A Quasi-Simultaneous FSI Method for Deformable Offshore Structures

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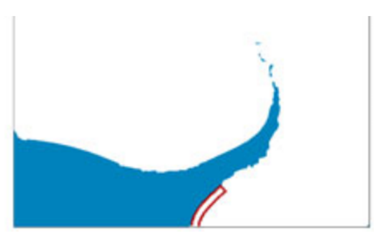
ABSTRACT

Offshore structures are designed to function for decades in extreme weather conditions in which even massive and stiff objects can undergo elastic deflections, motivating our research into the effect of hydroelasticity on offshore objects involving FSI: fluid-structure interaction. For the numerical coupling between the fluid flow and the structural dynamics we apply a segregated (or partitioned) approach (Park and Felippa, 1983). However, in contrast to a monolithic approach, a segregated approach introduces an iterative treatment of the two subproblems, with its accompanying convergence and stability issues. Over the years, various coupling strategies have been proposed, ranging from loose, to weak and strong coupling. It was found that the concept of added mass is very useful to understand the stability problems of these coupling approaches. Degroote (2013) presents an excellent overview of numerical ideas that have been proposed for FSI.

We apply the quasi-simultaneous coupling method that was originally developed by Veldman (1981) in the 1970s for aerodynamic problems of flow past aircraft wings. It is an extension of a weak coupling method with the stability and robustness of a strong coupling method. It introduces the concept of an interaction law: a simple description of one of the subproblems (in our case the structure) to be solved simultaneously (i.e., in a monolithic way) with the other subproblem (the fluid). Its stability depends on the difference between the physical contents of the interaction law and the 'real' physics, which makes its performance (apart from discretization effects) independent of the chosen numerical method for the subproblems. A special feature of this type of FSI coupling is that theory can be developed to design a favorable interaction law, which we build from the elastic modes of the structure.

We will demonstrate the quasi-simultaneous approach for added mass problems in FSI by test cases related to the offshore industry: (*i*) a tank with a flexible bottom, and (*ii*) a dambreak flow hitting an elastic monopile (see figure). Further applications can be found in Veldman et al. (2019).



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