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Comparison of the Results between Empirical and Numerical Tsunami Hazard Assessment for the East Coast of Korea

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1. Introduction

Tsunami risk assessment for a nuclear power plants became one of the major issue after the 2011 Fukushima NPP accident. For the performance of tsunami risk assessment, tsunami hazard analysis, tsunami fragility analysis and tsunami system analysis should be performed. In this study tsunami hazard assessment was performed for one of nuclear power plants in the east coast of Korean peninsula. Kim et al. [1,2] already performed tsunami hazard analysis using empirical method. Also, some of numerical research results about tsunami hazard were already shown by Rhee et al. [3]. In this study, all of previous tsunami hazard assessment results were summarized and compared.

2. Tsunami Hazard Assessment using an Empirical Method

Kim et al. [1,2] were already shown the results about tsunami hazard assessment using empirical method. For the development of tsunami hazard assessment, Kim et al develop a tsunami catalogue for the east coast of Korean peninsula by referred historical and instrumental tsunami record. After that various kinds of regression methods were applied to develop a tsunami hazard assessment. Finally exponential function was applied to tsunami hazard assessment and the final results of tsunami hazard are shown in Figure 1.

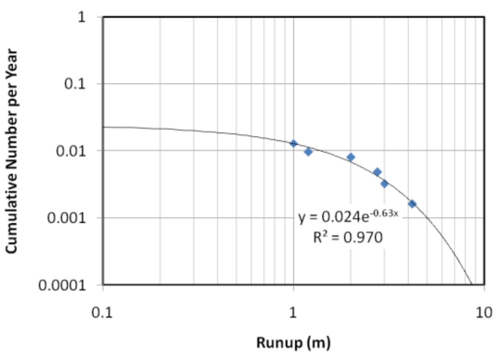

Figure 1. Tsunamis return period evaluation using an empirical method

3. Tsunami Hazard Assessment using a Numerical Method

3.1 Methodology for Probabilistic Tsunami Hazard Analysis

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. 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. 2 shows an outline of logic-tree approach used in this study [4].

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).

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

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.

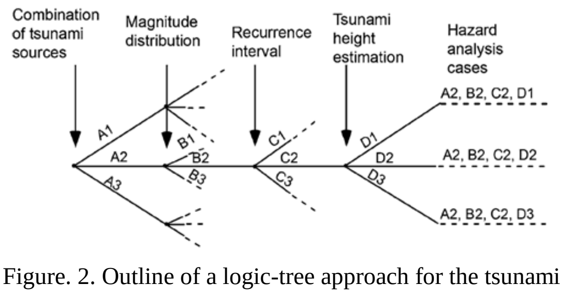

Figure. 2. Outline of a logic-tree approach for the tsunami hazard analysis [4]

For the analysis of the PTHA for the Korean 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. 3.

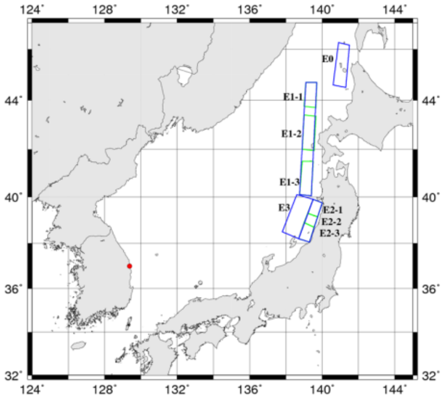

Figure 3. The location of the fault sources for tsunami hazard analysis and target NPP site

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) [5], were used.

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 [6]. 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.

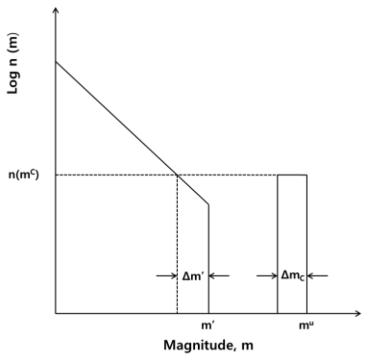

Fig. 3. Generalized frequency magnitude density function for the characteristic earthquake model [4]

3.2 Tsunami Propagation Analysis and Hazard Assessment

For the estimate a tsunami height as the input parameters for the tsunami hazard analysis, the tsunami propagation analysis was performed using the TSUNAMI_ver1.0 which was developed by Japan Nuclear Energy Safety Organization (JNES) [6] and COMCOT developed by the Cornell University. For the tsunami propagation analysis, the fault parameters had been estimated from the maximum magnitude by applying the scaling law. The fault parameters which were used to the simulation were defined in Fig. 5.

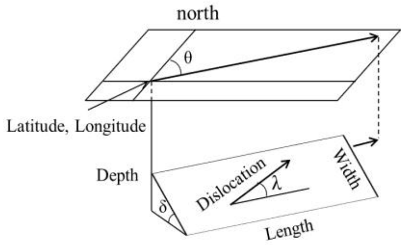

Figure 5. Definition of fault parameters [5]

For the verification of several numerical analyses, one of the previous tsunami simulations about Korea nuclear power plants were compared between the results of this study. The wave height time histories are shown in Figure 6. As shown in Figure 6, the maximum amplitudes were slightly different between the simulation method but all arrival times are similar.

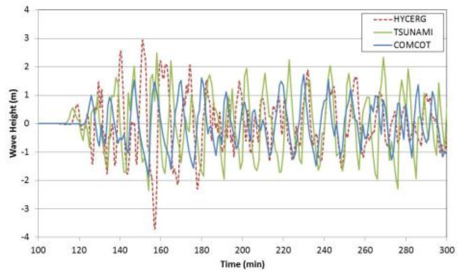

Figure 6. The verification results for tsunami simulation using TSUNAMI, COMCOT and HYCERG

3.3 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.

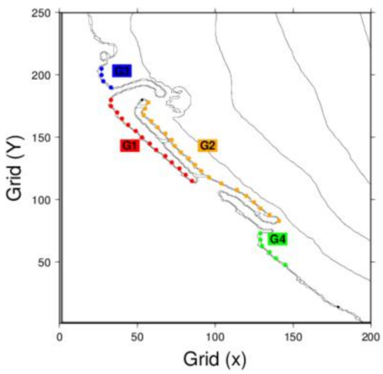

Fig. 7. The group of wave height sampling points (G1:front of intake, G2:front of breakwater, G3:left side of breakwater, G4:right side of breakwater) [7]

In the previous study [4], 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.

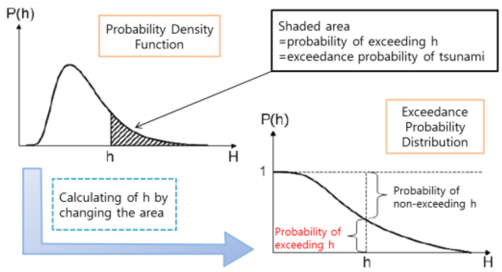

Figure 8. Concept of exceedance probability distribution [5]

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).

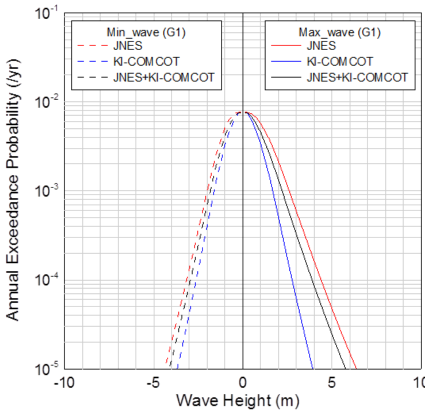

Figure 9. The tsunami hazard for Uljin NPP site

Finally, all tsunami hazard analysis results using the empirical and numerical method are shown in Figure 10. As shown in Figure 10, the results of empirical method were overestimated about tsunami hazard. The reasons are as below; first, when the tsunami hazard assessment using empirical method, all the east coast areas were considered as one region. That because the lack of information in historical records. It was very difficult to figure out a specific location of tsunami occurrence area only using the historical record. Second, a similar reason as the first reason, in the case of historical record, estimation of tsunami wave height was really difficult. Nevertheless, the tendency of tsunami hazard results was similar between all empirical and numerical assessment results. For more accurate tsunami hazard results, various kinds of study are needed.

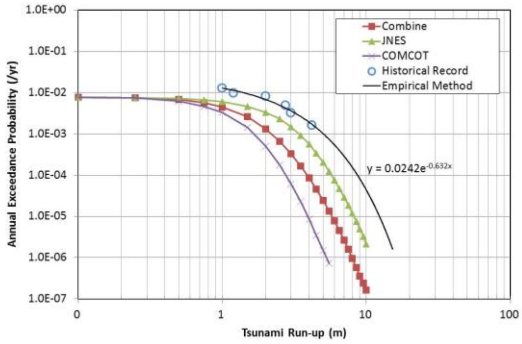

Figure 10. The comparison of the tsunami hazard results using empirical and numerical method

5. Summary

In this study, tsunami hazard assessments were performed using empirical and numerical method. For the performing numerical tsunami simulation, the TSUNAMI code and COMCOT were used. All tsunami hazard results were compared.

Acknowledgment

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