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Vortex kinematics around a submerged plate under water waves. Part II : Numerical computations

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Abstract

This paper presents numerical computations of the flow generated by a horizontal plate immersed in a regular wave field, and associated loads acting on the plate. This numerical work is the continuation of the Poupardin *et. al.* [1] experimental study. This numerical study is original in the way that the vortical aspects of the flow are not neglected. Therefore, a 2D Lagrangian Vortex method is used as a numerical scheme. These methods are particularly well suited for the computation of unsteady and highly rotational flows in an open domain. The velocity field is decomposed into rotational and potential components, using the Helmholtz decomposition. The rotational part of the velocity is calculated by the Biot-Savart equation using vortex particles. The plate is modelled by a distribution of normal dipoles and the wave field is taken into account by means of a Stokes formulation, which completes the potential part of the velocity.

Firstly, the numerical code is validated by means of comparison with the experimental results of Poupardin *et. al.* [1]. In particular, the complex vortical activity and the mean flow velocity field are well reproduced and physically analysed. Secondly, forces acting on the plate are analysed on a wide range of parameters by varying the plate immersions and lengths. In the end, a new scaling is found for the lift forces acting on the plate based on the modified Stokes velocity (*i.e.* the bottom Stokes velocity for a water depth equals to the plate immersion) and the square of the plate length.

Keywords: Numerical computations; Submerged plate; Hydrodynamics; Lagrangian vortex method; Water wave; Vortex dynamics.

1. Introduction

The interaction of waves with a submerged plate is an important topic widely treated in scientific literature. Such structures were firstly considered for coastal protection properties. Indeed, as they are suspended in the middle of the water