RECENT ADVANCES IN 3D MODELLING OF WAVE-STRUCTURE INTERACTION WITH CFD MODELS

Javier L. Lara, Environmental Hydraulic Institute "IHCantabria", Univ. de Cantabria, jav.lopez@unican.es
Inigo J. Losada, Environmental Hydraulic Institute "IHCantabria", Univ. de Cantabria, inigo.losada@unican.es
Gabriel Barajas, Environmental Hydraulic Institute "IHCantabria", Univ. de Cantabria, barajasg@unican.es
Maria Maza, Environmental Hydraulic Institute "IHCantabria", Univ. de Cantabria, mazame@unican.es
Benedetto di Paolo, Environmental Hydraulic Institute "IHCantabria", Univ. de Cantabria, dipaolob@unican.es

INTRODUCTION

Numerical modelling of the interaction of water waves with coastal structures has continuously been among the most relevant challenges in coastal engineering research and practice. During the last years, 3D modelling based on RANS-type equations, has been the dominant methodology to address the mathematical modelling of wave and coastal structure interaction. However, the three-dimensionality of many flow-structure interactions processes demands overcoming existing modelling limitations. Under some circumstances relevant three-dimensional processes are still tackled using physical modelling. It has been shown that beyond numerical implementation of the well-known mathematical 3-D formulation of the Navier-Stokes equations, the application of 3-D codes to standard coastal engineering problems demands some additional steps to be taken. These steps could be classified into three main groups relevant to: a) the modelling of the physical processes; b) the use of the tool and c) the applicability of the codes. This work presents an analysis of the use of three-dimensional flow models to analyze wave interaction with coastal structures focusing on recent developments overcoming existing limitations. Last modelling advances, including the implementation of new physics and pre-and post-processing tools will be shown with the aim of extending the use of three-dimensional modelling of wave-structure interaction in both coastal and offshore fields.

RESULTS

Numerical developments have been carried out on IHFOAM (www.ihfoam.ihcantabria.com) solver. It is a three-dimensional Navier-Stokes (NS) solver built on OpenFOAM® that allows reproducing free surface flows linking fluid pressure and fluid velocity.

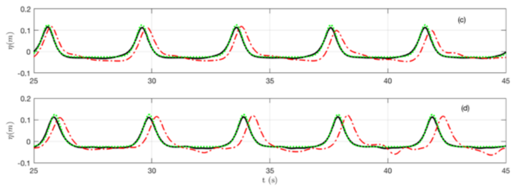

Figure 1. Free surface time history of a cnoidal wave (H=0.15 m, T=4 s) in h=0.4 m water depth. Dashed red line: Higuera (203) method. Dotted green line: Theoretical solution. Black solid line: Present method. Panels: wave gauges located at (c) 20 m and (d) 29 m from the wave generation boundary.

Regarding physical processes, this work covers features related to (1) joint wave and curr1ent generation, (2) extension of active wave absorption to deep water and (3) floating bodies by means of the overset method to accomplish with six-degree of body motions. According to wave generation, a new set of boundary conditions have been developed to include the vertical variation of the velocity profile. Flow definition above the mean level is also included, overcoming existing wave generation methods, such as Higuera et al. (2013). The new set of boundary conditions extends also the use of the model for joint wave generation and active absorption at the boundaries to deep waters. In addition, despite of improving the quality of numerically generated waves (see figure 1), it allows to include wave and current combined. Regarding floating bodies dynamics, the overset method is used to determine a six-degree of motion. The new implementation allows including multibody simulation interacting with waves and current. Different mooring types are also implemented.
The applicability of the model will be discussed in three examples. Validation of the new developments will be presented.

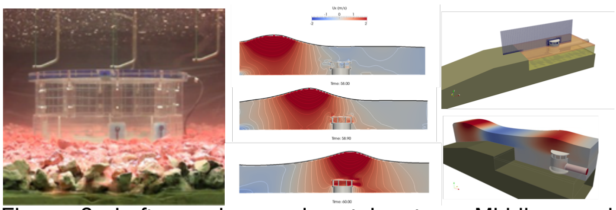

Figure 2. Left panel: experimental set-up. Middle panel: velocity (Ux) patterns corresponding to the largest wave passing over the intake structure. Right panel: Numerical domain including buried tower and pipe.

First, a methodological procedure using the new set of boundary conditions to mimic a wave basin will be shown. The example of the CCOB basin (30 m x 44 m x 4.5 m) at IHCantabria will be presented. Next, the analysis of waves interacting with a buried intake tower will be presented. Numerical results are validated by means of laboratory experiments. IHFOAM is able to predict flow induced pressures in the buried part of the intake tower (see figure 2). Finally, application to floating bodies will be presented. Modelling waves and current interaction with waves is validated with laboratory experiments for a taut mooring system.

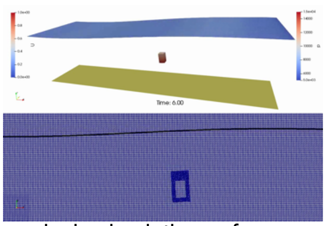

Figure 3. Numerical simulation of waves and current interacting with a floating body using the overset method.

REFERENCES

Higuera, P., Lara, J.L., Losada, I.J. (2013). Realistic Wave Generation and Active Wave Absorption. Application to OpenFOAM. Coastal Engineering. Vol 71, 102-118. ELSEVIER.