Extreme Wave Impacts on a Fixed Truncated Circular Cylinder

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Introduction

As part of the wider SuperGen UKCMER project entitled ‘Survivability of wave energy converter and mooring coupled system’ this preliminary work concentrates on the numerical and physical modelling of extreme wave impacts on a simplified model of a Wave Energy Converter (WEC).

Methodology

A physical representation of an extreme wave was generated in the COAST Lab Ocean Basin, at Plymouth University, using the NewWave, dispersive focussing, formulation of Tromans et al. (1991) [1] and the 100 year storm spectrum from the Wave Hub site. This wave was focussed on the centre of a 0.2m diameter cylinder which was fixed vertically to the wave basin’s gantry with a draft of 0.2m. An array of resistive wave gauges were positioned to record the surface elevation around the cylinder as well as the run up on its front side. Finally a pressure transducer was installed on the front of the cylinder at the still water level.

Using time series data from the experiments as the input boundary condition, a numerical simulation of the extreme wave impact was performed using the volume of fluid, Navier-Stokes solver provided with OpenFOAM® and the generic wave generation and absorption capabilities of the waves2Foam toolbox [2].

Results

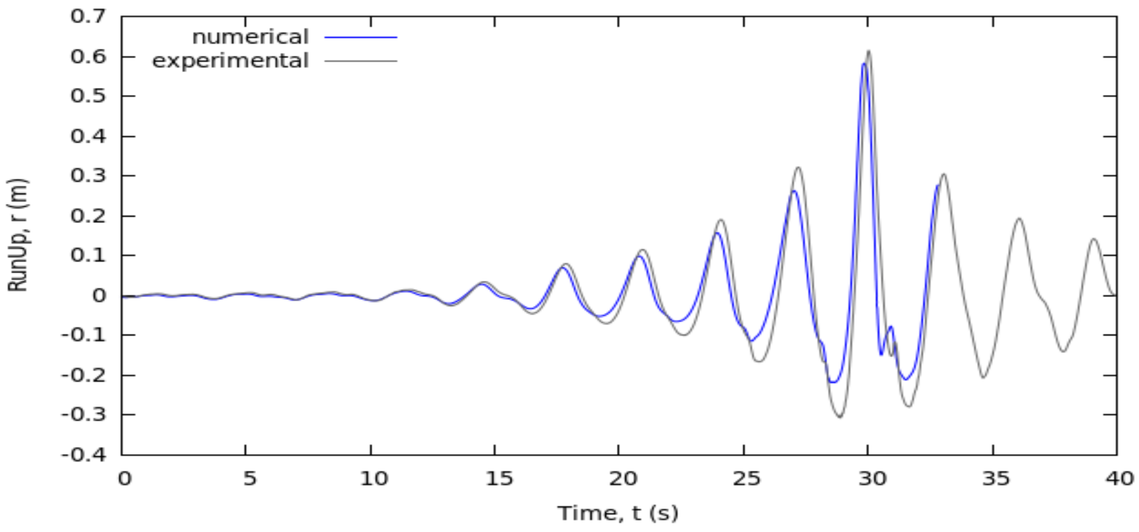

Figure 1: Comparison of the run-up on the front face of the cylinder.

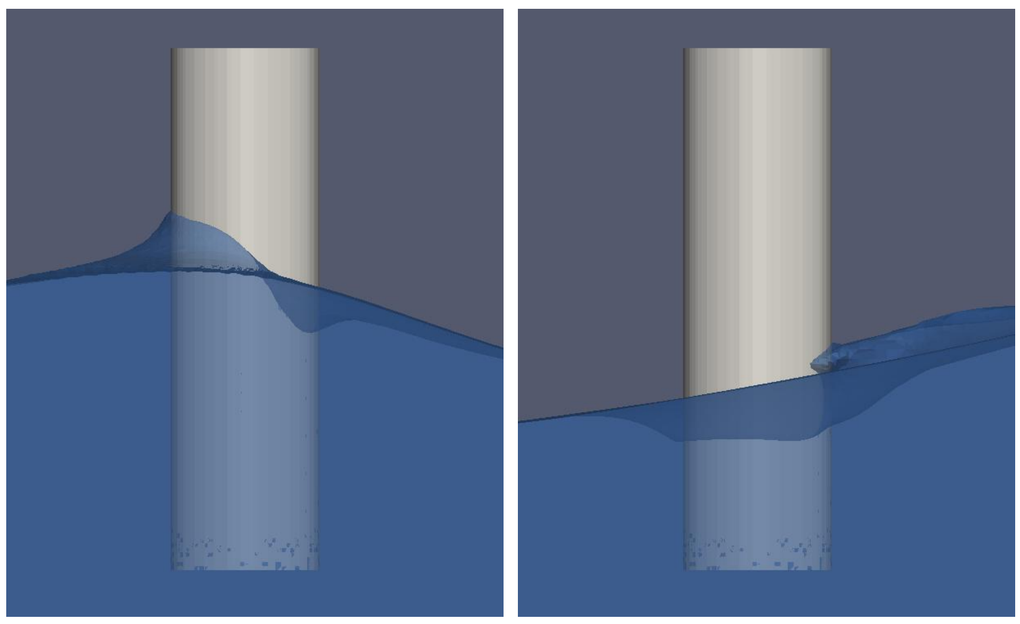

Figure 2: Plots of the water phase from the numerical simulation at t=29.8s (left) and t=30.2s (right). Wave travelling from left to right.

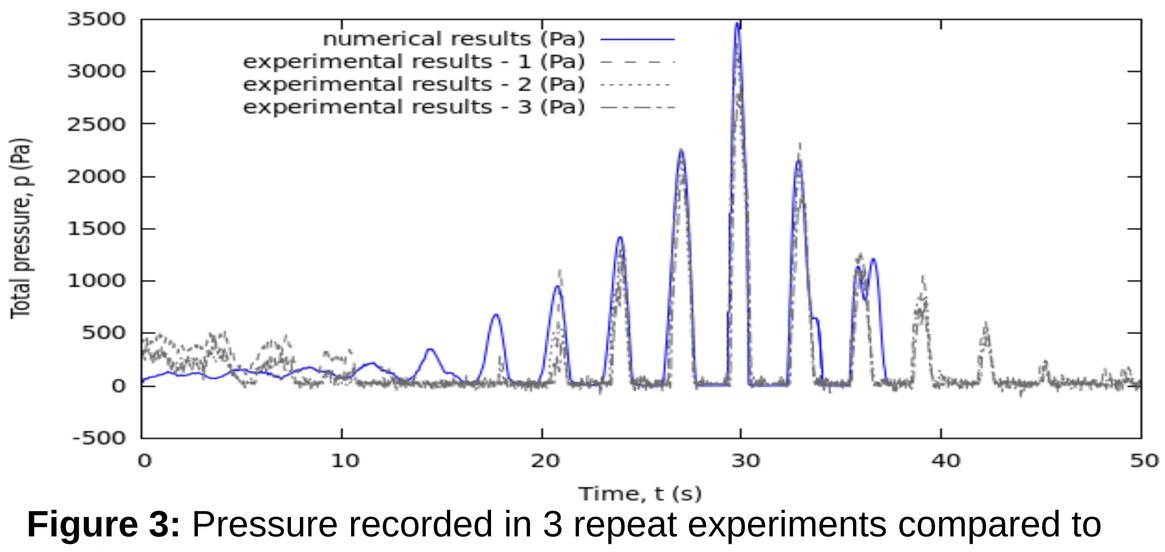

Figure 3: Pressure recorded in 3 repeat experiments compared to results from numerical simulations.

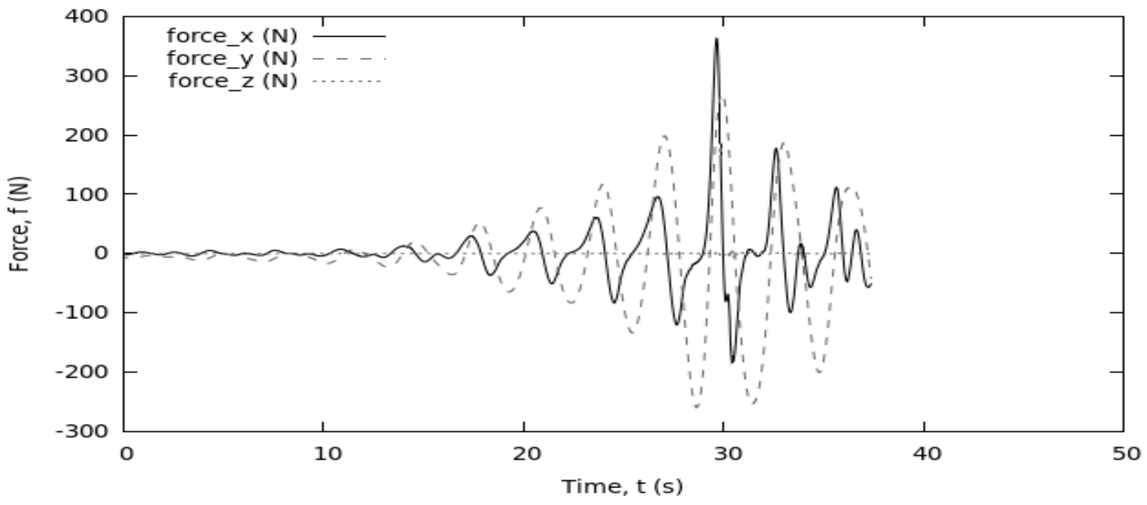

Figure 4: Force estimations on the cylinder (x is the wave direction, y is vertical and z is normal to the wave direction) from the numerical simulation. The buoyancy force have been removed from force_y.

Conclusions

In conclusion, the essential hydrodynamic phenomena associated with an extreme wave impact have been modelled well. The run up and pressure results agreed well with experiments which gives confidence that the hydrodynamic loading results are realistic.

References

1.PS Tromans, A Anaturk, P Hagemeijer (1991) “A new model for the kinematics of large ocean waves – application as a design wave”, in *Proceedings of the 1st International Offshore and Polar Engineering Conference, 1991:* Edinburgh, UK: 64-71.

2.NG Jacobsen, DR Fuhrman, J Fredsøe (2012) “A wave generation toolbox for the open-source CFD library: OpenFoam®”, *Int. J. Numer. Meth. Fluids*, 70(9): 1073-1088.