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Numerical simulation of random wave runup on seawall near shoreline with FUNWAVE model

Artur Palha, Conceição Juana Fortes
Laboratório Nacional de Engenharia Civil, NPE
Lisboa, Portugal

Hajime Mase
Disaster Prevention Research Institute, Kyoto University
Kyoto, Japan

ABSTRACT

FUNWAVE numerical model is particularly suited to model nonlinear wave phenomena in the nearshore coastal zone. However, due to its inherent limitations, no *a priori* values are known for the parameters to be used for a particular application of FUNWAVE. Hence every simulation provides significant knowledge on the parameters to be used on future situations, especially if complex phenomena as wave breaking and wave runup are present. In this paper, the FUNWAVE model (one dimensional version) is applied to the simulation of the experiments performed by Mase et al. (2006): i.e., the wave propagation on a channel with different slope profiles and a seawall, for irregular breaking wave conditions. The purpose of this study is to analyze the model's performance when simulating the main phenomena involved in nearshore wave propagation, with special attention to nonlinear phenomena and wave runup. In order to evaluate FUNWAVE's behavior a comparison is made between experimental and numerical results for surface elevation, significant wave height, wave period, power spectrum and bispectrum and wave runup.

KEY WORDS: Boussinesq; FUNWAVE; Runup; Bispectrum.

INTRODUCTION

As the wave propagates from offshore into nearshore regions, phenomena like shoaling, refraction, diffraction and wave breaking, for instance, affect the wave characteristics (amplitude, celerity and direction). Moreover, nonlinear phenomena (wave-wave and wave-currents interaction and harmonic generation) induce additional changes in the wave characteristics and especially on the wave profile. Sea surface profile becomes asymmetric with sharp peaks and broad flat troughs. Boussinesq-type equations (Kirby (1997)) are particularly suited to model nonlinear wave phenomena in the nearshore zone.

FUNWAVE (Kirby et al. (1998), Chen et al. (2000)) is an example of a wave propagation model, which is based upon the fully nonlinear Boussinesq equations derived by Wei et al. (1995). These equations describe the nonlinear evolution of waves over a slopping impermeable bottom without considering wave breaking. Their range of validity extends from shallow up to intermediate water depths.

To extend the validity of the model, several authors proposed modifications to the original FUNWAVE model. Kennedy et al. (2000) introduced some additional terms into the equations in order to take into account the bottom wave dissipation, wave breaking, wave generation inside the domain, numerical wave absorption in the boundaries of the domain and dynamic boundaries (varying in shape and in position with time). In what concerns wave breaking, an eddy viscosity formulation similar to that of Zelt (1991) was used. In summary, the current version of FUNWAVE model can be applied from shallow to intermediate water depth and is capable of simulating wave-wave interactions in shallow water, non-linear shoaling, wave reflection, wave breaking and swash oscillations.

Although, FUNWAVE model has been tested and verified in a number of cases (literature and laboratory experiments), which are described in Kirby et al. (1998) and Mil-Homens et al. (2005), for instance, the application of this model to other laboratory data is always important to evaluate the model performance in different situations. Notice that any application of FUNWAVE to a different bottom profile is not a simple change in the bathymetry but it implies an extensive tuning of the inherent parameters of the model. This is even more important when complex nonlinear wave phenomena like wave breaking and wave runup are involved since those phenomena are simulated by FUNWAVE using some simplification techniques. Comparison with laboratory data enables the test of FUNWAVE capabilities in those cases.

The availability of high quality laboratory experiments on wave runup, Mase et al. (2006), prompts the study presented hereafter. In fact, Mase et al. (2006) conducted several experiments, for irregular wave breaking conditions, on a channel with a beach profile which ends on a seawall. The objective of these experiments aimed at establishing formulas for the runup of random waves on seawalls located with their toes close to shorelines. The tests were performed for three kinds of beach topographies and two different seawall slopes. The water surface