Development of a numerical wave flume for the study of scour protection around offshore monopile foundations under waves and currents

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So far, the majority of the offshore wind turbines are supported by monopile structures. As any structure embedded in the seabed, erosion/scour may occur around the monopile foundations. In order to counter erosion, a scour protection is placed around the monopile's foundation on the sea bed. In this study, the behavior of the scour protection will be modeled using numerical tools.

De Vos et al. (2012) [1] give an overview of key experimental research carried out in the large wave flume of the Coastal Engineering Research Group - CERG - of Ghent University – UGent -, Belgium, regarding scour protection. Tests were carried out with a scale model (1:50) under the combined action of waves and currents. Three main failure modes have been distinguished: (i) damage of the scour protection by the flow, (ii) failure due to scour at the edge of the protection, and (iii) sinking of the scour protection.

The latter failure mode was studied by Nielsen et al. (2013) [2] and a numerical model for currents based on the Flow 3D software is proposed. This study concludes that a porous medium approach of scour protection can be used to determine the bed shear stresses underneath the scour protection, although calibration is needed.

Numerical models able to model the sinking failure of the scour protection around monopiles under the action of waves and currents using the porous medium approach are currently not available. The objective of this study is to cover this literature gap.

The toolbox selected for the development of the numerical model is OpenFOAM, Jasak (1996) [3], while the wave generation/absorption is performed using the module IHFOAM, Higuera (2015) [4]. In the latter module, the incompressible Volume Averaged Reynolds Averaged Naviers Stokes - VARANS - equations are solved in a finite volume discretization. In order to deal with the multi fluid (air, water) nature of the problem, the Volume of Fluid - VOF - method is used, which allows using the same set of equations to solve the momentum balance in both phases, thus, speeding up the calculations. The turbulence is modeled following the approach of Devolder et al. (2017) [5] as it has shown to reduce the turbulent kinetic energy production at the interface between the two fluids. Finally, the scour protection is considered as a porous medium as performed in Nielsen et al. (2013) [2].

The numerical model will be validated using experimental data. Physical model tests will be carried out in an upcoming European Hydralab+ project (spring 2018) which focuses on experimental modeling of scour protection around offshore wind turbine monopiles and is coordinated by CERG from UGent. The tests will be performed in the Fast Flow Facility in HR Wallingford with a scale of 1:8.33 and aim to extend and complement the 1:50 experiments performed by CERG (De Vos et al. (2012) [1]).

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