High-Fidelity FSI for Vertical and Oblique Slams of a Flat Plate in Calm Water[1]

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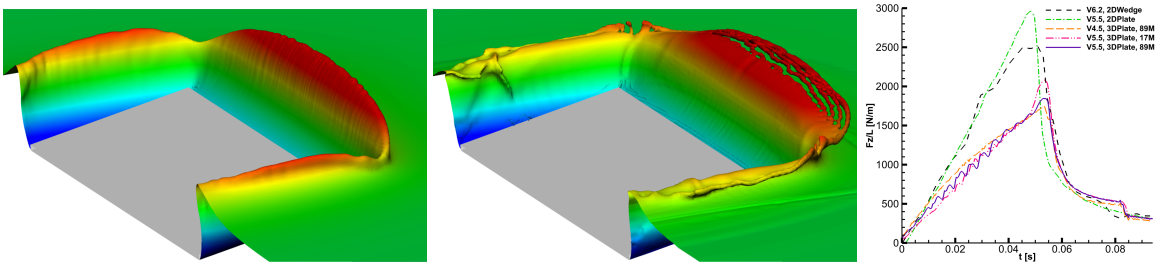
ABSTRACT

Slamming events of ship hulls lead to high-intensity impulsive hydrodynamic loads, which may reduce the lifetime of the vessel and cause structural damage. An accurate study of the complex phenomena associated to the water entry is necessary to improve safety and reliability of marine vessels. This is a challenging task due to the complexity of the interconnected phenomena involved: water entry of elastic structures with associated fluid-structure interaction (FSI), cavitation, ventilation, air entrapment and bubble formation, jet, spray, water sheet and droplets, each with different geometric scales.

The objective of the present work is a computational systematic study of the effects of different methods for evaluating the free surface (single-phase level set and fully-coupled two-phase volume of fluids, VOF) and the fluid-structure coupling (one- and two-way) on the hydrodynamic loads, structural response, and water jet/spray formation during vertical and oblique slams of a flat plate in calm water.

Computations are performed with the Reynolds-averaged Navier-Stokes equations code *CFDShip-Iowa*, used in earlier FSI studies [1]. V4.5 of the code evaluates the free-surface by a single-phase level set method, whereas a fully-coupled two-phase VOF is used in V5.5. V6.2 is a highly-accurate two-phase solver including surface tension and ability to resolve the smallest scale interface structuress. One- and two-way FSI simulations are performed using structural modal superposition. The trajectory is imposed. The water impact is assessed by pressure, global force, stress/strain, and water jet/spray. Comparisons with experimental data collected by the University of Maryland [2] are provided and discussed.



(a) Level set (V4.5) with 89M grid (b) VOF (V5.5) with 89M grid (c) Vertical force

Figure 1: Vertical slam: free-surface and vertical force acting on the plate.

REFERENCES

[1] Volpi, S., Diez, M., Sadat-Hosseini, H., Kim, D. H., Stern, F., Thodal, R. S., and Grenestedt, J. L. (2017). "Composite Bottom Panel Slamming of a Fast Planing Hull via Tightly Coupled Fluid-Structure Interaction Simulations and Sea Trials," *Ocean Engineering*, **143**, 240-258.

[2] Wang A., Kim H.-T., Wong K.P., Yu M., Kiger K.T., Duncan J.H., "Spray Formation and Structural Deformation during the Oblique Impact of a Flexible Plate on a Quiescent Water Surface," *32nd Symposium on Naval Hydrodynamics* (SNH), Hamburg, Germany, 5-10 August 2018.

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