Extreme wave impact on offshore platforms and coastal structures

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Introduction

Extreme waves and their impact loading on (floating) stuctures like ships, oil platforms or coastal protection systems (e.g. dikes), could only be studied experimentally. New hydrodynamic numerical models, based on Navier-Stokes equations in combination with a Volume-of-Fluid-based method are able to predict the hydrodynamic behavior accurately.

Dike break in Wijde Wormer, The Netherlands, 1825.

Particularly during extreme weather conditions, introducing *two-phase* flow is crucial for the loads on structures. Spray, bubble clouds and large air pockets seriously affect (peak) pressure levels.

Two-phase numerical model

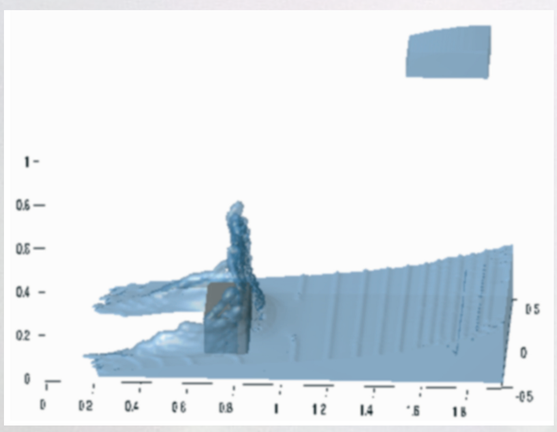
The current numerical model, ComFLOW, is an improved 3D Volume of Fluid Navier-Stokes Solver. For the proper quantification of water heights and pressure levels, the numerical model has been extended from a one-phase model to an (in)compressible two-phase model.

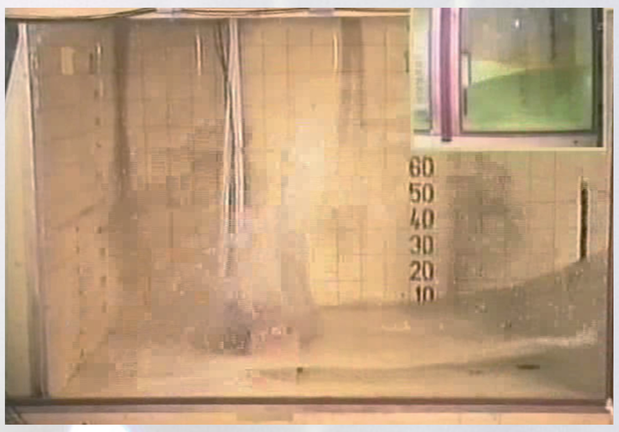
The major difference is the computation of velocity, pressure and density values for the air phase, which was not the case for the one-phase model. The incompressible model is based on the continuity and momentum equations, while the density at a specific location is calculated by weighted or harmonic averaging.

Protecting the Nation, Hans Brinker, or the silver skates, Mary Mapes Dodge, 1865.

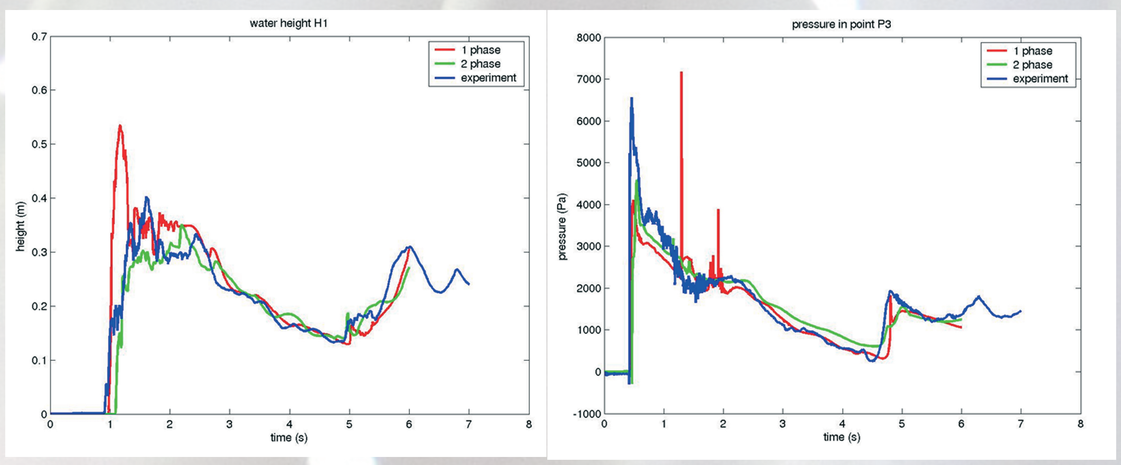
Results

The two-phase model has been tested on a dam break problem. Pressure levels are determined on a rectangular box, which represents a container.





The numerical results have been compared to measurements performed at MARIN. The figures below show the development of the water height (just left of the rectangular box) and the pressure level (at the front of the box).



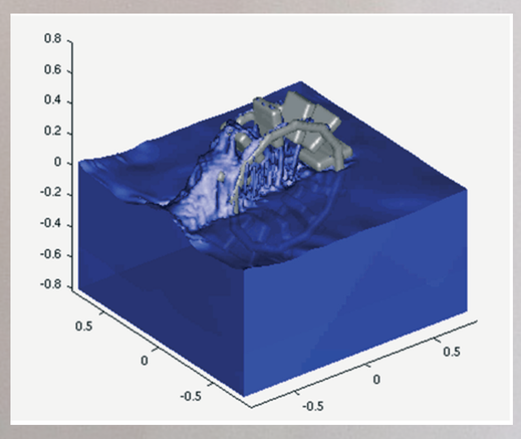
The accuracy of the predicted fluid and pressure levels increases when taking the second phase into account.

Numerical Features

Shown is a $O(n^4)$ problem with $n = 256$. The workload is about 3 Petaflop. Goal: $n = 1024$ (750 Petaflop).

Conclusions and Future Work

The numerical model is currently able to simulate the dynamics of hydrodynamic wave loading for many offshore applications.
In the future, the numerical model will be validated on more test cases, like sloshing in LNG tanks, wave run up at column structures and water entry of falling objects.



The extension of the incompressible two-phase model to a compressible two-phase model is another major challenge.

ComFLOW one-phase example (Peddle wheel by Iwanowski).

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