

Experimental and numerical investigation of wave impact on a vertical wall

Atle Jensen

Department of Mathematics, University of Oslo,
Po. Box 1053, NO-0316, Oslo, Norway.

Breaking waves is a topic of hydrodynamic wave theory for which our insight is still very limited. Qualitative description and classification are found in, for instance, Cokelet (1977); Peregrine (1983) and formation of plungers have been simulated since 1976 (Longuet-Higgins & Cokelet (1976)), but a number of aspects and applications for breaking waves still await proper analysis. In mid ocean breaking waves are important for momentum transfer from wind to ocean currents as well as mixing of the surface layers. From an engineering point of view plunging breakers and extremely steep waves may present extreme loads on structures and vessels, see Peregrine (2003)

In Jensen *et al.* (2003) the dynamics of incident solitary waves on the verge of onshore plunging, on a 10.54° slope, were investigated with the PIV technique. Among other things, acceleration distributions leading to reversal of breaking in overhanging waves were reported. In Jensen *et al.* (2005) another set of experiments with runup of solitary waves on a 7.18° slope was studied. The velocity and acceleration distribution in massive onshore plungers are measured with PIV and computed by a VOF technique. This investigation aimed at recognition of cases leading to extreme runup and onshore impact of tsunamis and swells.

The present study employs the same incident waves as Jensen *et al.* (2005), but the inclination of the beach is lowered to 5.1° . Waves may now develop large, but well defined, plungers as opposed to the collapsing breaker that was reported in Jensen *et al.* (2005). In some experiments a surface-piercing vertical plate, or a circular cylinder, is mounted at the beach. The aim of these experiments is to correlate the pressure, which is measured at the wall with three probes, with wave kinematics and assess the magnitude of the wave loads.

The wave tank is 1 m high, 0.5 m wide and 25 m long. At one end of the tank waves were generated by a hydraulic piston attached to a vertical paddle. The water depth was $h = 0.205\text{m}$ and the wall was mounted 0.237m from $(0, 0)$ - which is located at the crossing point between the beach and free surface. Velocities are measured with PIV applied to subsequent images from a high speed video camera and a Nd:YLF laser. The acquisition rate for the measurements are over 1000fps . Three pressure gauges are mounted on the wall with a spacing of 2.5cm . The figure shows the velocity field overlaying a raw image from the PIV recordings together with elevation measurements of the incident wave. The pressure is presented together with the corresponding velocity field at maximum pressure.

The surface elevation of the incident wave is measured by an acoustic wave gauge when it travels in finite depth. The top left figure in Figure 2 shows a solitary wave measured by this method. Free surface profiles are also extracted from digital images to acquire the spatial distribution.

The post-processing of the experimental results are still going on and a major challenge, with respect to both processing time and interpretation, is the huge amount of data acquired from the HSV system. A full compilation of the experimental data will thus require much time.

All experiments are going to be compared with a Navier-Stokes solver using the VOF technique. A first comparison between the experiments and Navier-Stokes solver is shown in figure 1.

References

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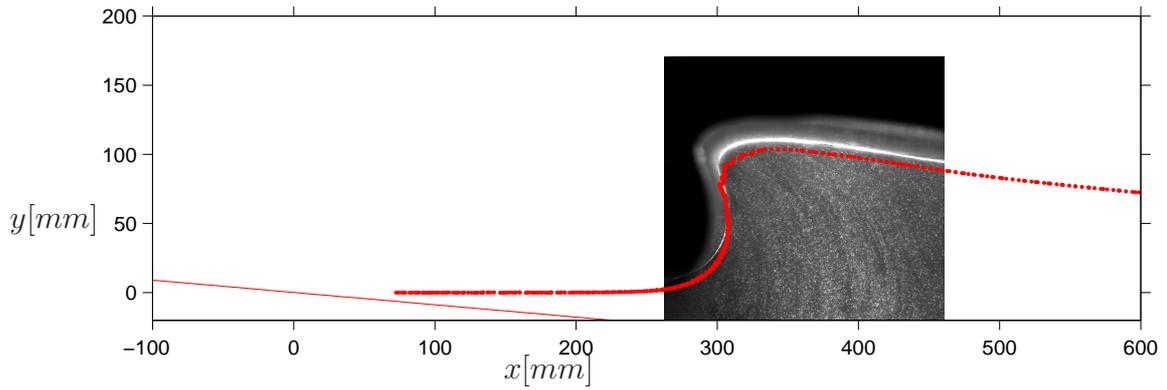


Figure 1: A comparison between an image from the PIV recording and the Navier-Stokes solver; free surface.

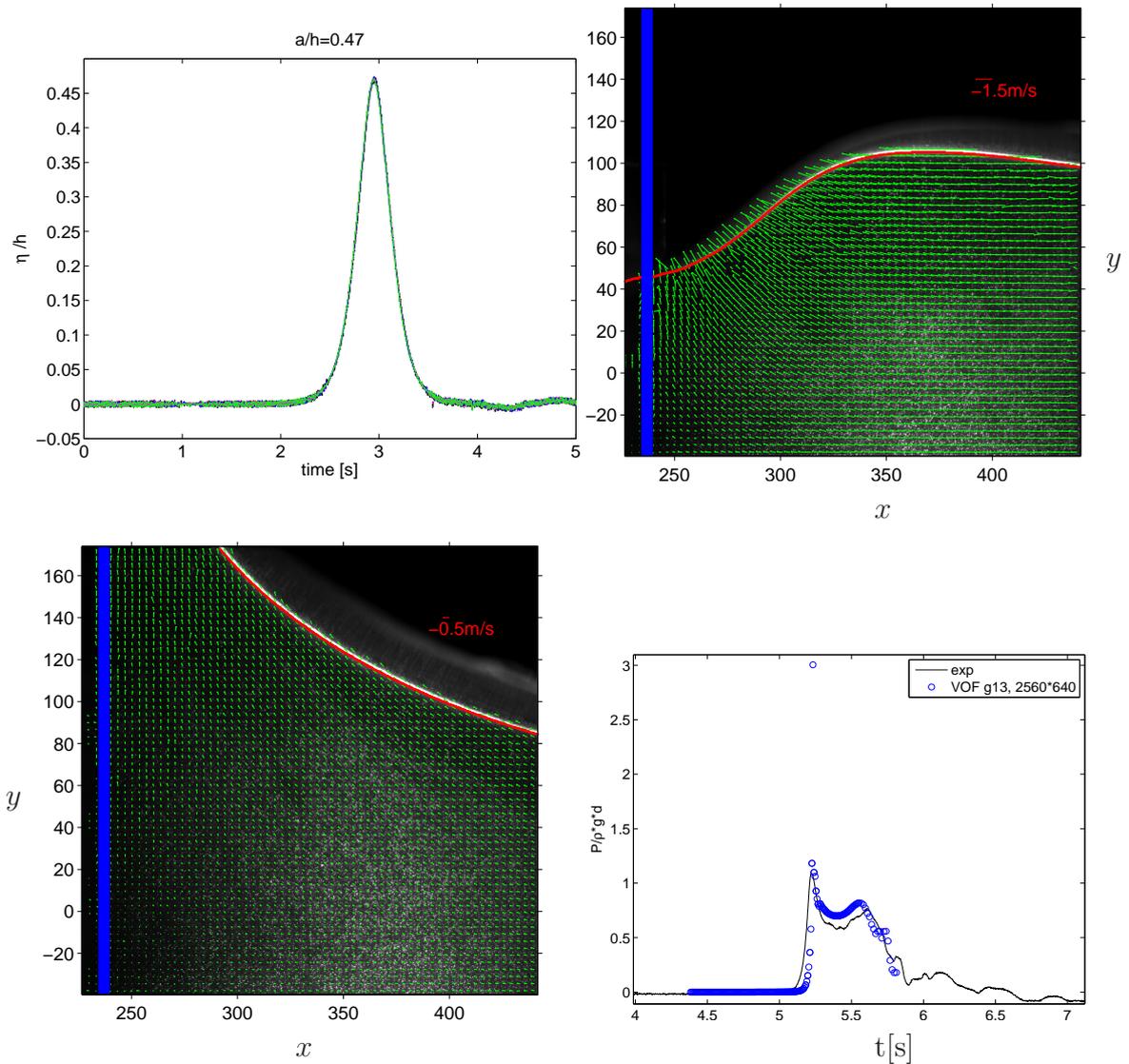


Figure 2: Top; left: elevation of the incident wave, $amplitude/depth = 0.47$. Right: PIV velocity field, $t = 5.05s$, blue is the vertical wall. Bottom; left: PIV, $t=5.22s$. Right: pressure distribution at the vertical wall compared with NS-VOF simulations.