Physical investigation of slamming loads on a 2D body

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Introduction

Slamming (water impact) is important in the design of both ships and offshore structures. It is defined by high localized pressure peaks. Examples of situations where slamming occur can be a ship bottom hitting water with high velocity, waves breaking upon platform columns or blunt transom sterns hitting waves. It has caused many serious accidents and damages also in the recent years. This may be part of the motivation behind the large amount of papers written on the subject.

Both analytical and numerical methods have been developed throughout time to estimate the slamming loads. As for most theories within hydrodynamics, model testing is needed for validation. Model testing is also important to gain increased understanding of the involved features of the slamming phenomenon.

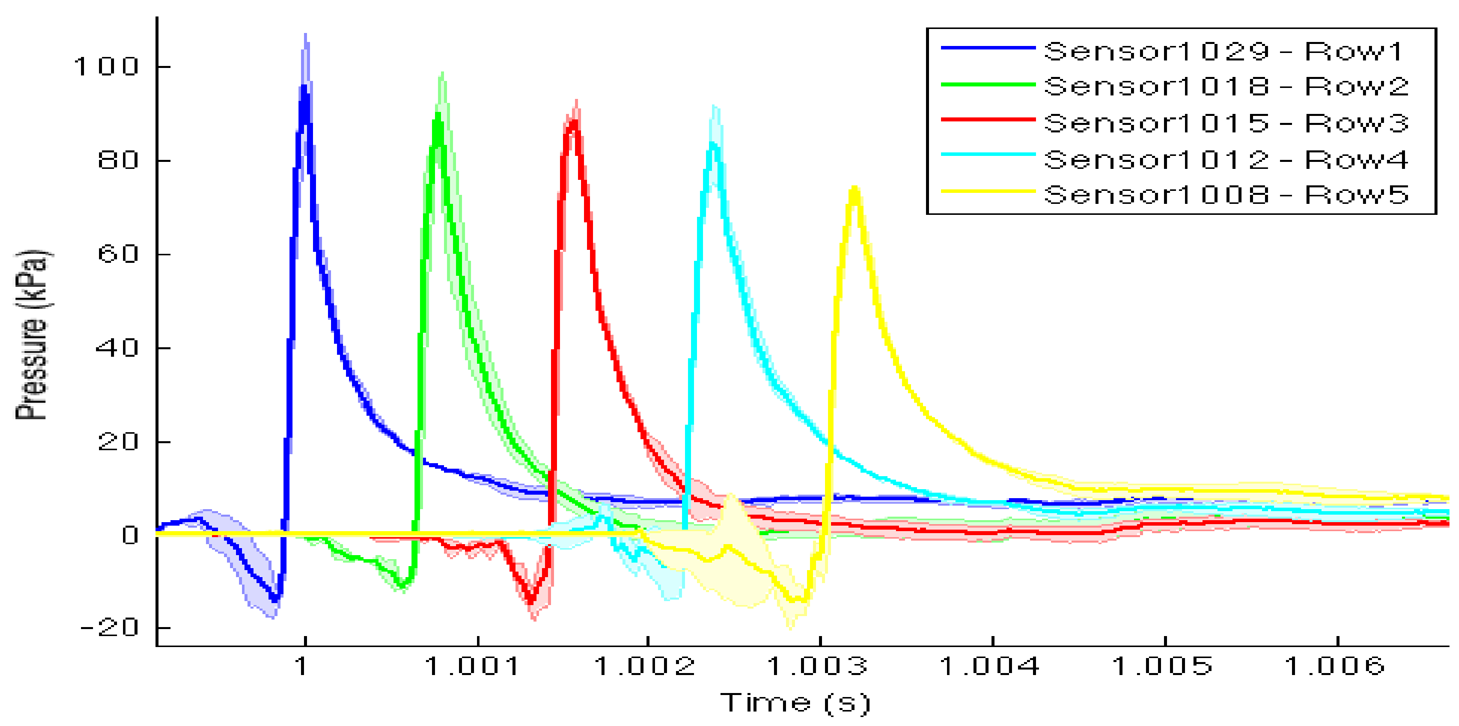
The most frequently applied experiment is the drop test of a body onto an initially flat free surface. When the body is blunt, the pressure peaks become very high and localised in both time and space. The time scale of the impact loads on a rigid body entering water is typically in the range of milliseconds. Many difficulties can be encountered during such experiments. The small spatial extent and short time duration of the pressure peaks set a higher level of requirements for the measurement system and the sensors. Influence of vibrations of the test rig and a varying impact velocity has also proved to be difficult to avoid. Despite these challenges drop tests have been performed for over 60 years.

The aim of this this thesis is to investigate the features connected with slamming by means of an analysis of a model test in 2D flow conditions.

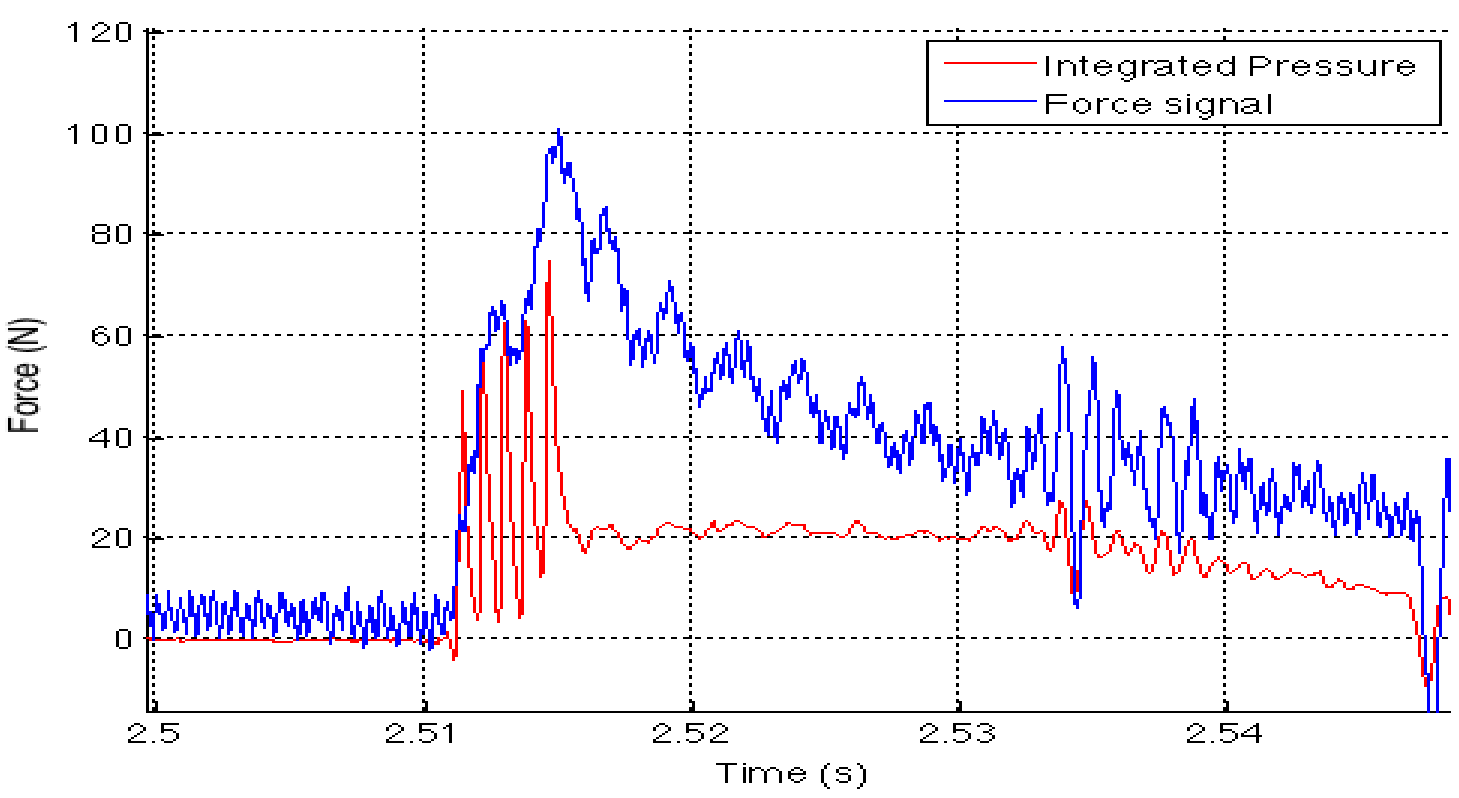
Scope of work

The following work is carried out in the thesis:

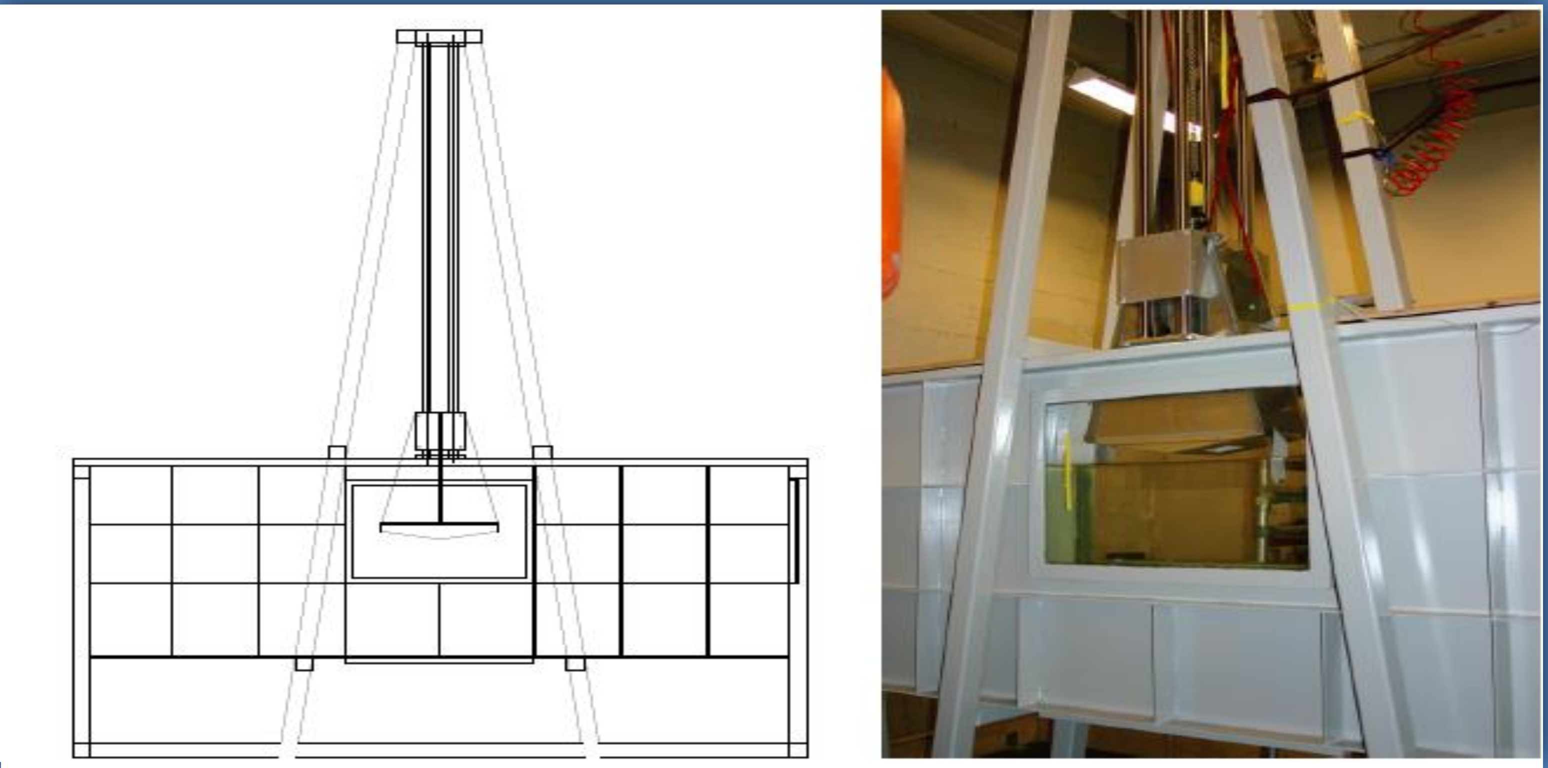
- A literature study on measurement techniques used in a slamming experiment.
- An analysis of a drop test of a wedge shaped section in 2D flow conditions carried out at MARINTEKS laboratories.
- An investigation of the repeatability, stochastic behaviour and non-linear features of the measured local quantities
- Comparison with results from a drop test reported by Yang et al. (2007).
- An evaluation of theoretical models suited to reproduce the main features from the drop test at MARINTEK.



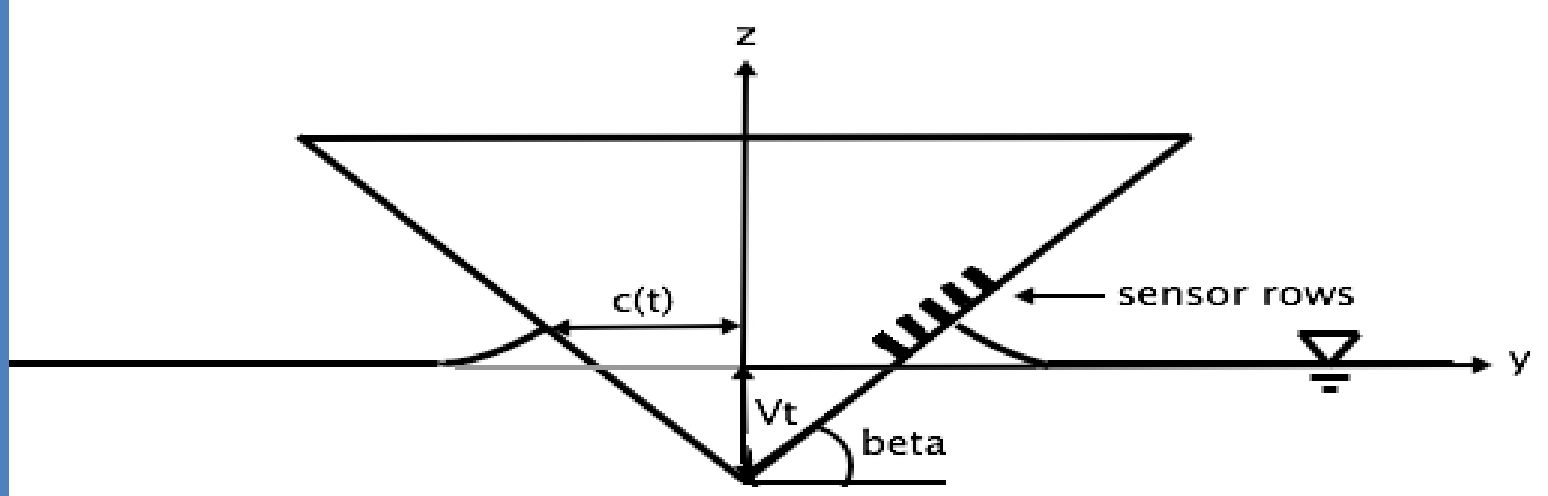
Pressure time history. Thick line = mean pressure, Shaded area = Standard deviation.



Force measurement compared to integrated pressure for 0.1 m drop height. Large discrepancy observed between the two.



Sketch and picture of experimental test set-up at MARINTEK.



Sketch of wedge upon water entry.

Results of experimental analysis

A free fall drop test of a two-dimensional wedge carried out at MARINTEK's laboratories has been investigated in this thesis. A rigid wedge with a mass of 70 kg and a deadrise angle of 10 degrees was dropped from three drop heights: 0.1, 0.25 and 0.5 m. Pressure, force and position was measured.

The following results deviate from expected behaviour:

1. Maximum pressure along sensor rows decreased with increasing distance from apex
2. The spatial distribution of the pressure coefficient was below the prediction by Wagner's theory (1932). The discrepancy increased with decreasing drop height
3. Negative pressures reoccurred before the pressure peaks
4. Force measurements compared to integrated pressure showed a large discrepancy for the lowest drop height

Changing velocity, hydroelasticitity and three-dimensional effects were considered, but rejected as explanations. An error estimate was made including disturbances in the free surface and and error in derived velocity. The conclusion is that the behaviour is caused by measurement errors, as the deviations from expected behaviour are inside the estimated error range.

Negative pressures reoccurred before the rise to peak pressure for all drop heights. It is concluded that this is most likely due to air being trapped in the curvature of the sensor. A small increase in pressure is observed before the negative drop. This can be explained by the air being compressed initially (causing the rise in pressure) and when the cavity collapse this causes the negative pressure.

The repeatability of the pressure peaks was found to be within the estimated error range. A variation between 15-20% was found.. As the peak pressures during impact are of a stochastic nature (Faltinsen 2010), a variation is expected.

References

Faltinsen,, O. M. (2010) *Hydrodynamics of High-Speed Marine Vehicles.* New York: Cambridge University Press

Wagner, H. (1932) Uber struss-und Geltvorgange ander Oberflasche von Flussikeiten. *Zeitschr. f. Angewande Mathematik und Mechanik,* Vol 12 (4), pp 193-325