NUMERICAL SIMULATION OF BERM AND DUNE EROSION DUE TO WAVE OVERTOPPING AND SEDIMENT OVERWASH USING OPENFOAM

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INTRODUCTION

The present work follows authors' previous works, published and presented at ICCE 2016 and Coastal Dynamics 2017 conferences (Karagiannis et al. 2016, 2017) and concerns the numerical simulation of berm and dune cross-shore profile evolution due to wave overtopping and sediment overwash through an innovative repetitive approach of coupling a hydrodynamic model, synthesized on the OpenFoam platform with a morphodynamic one, whose origin code is developed in FORTRAN by the authors. The hydrodynamic model is used for the wave propagation, while the morphodynamic one gets the results of the first model and yields the new cross-shore seabed formation. The above process is repeated until the equilibrium profile is achieved.

HYDRODYNAMIC MODEL ON OPENFOAM

The open source toolbox OpenFoam and the additional wave generation toobox waves2Foam (Jacobsen et al 2012) is used for the simulation of the wave propagation. The RANS equations are solved in conjunction with the ones of the Volume of Fluid (VOF) method for tracking the free surface. Also, the k-omega SST turbulence model for incompressible flow, available in OpenFoam libraries, was modified in order for the density to be included in the model's equations and is used for the turbulence closure. Furthermore, suitable boundary and initial conditions are chosen with the appropriate one for the wave generation at the inlet.

MORPHODYNAMIC MODEL

The hydrodynamic characteristics of the flow, i.e. near bottom horizontal velocity time series, surface elevation, turbulent kinetic energy k, undertow, etc, are obtained from the OpenFoam model. Then, the Camenen and Larson (2007) transport rate formula (involving unsteady aspects of the sand transport phenomenon) is adopted for estimating the sheet flow sediment transport rates, as well as the bed load and suspended load over ripples. Given the sediment transport rates, the changes in the beach profile are computed from the numerical solution of the conservation equation of the sediment mass, which is applied for several time steps. Then, the OpenFOAM model is applied again with the updated morphology to obtain the new transport rates. The above process is repeated as many times as it is required to reach the equilibrium profile.

NUMERICAL RESULTS - COMPARISON

Model results are compared with experimental data for surface elevation, wave overtopping (Roeber et al., 2010) and cross-shore berm and dune profile evolution (Kobayashi et al 2009, Figlus et al. 2011, Spyrou, 2017). The agreement between measured surface elevation and the experimental data (Roeber et al., 2010) is considered quite satisfactory (Figure 1). Satisfactory agreement is also obtained between measured and computed beach profiles (Figure 2).

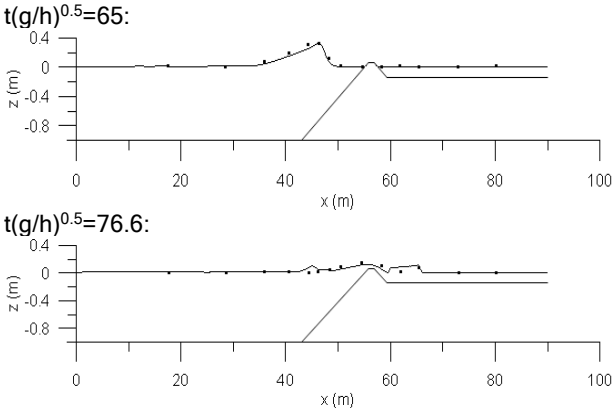

Figure 1 - Comparison of Computed and measured (Roeber et al 2010) Surface profiles of solitary wave transformation over an exposed reef crest

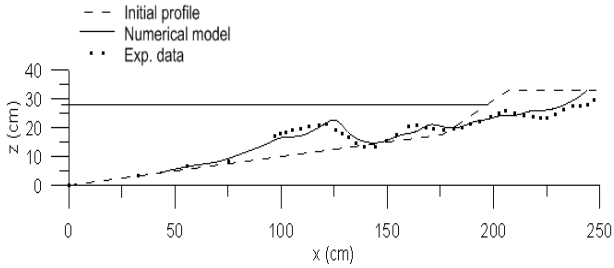

Figure 2 - Beach profile evolution: Comparison between model results and experimental data (Spyrou 2017)

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