Tsunami Hazard Evaluation for the East Coast of Korea by using Empirical Data

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1. Introduction

In this study, a tsunami hazard curve was determined for a probabilistic safety assessment (PSA) induced tsunami event in Nuclear Power Plant site. A Tsunami catalogue was developed by using historical tsunami record which happen before 1900 and instrumental tsunami record after 1900. For the evaluation of return period of tsunami run-up height, power-law, upper-truncated power law and exponential function were considered for the assessment of regression curves and compared with each result. Although the total tsunami records were only 9 times at the east coast of Korea during tsunami catalogue, there was no such research like this about tsunami hazard curve evaluation and this research lay a cornerstone for probabilistic tsunami hazard assessment (PTHA) in Korea.

2. Tsunami Return Period Assessment Methods

For the evaluation of tsunami hazard curves for east coast of Korea, tsunami propagation analysis should be performed from seismic source. But tsunami propagation analysis needs many efforts and has many uncertainties because of the lack of seismic source information. Therefore, in this study an empirical method was applied for an evaluation of tsunami hazard curve. For the regression for return period of tsunami in east coast of Korea, power law, upper-truncated power law and exponential function were considered but finally power law and general exponential function were used. The equations for power law and upper-truncated power law are shown in equation (1) and (2), respectively.

$$\dot{N}(r) = Cr^{-\alpha} \quad (1)$$

$$\dot{N}_T(r) = C(r^{-\alpha} - r_T^{-\alpha}) \quad (2)$$

3. Tsunami Catalogue

For the development of tsunami catalogue, instrumental records after 1900 were considered. After 1940, there were 4 times that a tsunami occurred on the east coast of Korea. The most vulnerable tsunami event happened in 1983. In 1983, the Akita earthquake happened on in the west side of Japan. In this time a maximum wave height was recorded of about 4.2m at the Imwon harbor. One person was dead and 2 persons were missing. Hundreds of boats and houses were destroyed and damaged. All tsunami events after 1900 were summarized including the 1983 event in Table 1.

Table 1. Tsunami events at the east coast of Korea after 1900

	Magnitude	Max. Wave Run up
1940. 8. 2.	7.0	Mukho: 1.2m
		Najin: 0.5m
1964. 6. 16.	7.5	Busan: 0.32m
		Ulsan: 0.39m
1983. 5. 26.	7.7	Sokcho: 1.56m
		Mukho: 3.9m
		Imwon: 4.2m
1993. 7. 12	7.8	Sokcho: 2.76m
		Mukho: 2.03m
		Pohang: 0.93m

For the assessment of tsunami events before 1900, the historical records were determined. "The annals of the Chosun dynasty" referred to the evaluation of the tsunami catalogue. Through the historical records assessment, 5 tsunami events in the east coast of Korea were found. All tsunami records in the 'The annals of the chosun dynasty' were summarized in Table 2.

Table 2. Tsunami events at the east coast of Korea before 1900

Date	Location
1643.6. 21.	Ulsan
1668. 7. 25	Cheolsan
1681. 6. 24	Yangyang
1702. 11. 28.	Gangwondo
1741. 7. 19	East coast

Finally, the tsunami catalogue was developed using a combination of historical and instrumental record as shown in Figure 1. This catalogue covers from 1392 to 2009, during 618 years. But as shown in figure 1, it can be recognized that tsunami events were recorded only in a limited period. From the 1392 to 1642 and from the 1741 to 1939, there were no tsunami event occurred. Although only 70 years from 1940 to 2009, there were 4 times tsunamis occurred. This unequal occurrence of tsunami event indicated that this tsunami catalogue has many uncertainties.

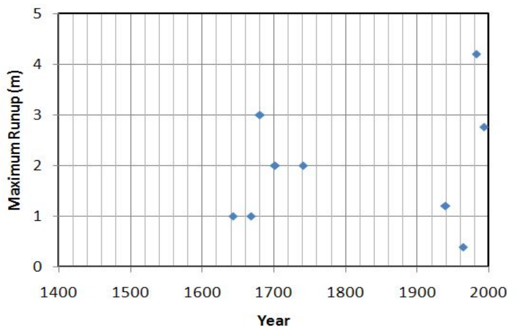
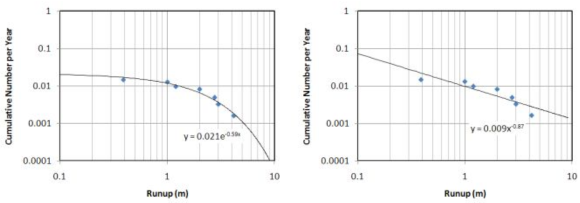


Figure 1. A tsunami catalogue of the east coast of Korea

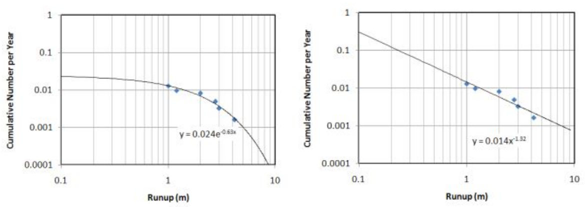
4. Tsunami Hazard Curve

The return period of tsunami events was determined using a power law and exponential function as shown in Figure 2. As shown in Figure 2, an exponential function matches the tsunami return period better and more over the power law makes a tsunami return period overestimated. The exponential function was more appropriate for the estimation of tsunami return period.



(a) Exponential function (b) Power law
Figure 2. Tsunamis return period evaluation by using empirical method

However, as shown in the figure 1, there was only one tsunami event where maximum wave height was below 1 meter. That because a small tsunami event couldn't be recorded by a writer of historical record. The small event of a small tsunami makes the tsunami return period become overestimated. For the decreasing of uncertainty of tsunami return period, a 1940 tsunami event where maximum wave height was recorded as 0.39m was deleted. Through this method, the tsunami return period was re-evaluated as shown in Figure 3. As shown in figure 3, the tsunami return period was decreased compared to the figure 2.



(a) Exponential function (b) Power law
Figure 3. Tsunamis return period evaluation by using empirical method in the case of exclude on 0.39m event

Finally, the tsunami return periods were summarized according to the 0.39m tsunami event in Table 3. As shown in Table 3, the return period of tsunami run up events were slightly changed according to the 0.39m tsunami event. In the case of the 10m maximum run up height caused by the tsunami event, a return period was 17383 year and 22690 year, respectively. The meaning of 10m maximum run up height is the ground level of Ulchin NPP site.

Table 3. The return period of maximum run up height caused by tsunami event in the east coast of Korea

	Include 0.39m		Exclude 0.39m	
Max Runup	Prob.	Return Period	Prob.	Return Period
1	1.16E-02	86	1.28E-02	78
5	1.10E-03	910	1.03E-03	972
10	5.75E-05	17383	4.41E-05	22690
15	3.01E-06	332114	1.89E-06	529507

5. Conclusions

In this study, a tsunami hazard curve was determined for a probabilistic safety assessment (PSA) induced tsunami event in Nuclear Power Plant site. A Tsunami catalogue was developed by using a previous tsunami records. For the evaluation of the return period of tsunami run-up height, power-law and exponential function were considered. Through this study, a return period of maximum tsunami run up was evaluated but tsunami propagation simulation will be needed for a more accurate determination.

ACKNOWLEDGEMENT

This work was supported by Nuclear Research & Development Program of the National Research Foundation (NRF) grant funded by the Korean government (MEST).

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