NUMERICAL SIMULATION OF WAVE INTERACTING WITH A SUBMARINE OUTFALL USING IH-2VOF

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1. Introduction

Worldwide, the use of submarine outfalls has been increasing rapidly. Reported accidents with such installations, including accidents in Portugal (Reis & Neves, 2003), have highlighted that their good working conditions are of mandatory importance to the environment, welfare of populations and economy, with accidents being described as having very high environmental, economical and social consequences. Although the science and technology for the design and construction of outfalls has advanced significantly in the last 30 years, major questions still remain unanswered, including the considerable shortcomings in the knowledge of forces induced by waves in submarine outfalls.

For simple horizontal cylindrical pipes, many researchers have conducted two-dimensional (2D) experimental tests and, recently, also some numerical simulations, to study forces, with regular and irregular waves (e.g., Sumer & Fredsoe, 2006; Aristodemo et al., 2010). The influence on forces of the ratio between the pipe distance from the bottom and the pipe diameter was also extensively studied in 2D experiments (e.g., Jarno-Draux et al., 1995), since it alters the magnitude and direction of forces on the cylinder.

The IH-2VOF numerical model (Lara et al., 2006) was extensively validated for studies of wave interacting with breakwaters. This model simulates very well the wave generation and propagation, crucial for the determination of forces on submarine outfalls. However, it was not validated for studying the interaction between waves and submarine outfalls.

In order to validate the application of IH-2VOF for wave interacting with submarine outfalls, the model is here applied to the experimental study presented in Jarno-Draux et al., 1995. The study includes analyses of convergence with the mesh discretization and results of the lift, drag and inertia coefficients are compared with the experimental results.

2. Case study

The submarine outfall is here represented by a circular cylinder with an external diameter of 0.02 m in a flume with a water depth of 0.27 m.

Different ratios between the pipe distance from the bottom, *e*, and the pipe diameter, *D*, were tested numerically, varying from 0.1 to 1.5.

The tests were conducted with the same regular wave conditions as in the experimental work: a wave period of 1.08 s and a wave height of 0.047 m.

The pressure obtained from the model are processed to obtain ensemble-averaged time-series of pressure around the structure and, based on that, the force will be calculated. Based on those forces, the lift, drag and inertia coefficients are calculated and compared with the experimental values. The surface elevation, the wave current and the velocity are also analyzed to characterize the flow around the structure. Figure 1 shows the time series of the horizontal free-stream velocity, u, aligned with the center of the pipe and the correspondent horizontal force, Fx, obtained for *e/D*=0.5 between 20 s and 50 s.

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For a number of carefully selected conditions of vortex patterns around the outfall, the flow pattern is studied in order to understand the mechanism of vortex shedding. Figure 2 shows an instantaneous vorticity distribution at middle of cylinder for the case of *e/D*=0.5.

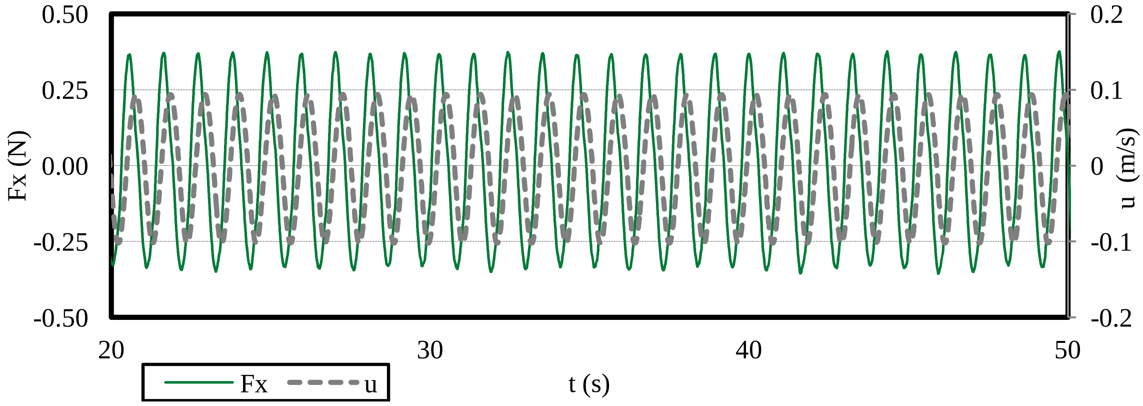

Figure 1. Time series of the horizontal free-stream velocity and the correspondent horizontal force obtained for *e/D*=0.5 between 20 s and 50 s.

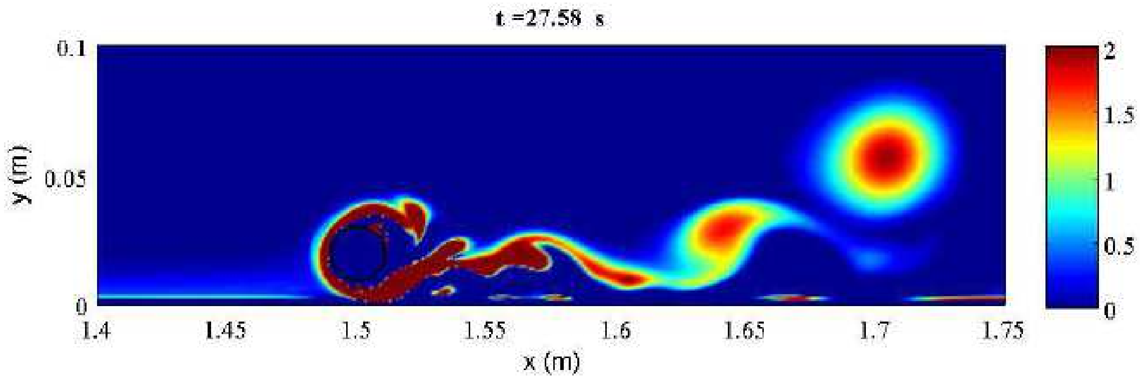

Figure 2. Instantaneous vorticity distribution at middle of cylinder in the case of *e/D*=0.5

After properly validated for this particular kind of wave-structure interaction, the information obtained could be very useful for development of practical design recommendations.

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