DISPERSION-CORRECTION OF FINITE ELEMENT MODEL FOR SIMULATION OF DISTANT TSUNAMIS

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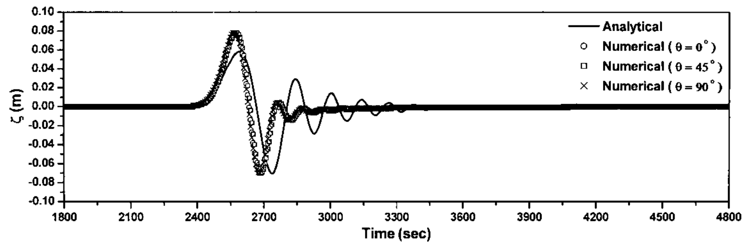
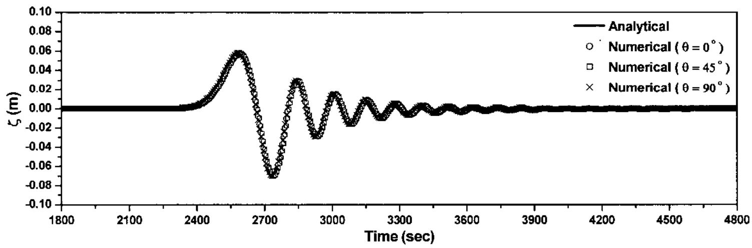
For the accurate simulation of tsunami propagation in a varying topography, the dispersion effect of waves should be carefully considered at every grid point in the whole computational domain. Since the grid size, which is determined by the Imamura condition to satisfy the dispersion relationships, changes according to the given water depth and time step, an adjustable grid system should be employed for varying topography. However, the grid size cannot be adjustable in two-dimensional cases. Thus, it is necessary to develop a numerical model that has the flexibility in mesh size to consider accurate physical dispersion relationships when the tsunami waves propagate far away from the source region over slowly varying topography.

In the present study we have developed a new finite element scheme, which satisfies a local dispersion relationships for slowly varying water depth. This scheme solves the simplified Boussinesq-type wave equation on an arbitrary triangular mesh system. The new scheme uses a dispersion-correction technique instead of adjusting the mesh size proposed by Imamura et al. (1988). Thus, we can achieve an accurate dispersion-correction although the mesh size does not meet Imamura's mesh condition. The numerical model developed in this study is tested for the cases of two-dimensional propagation of an initial Gaussian hump over various constant water depths, and the results are compared with analytical solutions.

Fig. 1 presents the comparison of analytical and numerical solutions calculated including or neglecting the dispersion-correction parameters γ proposed by this study. For the case of 1500m water depths, Δx (=2086m) is smaller than Δx_{Im} (=3087m). As a result, as shown in Fig. 1(a), the numerical solutions in the case of γ =0.0 show less dispersive nature in the surface profiles than the analytical solutions based on Boussinesq equations. The present numerical model with γ =-0.12 gives a correct dispersion effect as shown in Fig. 1(b). Therefore, we can conclude that the present numerical model is less sensitive to the choice of mesh size than the models of Imamura et al. (1988) and Cho (1995). In other words, if the dispersion-correction parameters γ calculated according to the given water depth, element size and time step are used, it seems reasonable to conclude that the present model should satisfy local dispersion relationships for the simulation of distant tsunamis propagating over a variable water depth as long as the depth changes slowly.



(a) Dispersion-Correction neglected ($\gamma = 0.0$)



(b) Dispersion-Correction Included ($\gamma = -0.12$)

Fig. 1 Comparison of computational and analytical time histories of free surface profile for the case of water depth $h = 1500$m ($\Delta x_{\mathrm{Im}} = 3087$m, $\Delta x = 2086$m).

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