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Sensitivity Analysis Maximum Height of Tsunami at the Uljin Nuclear Power Plant, South Korea

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Abstract

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Keyword: COMCOT; tsunami; logic tree; sensitivity analysis; Uljin nuclear power plant (UNPP);

1. Introduction

Japan is thought to suffer to have suffered economic loss estimated to be in the amount of between 230 trillion KRW to 360 trillion KRW from the Fukushima Earthquake and tsunami which struck on March 11, 2011. Japan also suffered enormous economic losses at the hand of a tsunami originating from the ocean floor near Sumatra Island in the Indian Ocean on December 26, 2004. Both earthquakes made nuclear power plants suffer from flooding causing enormous economic and environmental damage. The tsunami created initial damage at first and then secondary damage by destroying the nuclear power plant. The destruction of the nuclear power plant from the secondary damage increased the economic and environmental loss exponentially at the place of occurrence as well as in the world.

Korea is protected from damage caused by tsunamis given its location, but the east coast had sustained damage caused by tsunami several times, for instance, the Akita tsunami in 1983 and the Okushiri tsunami in 1993. Imwon Port on the east coast suffered from a tsunami hit to record the highest wave height of 3 to 4 meters according to observation records and the waves arrived at the coast about 100 minutes after tsunami (Choi et al., 2003; Choi et al., 2006; Lee and Lee, 2002)

Likewise, coastal area of East Sea is likely to suffer from damage from tsunamis. Tsunamis that could potentially strike the east coast where several nuclear power plants are located should be researched from the east coast of Korea as well as western coast of Japan.

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2. Numerical model

2.1. Model description

COMCOT (Cornell Multi-grid Coupled Tsunami Model) can be applied a spherical coordinate system and a Cartesian coordinate system. Also linear and non-linear can be selected by the governing equation. This study selected the governing equation according to domain by using the Cartesian coordinate.

2.2. Model domain

The Uljin nuclear power plant (UNPP) located coast of East sea. UNPP is to present in front of the seawall, it showed Fig. 1, the plant's location and topography.



Fig. 1. Site of Uljin Nuclear Power Plant

Mother domain (Fig. 2) was set to simulate a tsunami in western Japan and to include all of the East Sea. Nesting from the mother domain was used to make a grid and to make details of No.5 and to research using 6 domains. The most detailed domain is nest5 in front of the UNPP was used to estimate 14-meter height seawall accurately.

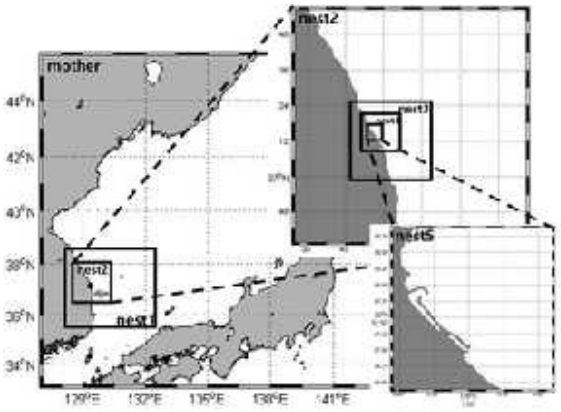


Fig. 2. Model Domain system

We have developed a program that uses the Nesting grid system, was performed domain and has been simulated tsunami, information each of which are shown in table 1.

Table 1: Domain and grid information

Domain	Shallow water eq.	Grid number / Grid size
Mother	Linear	484 x 381 / 3000m
Nest1	Linear	321 x 333 / 1110m
Nest2	Linear	414 x 357 / 370m
Nest3	Linear	363 x 378 / 123.333m
Nest4	Non-linear	303 x 279 / 41.111m
Nest5	Non-linear	282 x 303 / 13.7m

2.3. Initial condition

The findings of the tsunami model relied upon the reproduction of the initial condition. The initial condition made use of fault parameters, for instance, Okada's rule (Toshimitsu, 1985) and the Manshina & Smyile rule. The COMCOT, module that making initial condition is existed. But, in order to obtain more accurate results, which is using Okada's rule program for making initial condition was developed.

Fault parameters for tsunami wave simulation include fault latitude, longitude, depth (km), strike (θ°), inclination (δ°), angle of side slip (λ°), length of fault rupture (km), width of fault rupture (km), and dislocation of fault rupture (m) (Fig. 2). Strike (θ°) includes direction of fault in horizontal angle with both true north and the fault side, and inclination (δ°) indicating an inclination of fault perpendicular to the surface of the earth. The angle of the side slip (λ°) indicates the direction of movement between the top and bottom of the fault to measure in an anti-clockwise direction of the strike (Fig. 3).

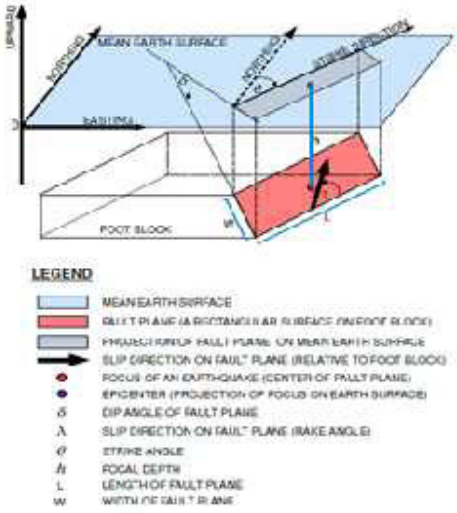


Fig. 3. Definition of fault parameters

2.4. Propagation test

1983 Akita tsunami was used to conduct model tests. 0m shows the initial condition of the Akita tsunami to research using the COMCOT model with FFI. As shown in the diagram, waves propagate at an interval of about 40 minutes. The wave was found to reach the east coast of Korea at 120min (Fig. 4).

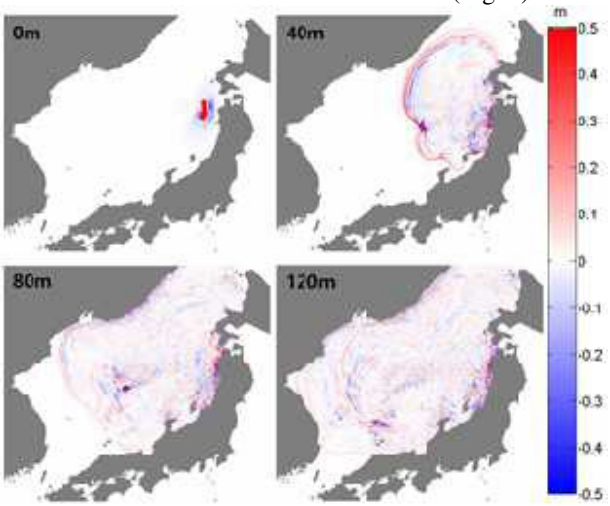


Fig. 4. 1983 Akita tsunami propagation

The 1983 Akita tsunami was used to conduct model tests and the nest 5 of the smallest area propagates wave in the seawall. Wave propagates from entrance to inner area of the seawall (Fig. 5).

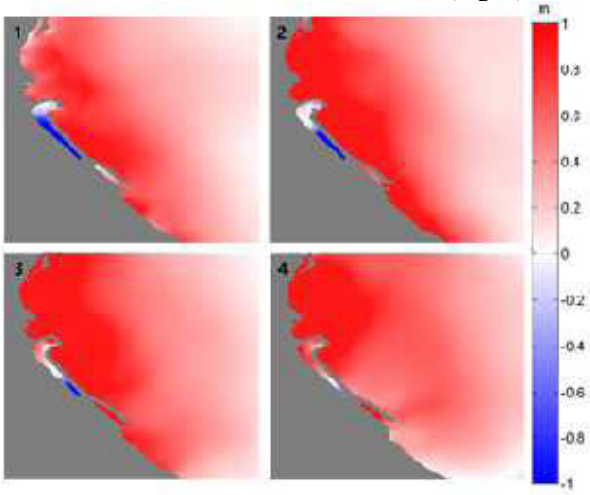


Fig. 5. Wave propagates in the seawall (40-second interval)

2.5. Logic tree

The logic tree of tsunami parameters were used considering size, place, time and the effects of a possible earthquake. The logic tree that can lower the cognitive uncertainty at a shortage of information may reflect the weight of variables of plenty of tsunami models (Eric L. GEIST and Tom Parsons, 2006, Rhee at al., 2014).

The information of the Society of Nuclear Energy of Japan was used to simulate the tsunami of fault earthquake source to give the largest moment scale (MW) based on scales of existing faults. Each seismic source the moment, for instance, E0 (M 7.8), E1-1 (M7.5), E1-2 (M 7.8), E1-3 (M 7.7), E2-1 (M 7.5), E2-2 (M 7.7), E2-3 (M7.5) and E3 (M 7.8) with a range of 7.5 – 7.8: This study selected 80 kinds of cases with range of 0.2.

The strike in the direction of width of fault varied depending upon place of tsunami, and same fault had the same strike place. For example, E1-1, E1-2 and E1-3 had same strike, and E2-1, E2-2, E2-3 and E3 had the same strike. (Fig. 6)

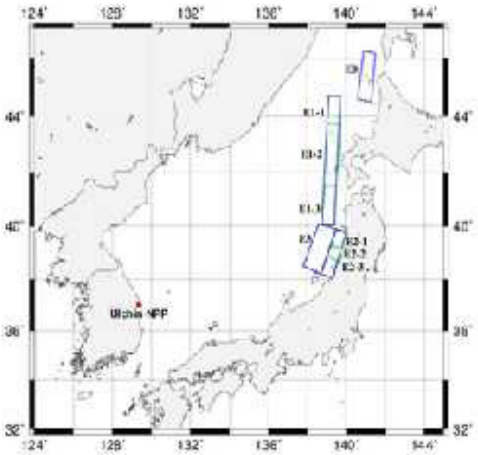


Fig. 6. Generation area of tsunami

3. Model result (sensitivity analysis)

The study investigated the mean of the three places around the seawall of the UNPP to estimate the maximum of the tsunami (Fig. 7).

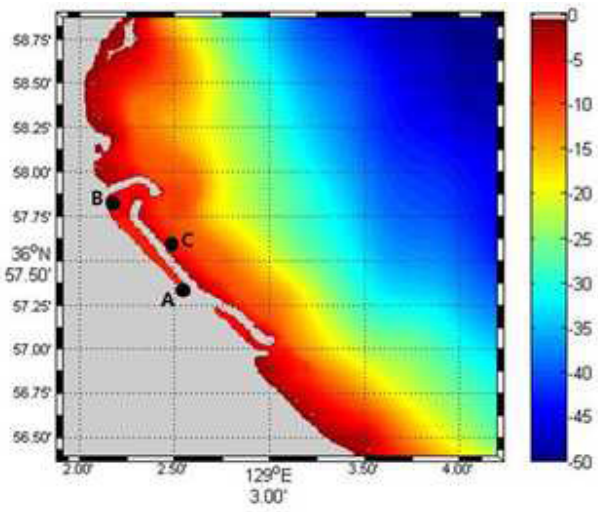


Fig. 7. Analyze mean maximum height of point at Uljin Nuclear power plant. (unit: m)

Fig. 8 shows a tsunami scale at each place divided into 1~5 case and 6~10 case, and the maximum wave height increased at a large scale regardless of the place of occurrence of the tsunami. The large scale at the same place increased to a maximum wave height around the nuclear power plant.

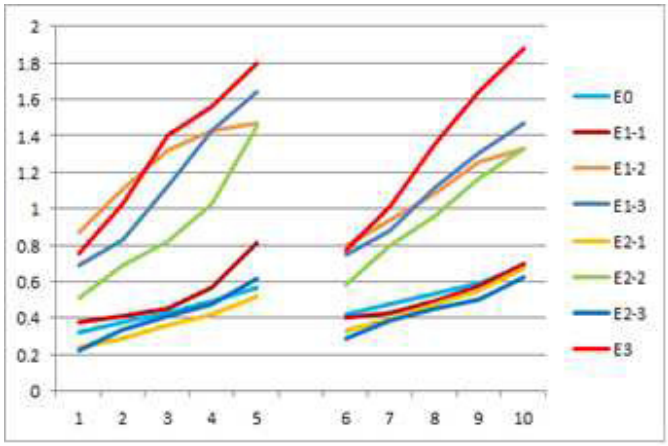


Fig. 8. Maximum height of occurrence point. (unit: m)

Fig. 9 show the maximum wave heights of the tsunami at both E0 and E3 depending upon the case were. With the same parameters, a smaller scale (7.6) was larger than that of the maximum wave height of tsunami at E0 at 0.4 meter by 1 meter. Maximum wave heights from earthquakes occurring around the nuclear power plant at the E3 area was likely to be the highest.

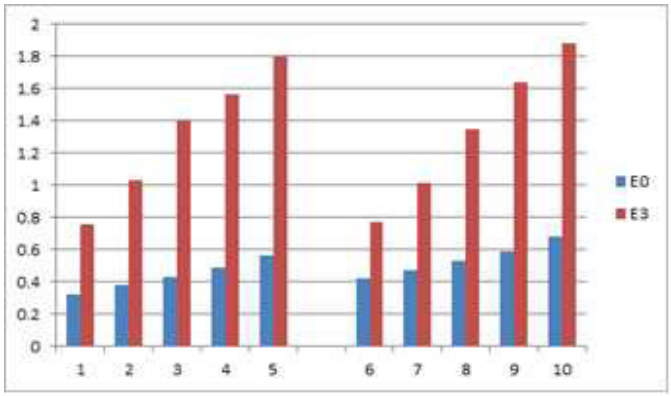


Fig. 9. Compare Point E0 and E3 maximum height. (unit: m)

With parameters of same scale (7.6 and 7.7), the maximum wave height of tsunamis at E1-2, E1-3 and E3 are likely to be larger than that of other areas. 7.6 and 7.7 of a simulation scale at all places of the logic tree were used to investigate maximum wave height (Figs. 10 and 11), and maximum wave height around the nuclear power plant at E1-1, E1-2 and E3 was likely to be large.

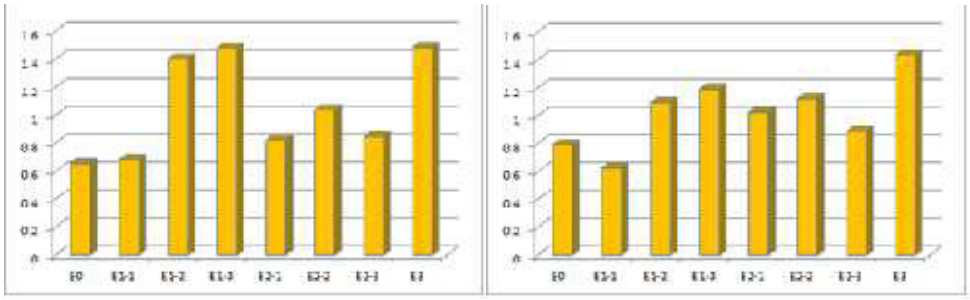


Fig. 10. Magnitude 7.6, according to point maximum height. Upside at dip 30, downside at dip 60. (unit: m)

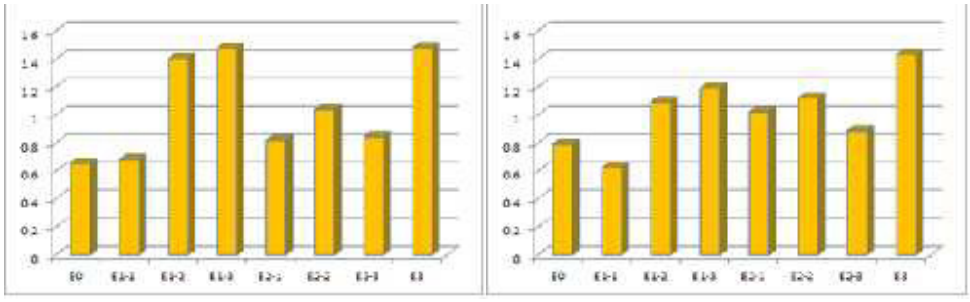


Fig. 11. Magnitude 7.7, according to point maximum height. Upside at dip30, downside at dip 60. (unit: m)

4. Conclusion

Simulated based on the logic tree the tsunami that might be using the COMCOT, occurring in the fault zone west of Japan. By simulating the total 80 case, to analyze the sensitivity depending on the fault parameter in the breakwater near the front of the UNPP. We applied initial condition program which is using Okada rule and performed our research by model composed of six domain. In the case of tsunami which can be generated by logic tree, 1. The larger earthquake magnitude scale at the same location, the higher maximum wave height which arrived at UNPP. 2. The case of E0 and E3 simulated by using the same parameter showed that E3's maximum wave height was twice as big as E0. 3. There was the largest maximum wave height in UNPP if tsunami is generated in E1-1, E1-2 and E1-3.

Acknowledgements

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