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Poster n°6

Experimental and numerical study of sloshing in a tank subjected to complex pitch excitation

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Introduction and objectifs

When a ship sails on the high sea, it is subjected to many forces from all directions. Ship motion is generally associated with resonant modes around natural periods contained in regular waves (Figure 1). This work focuses on the rectangular part of the ship, which represents a tank partially filled with water. For this purpose, an experimental study was carried out to analyze the sloshing within a partially filled tank of liquid under pitching motion. The main objective of this experiment is to obtain reference experimental results in order to validate a developed numerical model.

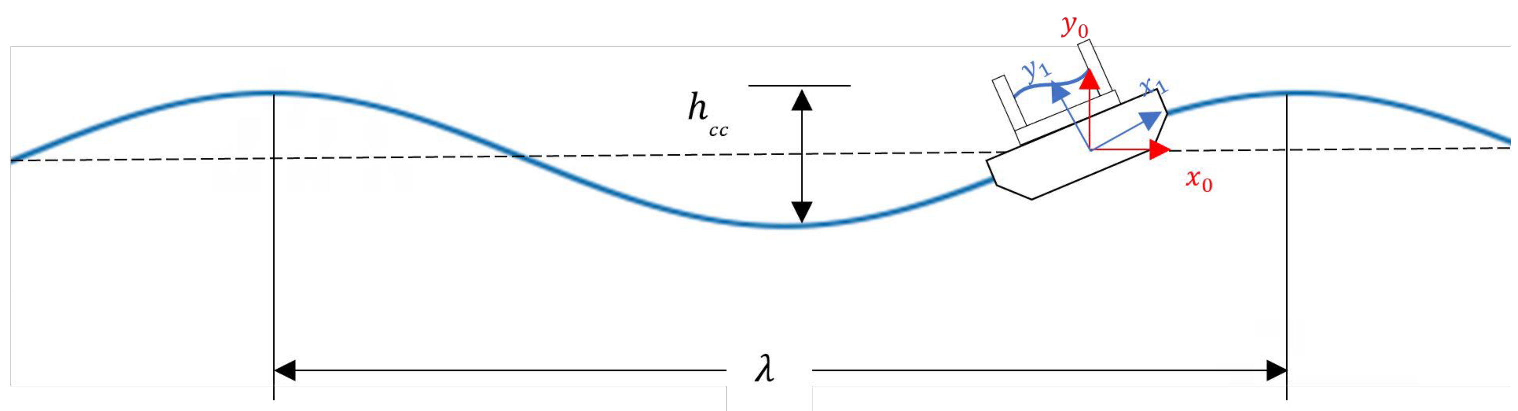

Figure 1 : Tank motion in a seaway

Method

The experimental setup (fig. 2.a) is used to evaluate the sloshing into a rigid rectangular tank subjected to pitch motion (short wave). We are interested on the impact of the maximum displacement of the tank and the characteristic period Tₚ of the rotation angle α(t) of the tank (fig. 2. b) on the sloshing. This setup makes it possible to validate the reduced 2D model of partially filled rectangular tank storage with a length of 250 mm, a height of 150 mm, and a filling height of 75 mm (50%)(Fig, 2.c). The numerical setup has been considered by coupling of the OpenFOAM code for fluid dynamics, based on the finite volume method, and FEniCS code for structural mechanics, based on the finite element method. The coupling is ensured by using the preCICE library. To express the pitch motion, a source term was added to the both domain fluid and structure. The pitch excitation applied is controlled by setting the electric motor rotation speed on 12 rpm, with a maximum displacement of the tank of 133.9 mm. It corresponds to the parameters of the swell : a wave period $T_p = 6s$, wave height $h_{cc} = 375\ mm$, and a wavelength $\lambda = 1400\ \ mm$.

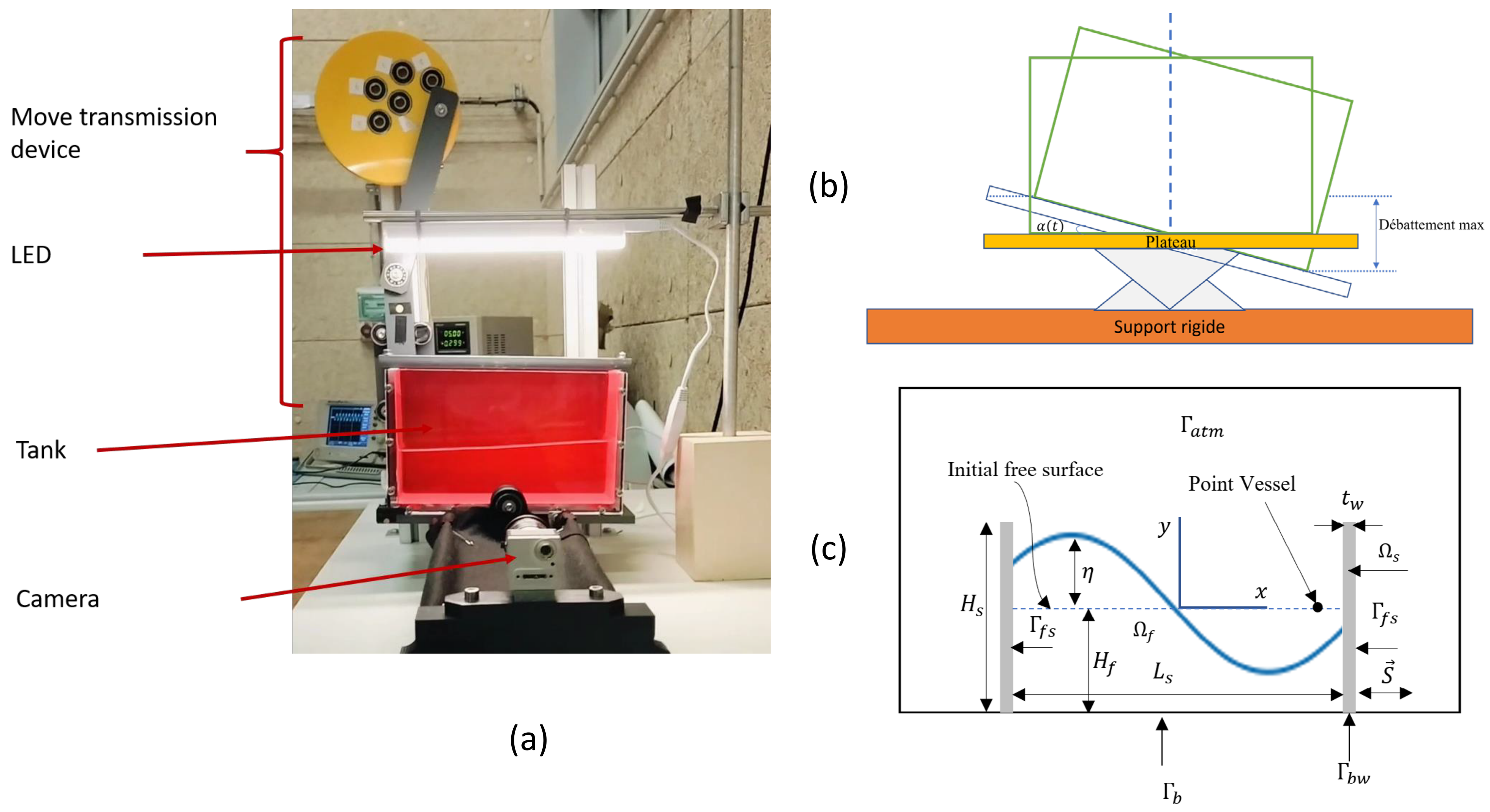

Figure 2 : (a) Experimental setup, (b) Tank rotation angle, (c) numerical setup

Results and discussions

- In the snapshots shown in fig. 3.a, the waves start to be generated around the middle of the tank for experimental and numerical cases.
- The free surface elevations results (fig. 3.b) are in good agreement; we observe an almost identical frequency and amplitude between simulation and experiment.

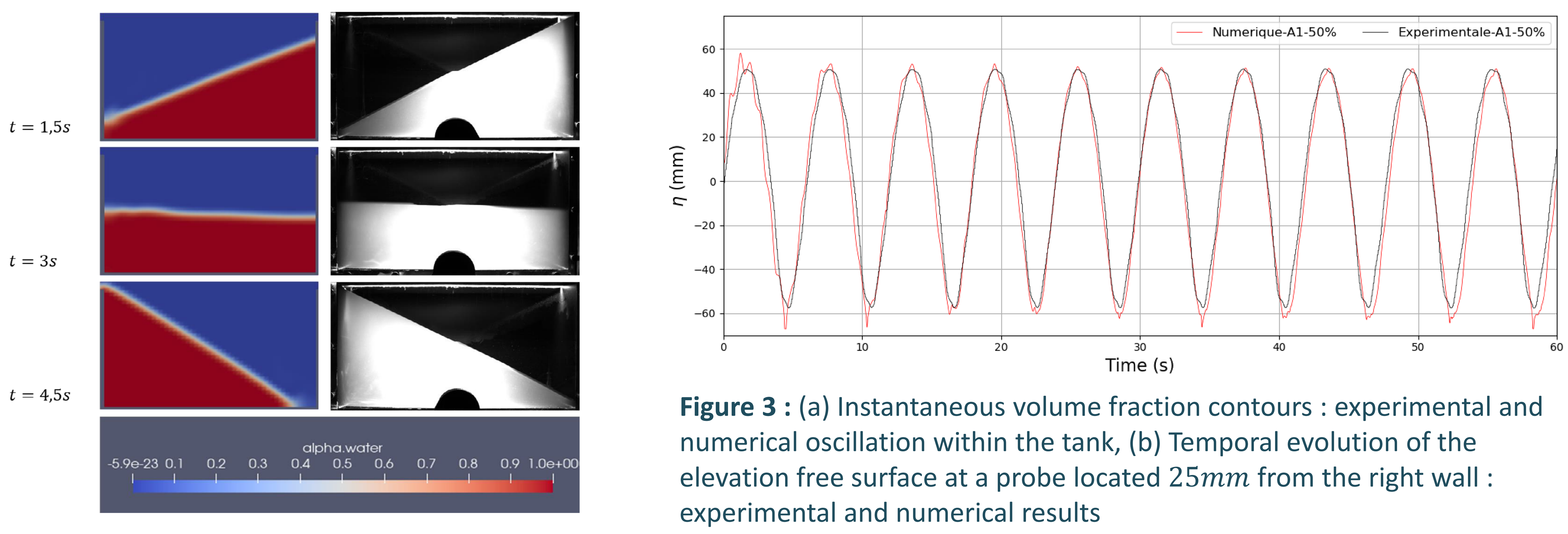

Figure 3 : (a) Instantaneous volume fraction contours : experimental and numerical oscillation within the tank, (b) Temporal evolution of the elevation free surface at a probe located 25mm from the right wall : experimental and numerical results

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GHOUINI F., KHA K. QN., BENAOUICHA M., SEGHIR A., GUILLOU S. S. AND SANTA CRUZ A., FSI MODELING OF LIQUID SLOSHING IN A FLEXIBLE FLOATING TANK UNDER REGULAR WAVE EFFECT. Larhyss Journal. (A paraître en septembre 2024).
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