FORCES INDUCED ON A VERTICAL BREAKWATER BY INCIDENT OBLIQUE WAVES

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INTRODUCTION

Over the last years some numerical models have been developed to accurately simulate wave interaction with all kinds of coastal structures. In this field, models based on the Volume Of Fluid (VOF) method have a great use, as they can accurately satisfy the pressure-velocity coupling of Navier-Stokes (N-S) equations unlike SPH models. As a first step, several models have been used to simulate wave interaction with coastal structures in two dimensions (2DV). Since these models have been thoroughly validated they are now an additional tool used in the design process of coastal structures. The main study parameters are wave induced loads (stability) and overtopping or wave reflection factor (functionality). Nevertheless the fact that that most of them are 2D is a limiting factor. This involves that wave incidence must be normal to allow the comparison of results. A qualitative progress is introduced with three-dimensional models. These are not so limited because they reproduce full 3D wave transformation processes as diffraction, which typically occur on breakwater heads. Also oblique or fully directional wave trains can be generated to study the influence of the angle of incidence on the aforementioned variables. The purpose of this paper is to test the capabilities of a fully three dimensional CFD code based on N-S equations to solve the induced hydrodynamics of oblique waves around vertical breakwaters. In order to do so, a comparison between induced pressure on the caisson will be carried out, using Goda and Goda & Takahashi theories.

NUMERICAL MODEL: IH-FOAM

The numerical simulations of the present paper have been fulfilled with the model called IH-FOAM, see Higuera et al., (2012a, 2012b). This solver is based on OpenFOAM open source model. It uses a finite volume discretization to solve the three dimensional N-S equations in two phases, tracking the free surface by means of the Volume Of Fluid (VOF) method. The newly developed Volume-Averaged Reynolds-Averaged Navier-Stokes equations (VARANS, see del Jesus 2011 for further details) have been implemented to account for the treatment of flow within porous media. The porous drag forces are modelled using the Forchheimer relationship. A k-ε turbulence model is used in both the clear fluid and the porous media flow region. Wave generation plus active absorption boundary conditions, both 2D and 3D, have been implemented to minimize wave reflection on the boundaries. Additionally, IH-FOAM is able to handle unstructured grids and fully parallelize them. All these features allow the model to represent accurately all sorts of coastal structures from permeable to impervious ones.

RESULTS

Numerical simulations have been carried out in order to validate the model. Figure 1 shows a train of regular waves interacting with a vertical breakwater head. Ten snapshots are presented. The simulation shows three dimensional diffraction patterns created by the waves' interaction with the structure. During the presentation the resulting forces on a vertical breakwater caisson will be shown, including uplift forces which appear due to the porous gravel bed foundation. Stability criteria of Goda and Goda & Takahashi will be tested against several cases of oblique wave trains.

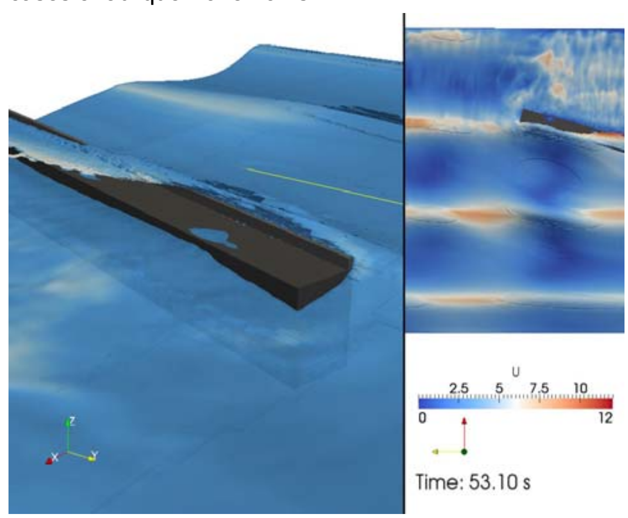

Figure 1 – Regular waves interacting with a vertical breakwater

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