COUPLING OF FLUINCO MESH-BASED AND SPH MESH-FREE NUMERICAL CODES FOR THE MODELING OF WAVE OVERTOPPING OVER A POROUS BREAKWATER

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1. Introduction

Smoothed Particle Hydrodynamics (SPH) is a recent numerical method for modeling complex flows such as free surface flows, wave breaking and overtopping produced by the interaction among waves and coastal structures. These are very challenging problems in Computational Fluid Dynamics (CFD). In this paper, the SPH numerical model developed at LNEC is validated for a porous breakwater (section of West breakwater of the Albufeira harbor, Algarve, Portugal). Within this objective, physical modeling at 1:30 scale was performed on a LNEC's wave flume with 49.4m length. However, as SPH model is not able to simulate entire flume, due to its high CPU time, a passive coupling technique between two numerical models was developed: wave propagation, in the first part of the flume, is modeled using the FLUINCO mesh-based code (Teixeira & Awruch, 2005); wave interaction with the coastal structure, in the second part of the flume, is modeled using SPH code (Didier & Neves, 2012). The passive coupling approach consists in transferring the wave propagation from the FLUINCO code to the SPH code.

This paper presents the coupling technique analysis and an application of the new integrated tool (composed by FLUINCO and SPH codes and the coupling approach) to the tests performed in the physical wave flume, comparing numerical results with experimental data.

2. West breakwater of the Albufeira Harbor and Physical Modeling

The West breakwater of the Albufeira harbor has a seaward 1.6:3 slope. The berm crest freeboard and the natural seabed is developed between +7.0m (ZH) (Chart Datum) and -4.5m (ZH), respectively (Figure 1). In the central zone of the crest there is a concrete slab with 3.0m width: the crest is located at +6.5m (ZH) and it is founded at +4.0m (ZH). The primary armour is made by two layers of 90 to 120kN rocks and presents an extremely high packing density due to the blocks arrangement (Neves et al, 2012), as can be seen in Figure 1.

The physical modeling of the breakwater section was performed at LNEC, in 1:30 scaled 2D model (Figure 2). The free surface elevation at 9 sections in front and inside the breakwater, the water level and the overtopping volume were measured.

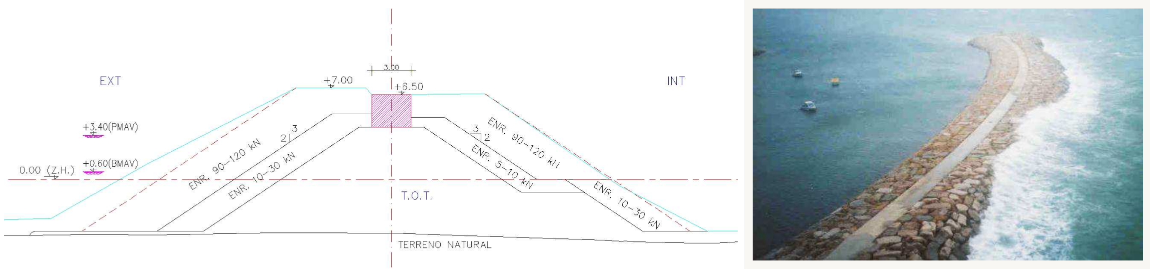

Figure 1. West breakwater of the Albufeira harbor: the cross-section and the West breakwater.

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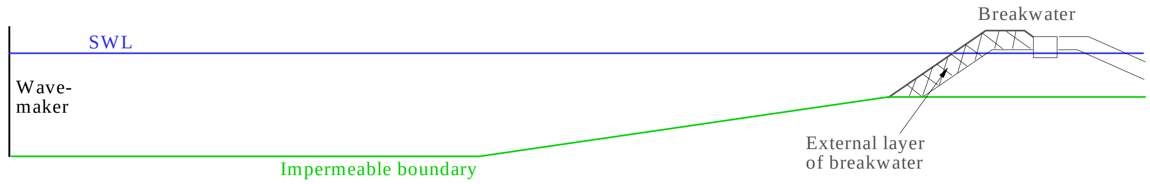

Figure 2. Physical modeling: Representation of the porous structure tested in the wave flume.

3. Numerical Modeling of the Wave Propagation and the Wave-Structure Interaction

The SPH numerical model can be only used for a small computational domain, typically with the extent of two wave lengths, due to the high CPU time. Thus, for modeling larger domains, and to decrease the CPU time, the coupling with other numerical wave propagation model was developed. Figure 3 presents the scheme of the coupling method. The coupling method consists in three steps: i) The wave propagation is modeled with the FLUINCO code which uses a finite element method for solving the RANS equations and an ALE – Arbitrary Eulerian-Lagrangian – technique for the free surface flow; ii) The coupling between FLUINCO and SPH models is performed as follows: In the coupling section of the wave flume (Figure 3), the spectral analysis of the time series of the free surface elevations obtained by the FLUINCO model, allows to define the main frequencies of incident waves and both the relative amplitude and the phase. These wave characteristics are reproduced in the SPH numerical model by the piston-type wavemaker motion; and iii) the interaction between the incident wave and the porous breakwater is modeled with the SPH code based on mesh free technique for solving the RANS equations in Lagrangian form.

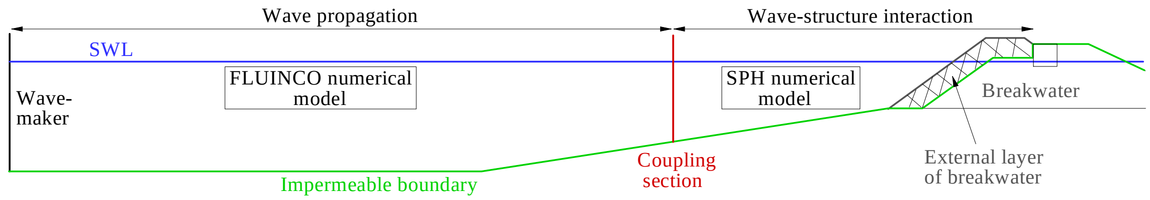

Figure 3. Numerical modeling: Representation of the two numerical wave flumes, the application zones for both the FLUINCO and the SPH numerical models

4. Expected Results

Numerical results obtained by the coupling of FLUINCO and SPH numerical models were compared with experimental data (free surface elevation, water level above the crest freeboard and wave overtopping volume), for a regular incident wave with 12s period, 4.5m wave height and a water level of +3.5m (ZH). An extensive analysis on the accuracy of the new coupling method is performed and the simulation of overtopping over the porous breakwater using the SPH code is evaluated.

It is expected that the validation of the passive coupling approach between both the FLUINCO and the SPH codes will be a step forward for modeling both wave propagation and the wave-structure interaction for a porous breakwater.

References

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