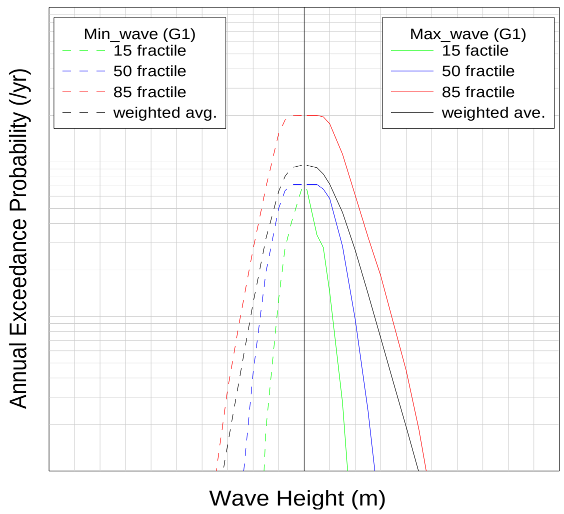

Fig. 9. The tsunami hazard for Uljin NPP site

5. Summary

The tsunami hazard analysis for the Uljin NPP site was performed. For the analysis, the method and source information which were suggested by AESJ were used. And the tsunami propagation analyses were performed by using the TSUANMI_ver1.o which was developed by JNES. The tsunami hazard for Uljin NPP site was calculated from the exceedance probability distribution with the wave heights. This study shows that the PTHA method could be applied for NPP sites.

Acknowledgment

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