11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

NUMERICAL SIMULATION AND EXPERIMENTAL VALIDATION OF GUIDED DITCHING TESTS

Martin Siemann[1], Dieter Kohlgrüber[1], Luis Benítez Montañés[2], James Campbell[3] and Alessandro Iafrati[4]

[1] German Aerospace Center - Institute of Structures and Design (DLR-BK), Pfaffenwaldring 38–40, 70569 Stuttgart, Germany, martin.siemann@dlr.de, www.dlr.de/bk/en
[2] AIRBUS MILITARY - Structural Dynamics and Aeroelasticity Dept, Pº John Lennon, s/n, 28906 Getafe Spain, Luis.Benitez@military.airbus.com , www.airbusmilitary.com
[3] School of Engineering, Cranfield University, Bedfordshire, MK43 0AL, UK, j.campbell@cranfield.ac.uk, www.cranfield.ac.uk
[4] CNR-INSEAN, Via di Vallerano, 139, 00128 Rome, Italy, alessandro.iafrati@cnr.it, www.insean.cnr.it

Key words: *Guided Ditching, Fluid-structure interaction, Water entry flows, High speed water impact, Experimental methods, Computational modelling.*

The oblique water entry of structures with high horizontal speed is investigated in this work. The most recent advances done in the computational models will be presented and comparisons with experimental data will be established. The activities are motivated by the necessity to improve understanding of the critical processes during ditching which refers to an emergency landing of an aircraft on water. This is of special interest to the aircraft industry, who must prove compliance to specific ditching paragraphs of the airworthiness regulations as part of the aircraft certification process.

The problem is complex, both from the computational and the experimental viewpoint, due to several reasons: it is characterized by sharp gradients with extremely small time and spatial scales which make it — even more than in other water entry problems — extremely challenging to capture them. This is further complicated by the requirement to capture non-linear structural deformation together with the description of the flow features. Moreover, due to the high speed involved and depending on the shape of the body, hydrodynamic phenomena like suction, ventilation and cavitation are likely to occur and affect the fluid-structure interaction.

In order to support the development of appropriate computational models, detailed experimental data is needed for validation. The only results available in this context date back to the 1950s [1]. Although very important for that period, the available data is not adequate to support code development, as there is no information about the structural deformation and the time resolution seems poor compared to today's state of the

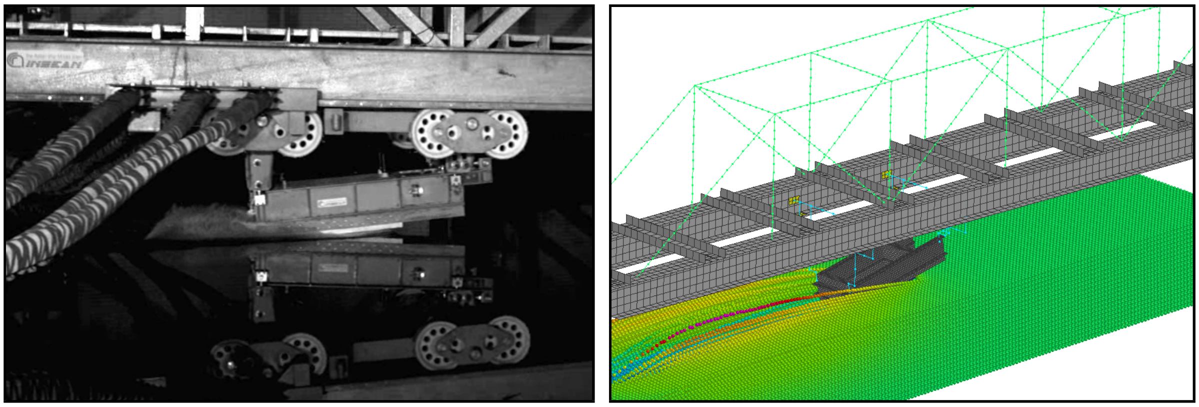

Figure 1: Guided ditching test: experimental observation and SPH-FE model during impact stage

art. The absences of suitable data lead to the requirement for a new experimental campaign to provide test data at representative impact velocities. Due to the number and complexity of the physical processes relevant for ditching, full-scale experimental results presented in this paper provide a significant step forward in the acknowledgment of these phenomena. The new experimental facility has been commissioned at the CNR-INSEAN site in Rome. It consists of a trolley moving along a guide track, see figure 1, with impact velocities in the $30 - 50m/s$ range. Parameters that are varied include pitch angle, shape of the structural panel, panel thickness and material. Measurements involve pressures, accelerations, forces and strains which are used for validation of the numerical models.

This paper will present an overview of the experiment and the data gathered. It will then discuss how the experimental results are supporting the development of improved computational models in the description of the physical aspects as well as the code reliability, accuracy and performance. In this context, improvements concerned with before mentioned issues and their application to the guided ditching load case are presented to show the state of the art of ditching simulations, including coupled SPH-FE models. Key aspects are the application of the mesh-free SPH method with improvements in terms of particle regularization techniques, pressure correction methods, boundary conditions and initial particle distributions.

Acknowledgments: Most of the work leading to the results presented has received funding from the European Commission's Seventh Framework Programme under grant agreement n^{o} FP7-266172 and was performed within the project SMAES — SMart Aircraft in Emergency Situations.

REFERENCES

[1] R.F. Smiley. *An experimental study of water-pressure distributions during landings and planing of a heavily loaded rectangular flat-plate model*, NACA Technical Note 2453, 1951.