Comparison of Tsunami Hazards between Japan and Korea

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1. Introduction

On March 11th, 2011, a tremendous earthquake and tsunami occurred on the east coast of Japan. This 9.0 magnitude earthquake was the fifth greatest earthquake ever experienced on the planet. The most remarkable problem was that the Fukishima NPP sites, including their cores, were damaged. The term 'core damage' can be found in safety reports or textbooks on nuclear engineering. Therefore, in this study, a tsunami hazard assessment was performed for Korean NPP sites and was compared to a Japanese tsunami hazard assessment based on a previous tsunami PSA study.

2. Tsunami Hazard Estimation of Japan

Japan has frequently experienced very significant earthquakes and tsunamis. Figure 1 shows the previous maximum tsunami wave height in Japan. As shown in the figure, Japan has already experienced a greater than 15m tsunami. The maximum wave height of the Fukushima NPP site was determined to be below 5m. However, the maximum tsunami wave height of the last earthquake was almost more than 10m, as shown in Figure 2.

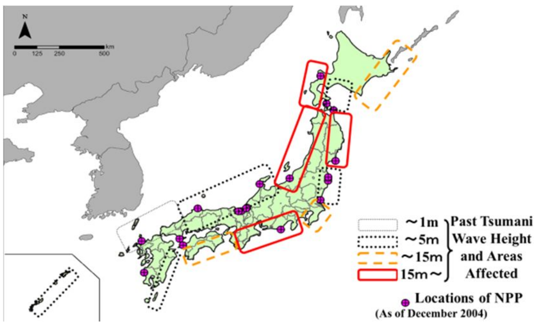

Figure 1. Maximum tsunami wave height in Japan (Mori, 2005)

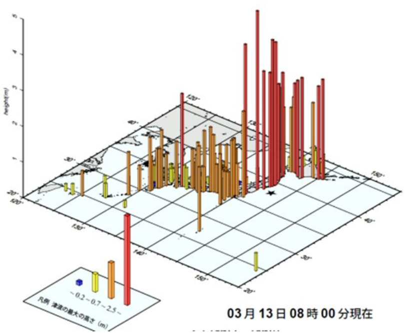

Figure 2. Observed maximum tsunami wave height of the recent Japanese earthquake

Burroughs and Tebbens (2005) evaluated tsunami run up heights for several Japanese cities located on the east coast of Japan based on a power-law scaling method. Figure 3 shows the maximum tsunami wave heights of major Japanese cities and the east coast of Korea. As shown in Figure 3, the return period of the maximum tsunami wave heights of Japan are much higher than those of Korea.

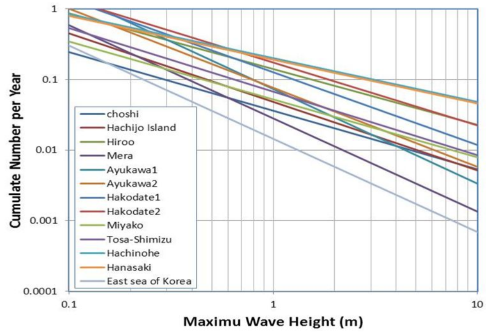

Figure 3. Maximum tsunami wave heights of major Japanese cities and the east coast of Korea (Burroughs and Tebbens, 2005)

Figure 4 shows a tsunami catalogue of Ayukawa, Japan, which is located near the Fukushima NPP area, and Figure 5 shows the tsunami return period in which the regression was performed by the power law. As shown in Figures 4 and 5, the tsunami return periods were not too different according to the selection of the target period.

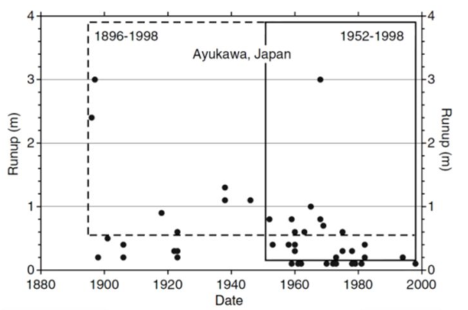

Figure 4. Tsunami run up heights reported for Ayukawa, Japan (Burroughs and Tebbens, 2005)

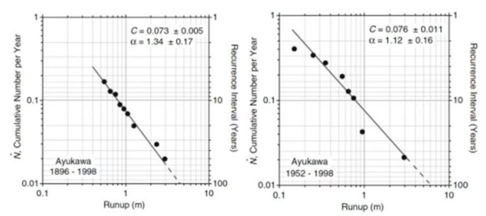

Figure 5. Cumulative frequency-sized distribution (Burroughs and Tebbens, 2005)

3. Tsunami Hazard Estimation in Korea

Kim and Choi (2010) already performed a tsunami hazard analysis by using an exponential function and power law. In this study, the tsunami return period was re-evaluated based on the power law. First, the tsunami height return period of Ayukawa and the east coast of Korea are compared in Figure 6 and Table 1. As shown, the return period for the same sized tsunami wave height in Ayukawa is almost 10-times larger than that of Korea.

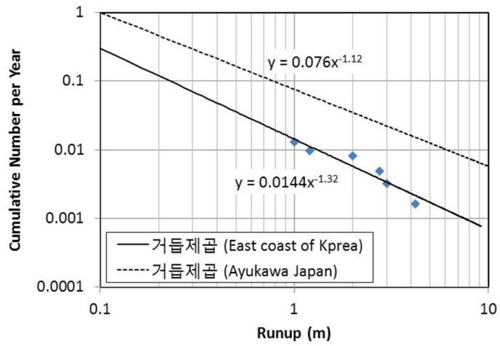

Figure 6. Return period based on tsunami height at Ayukawa and the east coast of Korea

Table 1 Return period based on tsunami height at Ayukawa and the east coast of Korea

	Probability per year		Return Period	
	Korea	Ayukawa	Korea	Ayukawa
1	0.01440	0.07600	69	13
5	0.00172	0.01253	581	80
10	0.00069	0.00577	1451	173
15	0.00040	0.00366	2478	273

For further comparison of tsunami wave height according to the regression method, the tsunami hazard curve determined by a type II distribution of the extreme value and upper bound to acceleration postulated method. These two methods are shown in equations (1) and (2), respectively (Ellingwood, 1990).

$$G(a) = 1 - \exp\left[-\left(\frac{a}{u}\right)^{-\alpha}\right] \qquad (1)$$

$$G(a) = 1 - \exp\left[-\left(\frac{\omega - a}{ua}\right)^{\alpha}\right], a \le \omega,\ u, a > 0 \qquad (2)$$

where, u,α and ω are the scale and shape parameters and the upper bound value, respectively. Using equations (1) and (2), the tsunami wave height was re-evaluated as shown in Figure 7 according to the regression method. The annual frequencies based on tsunami wave height are summarized in Table 2. As shown, these frequencies are similar until 5m, but are very different over 5m, according to the regression method.

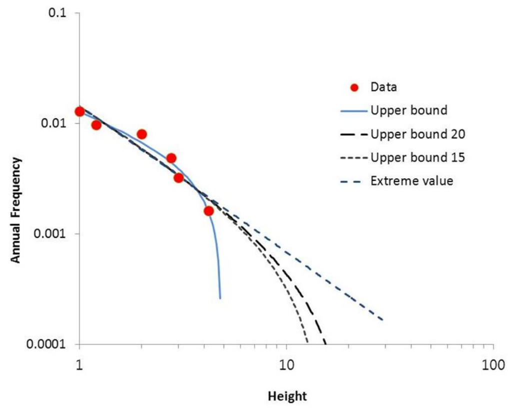

Figure 7. Tsunami wave height

Table 2 Annual frequencies based on tsunami wave height for Korea according to a regression method

	upper bound	upper bound 20	upper bound 15	Extreme value
1	0.01271	0.01424	0.01420	0.01438
5	-	0.00159	0.00154	0.00171
10	-	0.00043	0.00031	0.00068
15	-	0.00011	0	0.00040

4. Conclusions

In this study, the return periods based on the maximum wave height of a tsunami are compared between Japan and Korea. Through this study, it can be seen that the Japanese return period of a tsunami hazard is much higher than that of Korea. A tsunami hazard analysis using various regression methods for the east coast of Korea was also performed in this study. As a result, the probability of a tsunami hazard in Korea is much lower than that of Japan, but a more precise study will be needed for a more accurate determination.

ACKNOWLEDGEMENT

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