Characterization of wave loading by numerical modeling: case study of the harbours of Zeebrugge and Blankenberge

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The increasing storminess of the last decades, as dramatically remarked by the most recent events in the Northern Sea (e.g. Xaver storm in December 2013), is compelling many Countries in Europe, like Belgium, to review their coastal hazards concepts in order to upgrade the existing coastal defenses with the general intent of guaranteeing reasonable standards for human safety in extreme storm conditions. The Belgian coastline is one of the zones most exposed to wave attack and flooding, since it is a low lying area and because of its high touristic and recreational value. The Flemish Coastal Safety Masterplan was approved in 2011 to tackle these problems through the construction of new coastal defenses or the renovation of the existing structures.

For this reason, the wave action on the new defenses has to be properly characterized, in order to prevent their failure, but the classical approaches (i.e. theoretical formulae) cannot be applied in most of the cases where the particular geometries or hydraulics conditions require extra analysis. Hence numerical modelling can represent an alternative technique, cheap solution and useful tool to analyze the interaction between sea waves and coastal structures that otherwise requests physical experimental campaigns that often are real time consuming and not fully affordable.

The present work describes the validation and application of a mesh-less numerical model for wave loading assessment on coastal structures to face real-life problems from the Belgian coast. The so-called DualSPHysics model has been applied to assess wave loading on the new topping structures and storm return walls conceived for the harbors of Zeebrugge and Blankenberge. DualSPHysics is based on the lagrangian Smoothed Particle Hydrodynamics method and implements a GPU technology (Graphic Unit Interface) that reduces drastically the computational time, making the model less resource-demanding.

DualSPHysics has been applied to different cross sections of the aforementioned harbors and the wave forces due to the predicted maximum waves have been calculated (example in Fig. 1). In some case, when possible, the results have been compared with theoretical solutions, proving the good performance of the analysis. The results underline the capability of the model to reproduce the wave action on coastal structures especially when no formulations from literature can be applied.

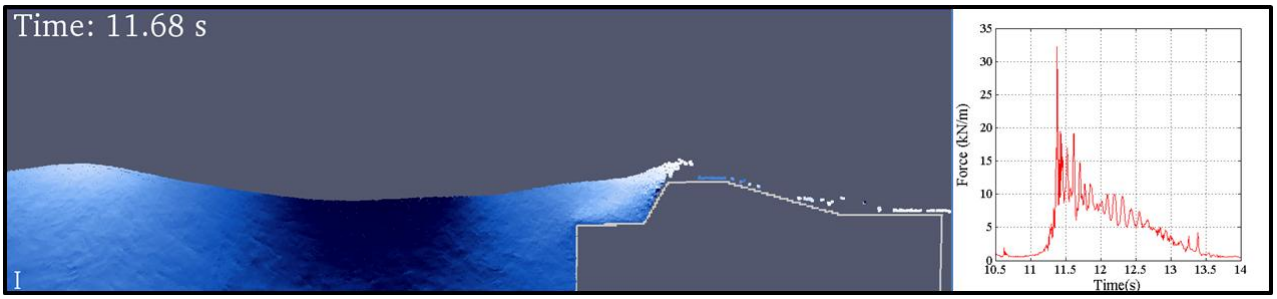

Figure 1 Sketch of numerical modelling and example of the measured force signal