WEAKLY NONLINEAR AND WEAKLY DISPERSIVE WAVE EQUATIONS FOR RANDOM WAVES

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Abstract

Water waves observed in shallow-water region have wide ranges of periods and extraordinarily irregular shapes. Therefore, in order to suggest the solution and the analysis of various problems in a real coastal region, it is so important to consider the irregularity of waves. Spectrum theory which express waves having various period as energy of each period have been used widely for generation and analysis of random waves (Goda, 2000). Suh et al. (2001) and Jung et al. (2004) calculated reflection of random waves of perforated wall caisson and submerged breakwaters by summing each numerical results of regular waves, predicted results from the eigenfunction expansion method were in a good agreement with the results of laboratory experiments. Suh et al. (1997) and Lee et al. (2003) analyzed propagation of random waves over a rippled bed by using an extended mild-slope equation being able to apply rapidly varying topography. However, the depth condition was restricted to deep water and intermediate depth zone. Liu et al. (1992) found that the nonlinear energy interaction of each wave period must be considered in shallow water condition.

Prüser et al. (1986) directly analyzed the Boussinesq equations by using a time-marching scheme, nonlinear energy interaction among wave components composing random waves was calculated. Liu et al. (1992) derived governing equations of long waves and carrier type waves composing wave groups, nonlinear transformation between long and carrier waves was calculated by coupling this two governing equations. However, Liu et al.'s equations were not able to consider wave reflection due to variation of bottom topography. Liu and Cho (1993) extended Liu et al.'s research. They derived the governing equation of reflection of long waves additionally but neglected reflection of carrier waves.

In this study, a couple of ordinary differential equations having exact solution in shallow water and intermediate depth are derived from the Boussinesq equations by using Fourier decomposition. Newly derived equations include nonlinear energy interaction and optional shapes of free surface displacement expressed by using a Fourier transformation. Reflection of both long and carrier waves is included in the governing equations. The TMA (TEXEL storm, MARSEN, ARSLOE) shallow-water spectrum is used for generation of random waves. Bouws *et al.* (1985) firstly reported the TMA shallow-water spectrum, and they improved the JONSWAP (Joint North Sea Wave Project) spectrum.

By using derived governing equations, nonlinear energy interaction and the Bragg resonant reflection of random waves over a rippled bed are analyzed for cases of peak

enhancement factor $\gamma = 2$ and $\gamma = 20$. Especially, at the case of narrow-banded spectra, the reflected energy is relatively large because of the concentration of wave components having an angular frequency near the Bragg reflection condition. For the shallow-water regions, evolution and reflection of random waves are considerably influenced by nonlinear interactions among different harmonic components.

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