Extension of the validation cases of a numerical model of the flow within the scour protection around monopile foundations

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Currently, monopiles are the most used support structure for offshore based wind energy production units. As any structure embedded into the seabed, scour holes appear due the hydrodynamic action of waves and currents leading to a loss of stability. In order to counter the effect, the hydrodynamic conditions into the soil, scour protections are placed around the monopile. Nevertheless, the hydrodynamic conditions can also lead to the failure of the scour protection as stated in [1]. [2] concludes that a numerical model of the scour protection and the hydrodynamic conditions can predict the shear stresses within the scour protection. In [1], it is shown the lack of a model able to simulate the combined action of waves and currents and a full depth numerical flume for modeling the behavior of water around monopiles and within their respective scour protection made of rip-rap material is proposed. The latter numerical flume will be referred in this abstract as “the model”. In [1], the model has been validated and compared to the experimental and numerical results presented in [2]. This validation has been done for current conditions only.

The model is developed using the OpenFOAM toolbox [3]. Wave generation/absorption as well as currents generation is performed using the module IHFOAM [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 multiphase (air, water) nature of the problem, the Volume of Fluid - VOF - method is employed, which allows using the same set of equations to solve the momentum balance in both phases, thus, speeding up the calculations. The scour protection is considered as a porous medium as performed in [2].

The current research provides an extension of the validation cases presented in [1] by further comparing the results of the numerical wave flume with the experimental results for different scour protection thicknesses (one, two and four protection layer thicknesses) in current conditions as presented in [2].

The comparison shows the robustness of the numerical model which is in good agreement with the experimental results for one, two and four layer thicknesses. In conclusion, the developed numerical current flume captures the horseshoe vortices penetrating the scour protection.

Further research will focus on the sensibility analysis of the model to different parameters of the grid (cell size in the free surface, around the pile and the scour protection) and the porous medium approach (A, B, C coefficients in the Forchheimer equation).

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References

[1] Arboleda C., Wu M., Troch P., Stratigaki V., 2018. Development and validation of a numerical model of scour protection around monopiles under currents. Scour and Erosion IX: Proceedings of the 9th International Conference on Scour and Erosion (ICSE 2018), November 5-8, 2018, Taipei, Taiwan, CRC Press, October 10, 2018.

[2] Nielsen A. W., Liu X, Sumer B. M., Fredsoe J. 2013, Flow and bed shear stresses in scour protections around a pile in a current, Coastal Engineering 72:20-38

[3] Jasak H. 1996, Error Analysis and Estimation for the Finite Volume Method with Applications to Fluid Flows, PhD. Thesis, Imperial College, University of London

[4] Higuera P. 2015, Application of Computational Fluid Dynamics to Wave Action on Structures, PhD. thesis, Universidad de Cantabria

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