Run-up over variable slope bottom. Validation for a weakly nonlinear Boussinesq-type of model.

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1 Overview

The interaction of waves with the coast involves a great number of phenomena which influence in different ways the human activities near the sea. The main problems are caused by the erosion of beaches and the inundation of the land behind the coastline. These two effects are correlated; indeed the erosion of the coast can enhance the extreme waves to reach the buildings or infrastructures near it, thus causing flooding with dramatic effects. For such a reason, the eroded coasts in front of inhabited zones are usually object of coastal protection works, i.e. construction of structures and/or sand nourishment. In both cases the cross-shore profile of the coast is modified and typically presents several ranges with variable slope.

In the last decade, several authors have studied the run-up and overtopping of coastal structures and beaches. Such studies represent an important tool for the coastal design and management. In particular Pullen et al (2007) collected a wide series of experiments and furnished several formulae for the maximum run-up covering also the case of variable sloping bottom. The same authors have also inserted all their experimental data in a neural network system which can be used for the cases falling out of the limit of applicability of the formulae.

However, the use of such a formulation represents an empirical approach to the problem and it is not correlated to the physical phenomenon of the wave approaching a slope. For such a reason the present contribution aims at validate the physically based Boussinesq-type of model of Lo Re et al. (2008) for the variable slope bottom case. Moreover, the experimental results showed here are referred to a physical model configured in order to analyze the wave run-up effect of varying bottom slope, typical of several real cases.

2 Description of the numerical model

The adopted one horizontal dimension Boussinesq-type of model (Lo Re et al., 2008) represents an extension of the model developed by Musumeci at al. (2005) in order to provide a more physically based swash zone boundary condition and a fairly correct estimation of wave run-up. In particular, the dynamics of the wave propagation within the surf zone is represented through a weakly dispersive fully nonlinear Boussinesq-type of model. The flow is assumed rotational after breaking and the governing equations are derived with no assumptions on the order of magnitude of the nonlinear effects. Moreover, in such a model the velocity is influenced by the effects of vorticity due to breaking, and the vorticity transport equation is solved analytically under the assumption of depth constant eddy viscosity. The amount of vorticity introduced by the breaking process is determined through the adoption of the concept of the surface roller and by means of an analogy with the hydraulic jump.

The shoreline boundary condition is developed with a fixed grid method with a wet-dry interface. In order to resolve the problems due to the numerical scheme during the onshore movement of

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the shoreline, a linear extrapolation (Lynett et al., 2002) near the wet-dry boundary is used and coupled with the shoreline equations.

3 Experimental set-up

Some experiments on sloping beaches have been carried out in the past from one of the authors of the present contribution. Here the main results have been applied for the validation of the adopted model. In particular, the experimental investigation has been conducted in the laboratory at University of Catania showed in Figure 1. In such a Figure the bottom profiles are also shown. In particular, each bottom profile is made up by three slopes: the first and the last slopes are constant (angle of 10° and 2° respectively), the middle one has angle which varies between 30° and 70° with respect to the horizontal plane.

The experiments have been conducted with monochromatic waves, the acquisition of wave heights has been conducted by a resistive probe place in a region located out of the initial slope. The analysis of the wave run-up has been carried out by a digital camera which allows 25 frames per second. Each registered image has been calibrated in order to obtain the real dimensions of the phenomenon to be registered. The water depth at the wave gage has been ranged between 16 and 25 cm, the wave period has been varied between 1.3 to 3.3 s and the wave heights are in the range between 1.5 and 12 cm.

The Run-up measured has been related to the wave height and the water depth, moreover it has been compared to the results obtained by the adopted numerical model in the same condition, obtaining a fairly good match.

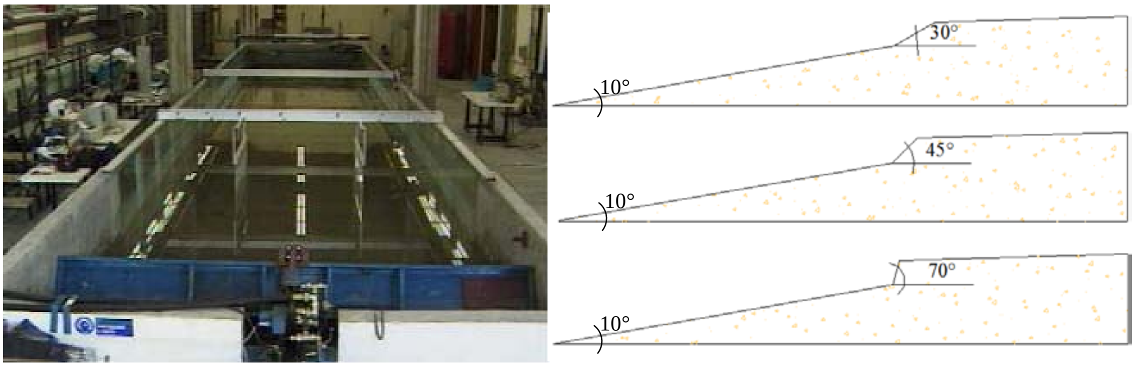

Figure 1: Picture of the wave flume at University of Catania with indication of the experimental set-up, i.e. bottom slope angle varying between 30 and 70 degrees.

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5 References

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