The Effect of Porous Bottom Media on Wind Wave Model

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ABSTRACT

The current phase-average wind wave model does not include the effect of porous bottom media on wave energy dissipation. The present paper incorporates the dissipation coefficient for porous bottom media in the wave action equation (WAE) of Wind Wave Model (WWM) (Hsu et al., 2005). The coefficient is obtained from the analysis mild-slope equation proposed by Rojanankmthon et al. (1989), and imitated Isobe (1987) method to add the effect of porous media in the WWM model. The accuracy of this model has been verified by comparing the experimental and numerical results. Several typical real sites were investigated using the present model.

KEY WORDS: Wind wave model; phase-average; porous bottom media; mild-slope equation; wave damping.

INTRODUCTION

Wave model simulation is one of the main sources for the practical marine and coastal engineering units to obtain the design wave conditions. Wave generation, dissipation and transformation are influenced by many complex physical mechanisms (seabed topography, wind, currents, wave interaction, shoaling, breaking, bed friction, porous bed, etc.). The important physical mechanisms of waves are considered more complete, the simulation results of wave characteristics and distribution should be more realistic.

The combined effect of the wave refraction and diffraction on the wave transformation can be accounted for by using mild-slope equation (MSE), Boussinesq equation (BE) or wind wave model (WWM). The MSE is a phase-resolving wave model which was first developed by Berkhoff (1972) for describing wave transformation in a slowly varying sea bottom. The EMSE has been developed to extend the MSE to the case of wave propagation over a rapidly varying seabed (e.g. Liu, 1990; Massel, 1993; Chamberlin and Porter, 1995a, 1995b; Hsu and Wen, 2001a, 2001b; Hsu et al., 2006). The BE is the other type of phase-resolving model to account for nearshore wave processes in which nonlinearity and frequency dispersion are included. Many numerical models have been developed to accurately simulate wave propagating from deep water to shallow water (e.g. Madsen and Sorensen, 1992; Nwogu, 1993). The new version extended the usefulness of BE to a higher-order nonlinearity by introducing the Padé approximation (Wei et al., 1995; Gobbi et al., 2000; Madsen et al., 2003; Fuhrman and Madsen, 2009).

The other phase-averaged model for simulating the variation of wave spectra for random short-crested waves in large-scale oceanic deep water and small-scale shallow water regions. Typical examples of commonly used models are WAM (WAMDI Group, 1988), SWAN (Booij et al., 1999a, 1999b), STWAVE (Smith et al. 2001), TOMOWAE (Marcos, 2003) and WWM (Hsu et al. 2005; Liu et al., 2011). The processes of wave generation, dissipation and nonlinear wave-wave interactions are well accounted for in these models based on WAE. The main effects have been taken into account include wind-wave generation (Snyder et al., 1981; Cavaleri and Malanotte-Rizzoli, 1981; Komen et al., 1984; WAMDI Group, 1988; Janssen, 1991), nonlinear wave-wave interactions (Hasselmann, 1962, 1963a, 1963b; Hasselmann et al., 1985; Eldeberky and Battjes, 1995; Eldeberky, 1996), whitecapping (Hasselmann, 1974; Komen et al., 1984), bottom friction (Cavaleri et al., 1988; Bertotti and Cavaleri, 1994; Young and Gorman, 1995), and wave breaking (Divoky et al., 1970; Chen and Wang, 1983; Battjes and Stive, 1985; Eldeberky and Battjes, 1995). Toledo et al. (2012) construct an extended WAE in terms of linear wave theory of MSE that has an improved behavior for rapid spatial bottom changes as well as ambient current changes. The phase-averaged wave action balance equation was formulated by Holthuijsen et al. (2003) and Liu et al. (2011) to include wave refraction- and diffraction-induced directional turning rate of the components.

For a sandy beach, between each sand grain and its neighbors are spaces that allow water to percolate through the sand. Wave energy reduction on the seabed increases so that wave energy transmitted to the nearshore decreases. It is desirable to extend WAE to apply in porous sea bottom situations. This could provide more reliable results to the scientific approach and engineering practice. The aim of the present study is to construct WWM (Hsu et al., 2005; Liau et al., 2011) to account for wave spectral evolution over a abruptly varying porous seabed in the presence of current. Based on the EMSE (extend MSE) of permeable sea bottom configuration, the WAE is derived by taking into account of energy dissipation effect induced by porous bottom media. A derivation of EMSE with higher-order components in the presence of