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A Sensitivity Analysis for Strike, Dip, and Rake of a Fault in a Tsunami Simulation

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1. Introduction

A major accident occurred at the Fukushima NPP site by a tsunami produced from the mega earthquake of east Japan in 2011. Damage by the exposure of radioactive material occurred, and the problem safe of nuclear power was raised. After the Fukushima accident occurred, a hazard analysis on a tsunami was needed. A tsunami hazard analysis was performed for an NPP site using a logic tree, which was used in the PSHA. The logic tree for the tsunami hazard analysis was a combination of tsunami source, magnitude distribution of a characteristic tsunamigenic earthquake, their recurrence interval, and a tsunami height estimation procedure based on a numerical simulation [1]. The most different thing in the logic tree used for the PSHA and PTHA is the wave height of the tsunami, produced from an earthquake. Before performing the tsunami hazard analysis, this study summarized the definitions of a fault strike, fault dip, and rake, and performed a sensitivity analysis to obtain the effects of the parameters on the wave.

2. Data

The parameters of a tsunamigenic fault were used in the numerical simulation of wave height, and these parameters are the latitude, longitude, depth, strike, dip, rake, length, width, and slip. The sensitivity analyses on all parameters should be performed. However, the fault strike, dip, and rake were only considered for sensitivity analysis in this study.

2.1 Strike, dip, Rake

The fault orientation is specified by the strike and dip, and a rake is used to specify the direction of the slip. The definitions of the fault strike, dip, and rake are illustrated in Fig. 1. A fault has two surfaces, and the one illustrated is the surface of the foot wall. The other surface is known as a hanging wall.

The fault strike is the direction of a line created by the intersection of a fault plane and horizontal surface, 0° to 360°, relative to North. The fault dip is the angle between the fault and horizontal plane. The rake is the direction a hanging wall block moves during a rupture, as measured on the plane of the fault. It is measured relative to the fault strike, ±180°.

A rake of ±180° means the hanging wall moved toward the observer (right lateral motion). For any rake>0°, the hanging wall moved up, indicating a thrust or reverse motion on the fault, for any rake<0° the hanging wall moved down, indicating a normal motion on the fault [2].

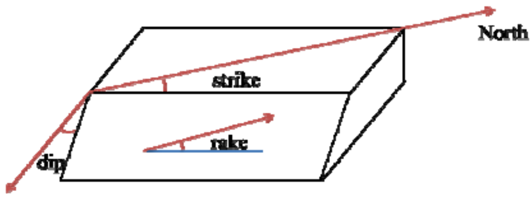

Fig. 1 Definition of the fault strike, dip, and the rake

2.2 Fault model

The parameters on the fault model were summarized in Tables 1 and 2. Table 1 shows the parameters used in the sensitivity analysis, and Table 2 presents the other fault parameters. The fault parameters which were not selected in the sensitivity analysis were quoted from an east coastal standard fault model of the East sea, which was suggested by JSCE (2002) [3, 4].

Table 1 Parameters on the fault strike, fault dip, and rake for a sensitivity analysis

strike	dip	rake
5°	30°	0°
15°	60°	45°
30°	90°	90°
330°	120°	
345°		
355°		

Table 2 Parameters on the fault model

latitude	longitude	depth
40.8	139.2	0
length	width	slip
131.1 km	30 km	5.45 m

3. Tsunami Simulation

This study performed a numerical simulation for the wave height using the TSUNAMI code [5]. Fig. 2 shows the maximum wave height on strikes of 30° and 330° in the far field simulation. We can see that the wave height and propagation were affected by the strike. The wave propagation mostly depends on the fault strike because the wave propagated with the vertical direction of the fault plane. Fig. 3 shows the time histories of the wave heights on the fault strikes at offshore in the near field simulation. The arrival time of the maximum wave height was influenced by the fault strike.

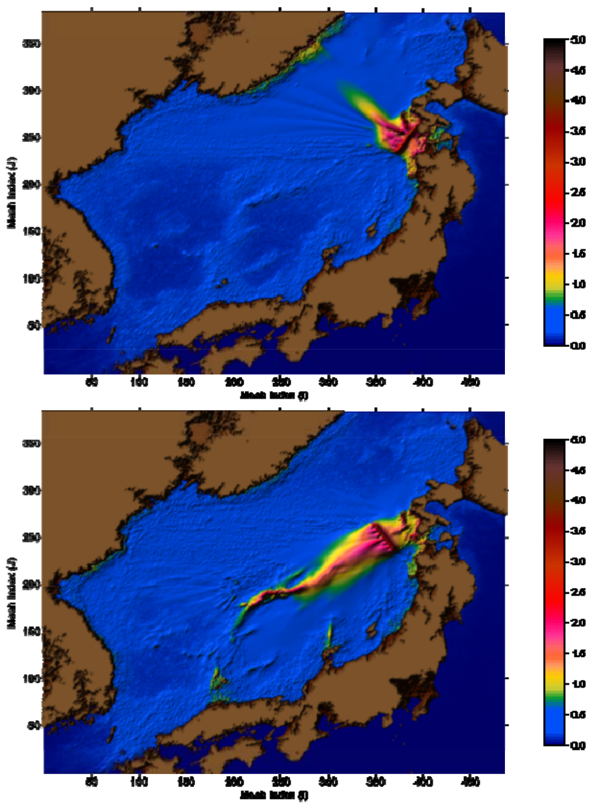

Fig. 2 Maximum wave height according to the fault strike (top 30° and bottom 330°) in the far field simulation

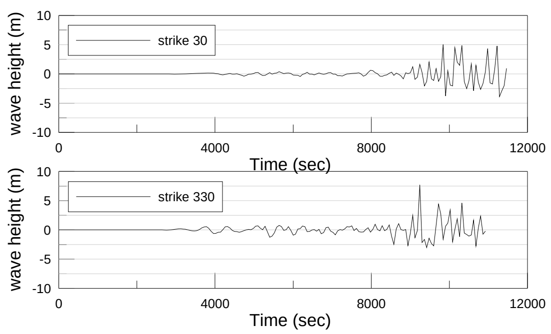

Fig. 3 The time histogram of the wave height on the fault strike at offshore in the near field simulation

Through a sensitivity analysis on the fault dip and rake, the wave height on the rake shows a noticeable difference in the far field simulation, and the effect of the rake was greater than the fault dip in the near field simulation. Fig. 4 shows the influence of dip and rake for maximum wave height. The median wave height according to the rake was increased with the rake increase.

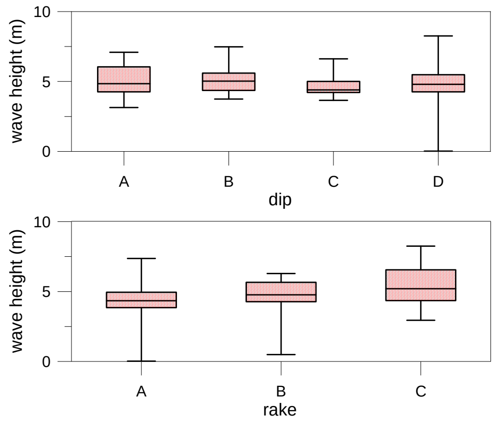

Fig. 4 The box plot of maximum wave height on the dip and rake at offshore in the near field simulation (top (dip) A=30, B=60, C=90, D=120, bottom (rake) A=0, B=45, C=90))

4. Conclusion

This study performed a sensitivity analysis on the fault strike, dip, and rake using a numerical simulation. The sensitivity analysis results show that the wave height and propagation depend on the fault strike, dip, and rake. The computed results from the far and near field simulation were also compared. Finally, this study suggests that the most effective parameter on the direction of the wave propagation was the fault strike, and the rake had the largest influence on the maximum wave height.

ACKNOWLEDGEMENT

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